TALLINN UNIVERSITY OF TECHNOLOGY
SCHOOL OF ENGINEERING
Technology of Wood, Plastics and Textiles

# MODERN EMBROIDERY TECHNOLOGIES IN GARMENT PRODUCT DEVELOPMENT ON THE EXAMPLE OF EVENING GOWN

# KAASAEGSED TIKKIMISTEHNOLOOGIAD RÕIVASTE TOOTEARENDUSES PIDULIKU KLEIDI NÄITEL

MASTER THESIS

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(*On the reverse side of title page*)

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# THESIS TASK

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**Thesis topic**:

(in English) Modern embroidery technologies in garment product development on the example of evening gown

(in Estonian) Kaasaegsed tikkimistehnoloogiad rõivaste tootearenduses piduliku kleidi näitel

**Thesis main objectives**:

1. Exploring the possibilities of how to use embroidery and novel embroidery techniques in modern product development
2. Development of several embroideries
3. The development process of dress and belts

**Thesis tasks and time schedule:**

| No | Task description | Deadline |
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| 3. | Different types of materials used for embroidery | 24.05.2019 |
| 4. | Testing of dress fabrics and embroidery threads | 15.02.2020 |
| 5. | Dress and belts sewing process | 28.03.2020 |
| 6. | Making the embroidery of belts | 16.04.2020 |
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# CONTENTS

# INTRODUCTION

Embroidery is a decoration of products from various materials with an ornamental pattern or plot image made by threads and other materials manually using a needle or machine [1]. Historically embroidery is one of the most popular types of folk art. Embroidery came into existence with the first stitch made by the prehistoric humans to bind the hide of a killed mammoth. Sewing first appeared as a necessity and later the complexity of embroidery and materials used reflected the social status of a person [2]. Silk, golden and silver threads as also different gems and pearls were used in embroideries decorations of gloves and interior designs of rich people. But not only rich people were the ones who enjoyed embroideries. Embroidery was also widely used in poor people clothes and households. Although poor people could not afford silk or golden threads beautiful embroideries were done using cotton or wool threads.

Before the 19th century it was a big handwork to make an embroidery. It took a lot of time and attention, but at the beginning of the 19th century, Joshua Heilmann, the famous French inventor, created the first hand-embroidery machine and at the end of the 19th century the first automatic embroidery machine was invented by Isaac Groebli's son [3].

Nowadays embroidery is not broadly used, it has been replaced with much cheaper, easier, and quicker method printing onto textiles. Even being used much more real it still adds beauty and originality to the clothes making them unique. Many famous designers are using embroidery on their clothes: Zuhair Murad, Michael Cinco's, Balmain and Guo Pei. Despite the fact that embroidery technology is so advanced now and allows to create any kind of embroidery, many designers still prefer to use hand made embroidery, which makes clothes very special and luxurious. Machine embroidery is more used in mass production or for prêt-à-porter clothes. Thanks to the development of technology, the process of embroidery has become much easier and faster. Various materials, software, and threads allow creating incredible designs.

The aim of this master thesis is to get acquainted with the history of embroidery, materials used for it, embroidery machines and software used and to explore the possibility of using embroidery in modern product development. An evening gown was chosen to see how different embroideries done with different threads can influence the perception and the mood of the dress. The belts were chosen to become an interchangeable accessory. It is important to mention that it was decided not to make the expensive luxury gown, but try to develop affordable evening gown for a local

consumer. The next part of the work was to develop the evening gown and the embroidered belts for it.

The first part of the master's thesis provides a theoretical part. It consists of an overview of embroidery and embroidery machines, a review of different types of embroidery machines, an overview of different threads, backings and toppings and embroidery software used for machines nowadays.

Nowadays there are a lot of different textiles made by different producers on the market. The quality and the safety of the fabric becomes very important. The last part of the theoretical part focuses on the description of different materials testing which were chosen and performed to select a fabric with the best features for the designed evening gown and belts.

The second part of the master thesis focuses on a practical part. It includes: an overview of fabrics tests done to choose the best fabric for evening gown and belts, and embroidery tests done to see resistance to the wearing.

Overview of evening gown development process: taking of body measurements, patterns construction and correction and dress sewing technology description. The last part is delegated to belts pattern construction, embroidery creation and embroidery software use as also belts sewing technology.

Keywords: evening gown, embroidered belts, threads, embroidery machines, master thesis.

# 1 HISTORY OF EMBROIDERY

Embroidery is one of the most common types of folk and applied arts. It came into existence with the first stitch made by the prehistoric humans to bind the hide of a killed mammoth. Sewing first appeared as a necessity. Over time, embroidery came to be as a decorative addition to sewing [2].

In Ancient Egypt, embroidery became an art, with noble women working to adorn the clothes of pharaohs and their entourage. Figure 1.1 shows the clothes of pharaohs and rich ancient Egyptians. The complexity of the design reflects the social status of the wearer. Beads were also invented in Egypt, and soon everyone in the ancient world was striving to make beadwork [4].

Luxurious goldwork embroidery came from the East. The works of art created by the local craftsmen cost a fortune. Roman and Greek spent large amounts of money on embroidered fabrics. The obsession with the embroidery grew to the point where the government had to interfere, attempts were made to ban or at least reduce the popularity of the embroidery. And thus, original Greek embroideries appeared, elegant, tasteful, and restrained [4].

Figure 1.1 Egypt clothes [5], [6]

## 1.1 Medieval embroidery

The Middle Ages inherited the ancient art of embroidery. Throughout Europe, noble ladies spent their time by the window with the embroidery hoop creating beautiful patterns. Embroidery was considered to be the most appropriate pastime for women.

The most popular embroidery - the cross stitch technique - appeared in the Middle Ages. It is believed that its emergence was associated with the Crusades, the ladies decorated clothing with the cross to protect their knights from the evil pagan spirits [4].

Each country contributed something to the art of embroidery. Tapestries and large embroidery panels, became popular all over Europe. They were very expensive and adorned only princely castles and royal palaces. It was very difficult to create such an embroidery, but the finished work was truly the work of art (Figure 1.2). Ecclesiastical embroidery was especially luxurious. The parishioners were awestruck with the opulent clergy robes [4].

Figure 1.2 Medieval embroidery [7], [8]

## 1.2 Far eastern embroidery

As early as the 6th-5th century B.C., the Chinese embroidered on silk using gold and silver threads, and sometimes hair. Chinese often used flowers and birds in embroidery (Figure 1.3). Five distinctive features were typical for Chinese embroidery: varied kinds of threads, a high color contrast, the gold thread sew as the contour line of embroidery patterns, complicated and gorgeous decorative motif, and male

embroiders (Figure 1.4) [9]. Embroidery designs were rich in life and full of colors. Later embroidery appeared in Japan, largely echoing the Chinese tradition [4].

Figure 1.3 Chinese embroidery birds [10]

Figure 1.4 Chinese embroidery dragon [11]

## 1.3 English embroidery

Having severed ties with the Catholic church, England experienced a new flourishing of arts. Embroidery not only adorned the clothes of noblemen, it was also used in arts and daily life. Embroidered paintings led to embroidered illustrations as on Figure 1.5 and book covers. It was then that embroidered portraits also came into fashion. Embroidery adorned belts and purses, hats and shoes, as well as interior details [12]. Both noble ladies and poor English peasant women were passionate about embroidery. Albums with a collection of embroidery patterns were published all over the country [4].

But what England is truly proud of is embroidered glovesFigure 1.5 English embroidery , Figure 1.6 English embroidered gloves Gloves used to be a much more important garment than they are now. Everyone knows, if a gentleman throws his glove at the feet of another gentleman, it means he is challenging him to a duel. And that is not the only etiquette rule associated with gloves. Back then, men used to present the lady with their glove as a marriage proposal. In the 17th century, stumpwork became widespread. Usually it depicted familiar themes, and the clothing of the embroidered people was made of patches and ribbons [4].


Figure 1.5 English embroidery [7],

Figure 1.6 English embroidered gloves [13]

## 1.4 French embroidery

Interior design embroidery is an interesting aspect of French applied art. When the Sun King moved from the gloomy bare Louvre to the luxurious Versaille, France became obsessed with interior decor. Interior design embroidery is an interesting aspect of French applied art. When the Sun King moved from the gloomy bear Louvre to the luxurious Versaille, France became obsessed with interior decor. Decoration with embroidery was everywhere. Embroidery decoration was used on the book covers and in the books (Figure 1.7), bags (Figure 1.78), wallets, snuff boxes, curtains and chairs and many other things of the rich people [4].

Figure 1.7 Book with embroidery [7]

Figure 1.8 Little bag with embroidery [7]

## 1.5 German embroidery

Saxony white on white embroidery made German embroidery famous all over Europe. This embroidery was based on Dresden whitework. The bedding became a hit, and

since then embroidered bedding became a staple of luxurious bedding in all European royal courts.

Berlin embroidery is known for being the first embroidery pattern to be published as a familiar template with colored squares. These templates became popular throughout Europe, thanks to female customers (Figure 1.9) [4].

Figure 1.9 German embroidery [7]

## 1.6 Italian embroidery

Bright, whimsical and magnificent (Figure 1.10), Baroque embroidery reigned supreme for a long time in Italy. Italian clothing was so colourful see Figure 1.101, it was ridiculed in prudish England. However, the Italians were not embarassed at all. Large embroidery in a variety of bright and vivid colours was an important part of their clothing [4].

Figure 1.10 Italian Embroidery on Iron Stand [14]

Figure 1.11 Embroidered Velvet [15]

## 1.7 Embroidery in Russia

In Kievan Rus', ecclesiastical embroidery was particularly luxurious (Figure 1.12). The use of pearls in embroidery distinguished it from its western counterparts. Clergy

clothes, icons, and book covers – all religious items were embroidered with gold and pearls. Embroidered clothing was also common. Depending on financial situation, it could be a modest folk embroidery (Figure 1.123) or luxurious gold and silver patterns embroidered on the clothing of nobility. Starting with Peter the Great, embroidering accessories and small toilette articles, as well as borrowing western techniques and motifs became popular [4].

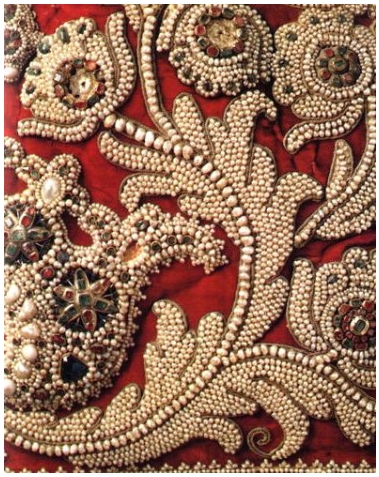


Figure 1.12 Russian pearl embroidery [16]

Figure 1.13 Pillow with Russian embroidery [17]

# 2 THE HISTORY OF MACHINE EMBROIDERY

Before the beginning of the 19th-century embroidery was done by hand, it took a lot of experience, time and patience to make it. In 1829, Joshua Heilmann, the famous French inventor, created the first hand-embroidery machine, see it Figure 1.14. Just a year later, Franz Mange from St. Gallen, Switzerland purchased two such machines on the condition that no other machine would be sold to anyone in Switzerland or its immediate surroundings without his consent [18]. However, Mange allowed Maschinen-Werkstätte und Eisengießerey company the production of such machines. Several machines were even exported abroad, although it was not successful. In the late 1830s, the new owner of the Mange company, together with the mechanic Anton Saurer, improved the design of the machine, resulting in better quality of the embroidery, which came very close to that of hand-embroidery [3].

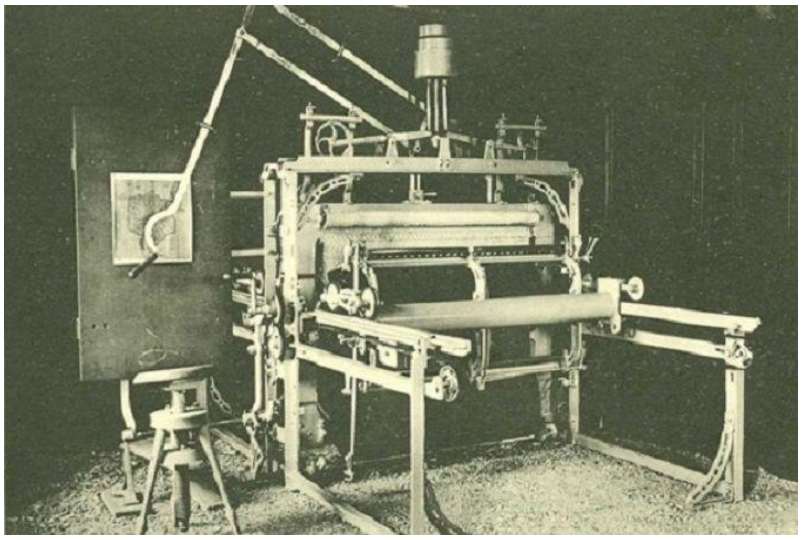


Figure 1.14 First hand-embroidery machine [3]

In 1840, the first large machine embroidery factory was built in St. Gallen. In 1855, the machine was showcased at the International Exhibition in Paris, causing quite a stir. Machine embroidery has been widespread since then. By 1875, there were about 3000 (1500, according to other sources) embroidery machines in the canton of St. Gallen.

The working principle of this machine is the same as hand embroidery. The machine consists of a frame (hoop) with the fabric stretched over it. The frame is suspended, so that it will move freely in both directions (horizontally and vertically). The movement is achieved with the help of a system of levers, constituting the pantograph. The worker traces the handle of the pantograph along the pattern located

by the machine. There are carriages on both sides of the hoop, which move closer and then move away from the hoop, with each supporting one, two or three rows of clamps. These clamps grip needles, the latter have points on either end of the needle, and an eye in the middle with a thread of a certain length. The process is quite similar to embroidering with a hoop. The carriage with the 2 needles gripped by the clamps is brought extremely close to the hoop, so that the needles pierce the fabric.Then another carriage is moved to the needlepoints protruding from the other side of the fabric and its clamps grip the needles, while the clamps of the first carriage release them. Then, the carriage moves away from the fabric, pulling the entire length of the thread through.  Then, the hoop is moved to a new position, and the operator again brings the carriage to the fabric, with the needles piercing it in a different place, and then the process is repeated in reverse [3].

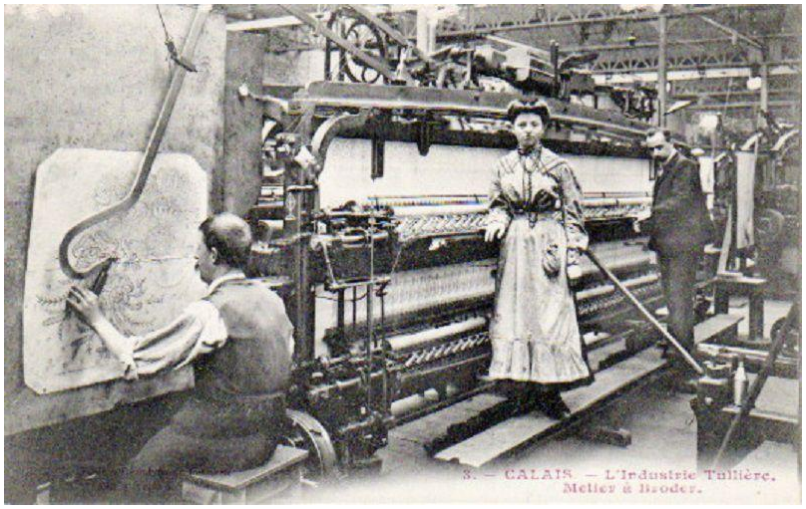



Figure 1.15 Heilmann embroidery machine [3]

A photograph of a Heilmann embroidery machine at work in a factory in Calais, France is depicted in this 1905 postcard Figure 1.15. The embroiderer is on the left. His left hand guides the pantograph, moving it along the lines of the enlarged design. Today we would call it an embroidery pattern. Through a system of levers, the pantograph moves the vertically stretched fabric to the desired position relative to the needles. He uses his right hand to move the wheel, which pushes the needles through the fabric, whilst using his feet to manage the clamps holding the needles. Such work required considerable physical effort, which is why the machine operator is a man. On the right there is a female assistant, who monitors the work of needles and repairs broken threads. Notice the continuous line of spools of thread at the assistant's waist level and near the bottom. The number of spools corresponds to the number of needles on this machine. The speed of the machine's embroidery process was equal to that of

hand embroidery, however the machine could save time by making several patterns at the same time [3].

Another revolutionary aspect of the embroidery machine invention, was the fact that it could be used in small houses, artisanal workshops, and remote corners of the world, as opposed to the invention of machines in other industries, which always entailed the appearance of a large factory to accomodate it. Embroidery machines were relatively small in size, so regular people could place them in their house or a household structure. The machine was maintained by the entire family, as it became a significant source of income for peasants and craftsmen. In some parts of Eastern Switzerland, in 1880, there was one machine per 20 residents, and entire villages were turned into machine embroidery factories.

Heilmann embroidery machine dominated until the end of the 19th century. Still, in 1863 Switzerland's Isaac Groebli invented a different type of embroidery machine, which borrowed the working principle from the recently invented sewing machine [3].

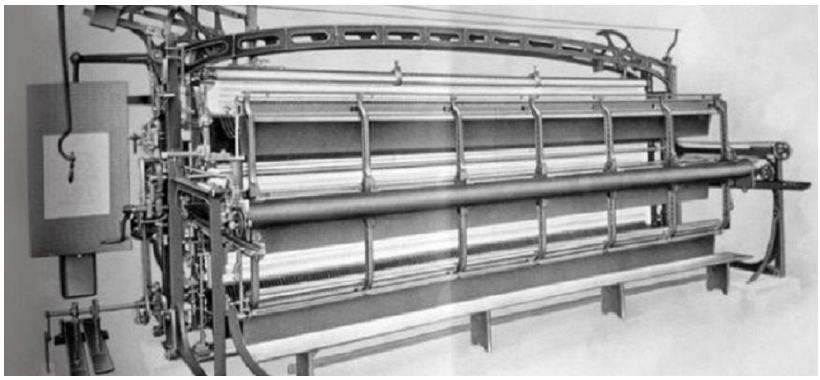


Figure 1.16 Schiffli embroidery machine [3]

From its predecessor, the Heilmann machine, the handle and pantograph mechanism were borrowed. However, there were also significant differences. Like in the sewing machine, the eye of the needle was located at the tip. Two threads were required, with one coming from the shuttle behind the fabric. The shape of this shuttle resembled a boat ('Schiff' in German), which is why all such machines were called Schiffli (Figure 1.16). The working principle is the same as that of a sewing machine, with the exception that the fabric is stretched vertically. There could be a lot of such needles. Currently, the University of Manchester in England owns a working Schiffli machine, which is about 100 years old. It has "only" 86 needles, and the embroidery field is 2 meters wide.

In 1898, Isaac Groebli's son invented an automatic Schiffli machine. It got rid of the pantograph and incorporated a Jacquard system of punched cards. In 1900, the machine became electrically driven. The machines were equipped with several hundreds of needles and were so massive, they were only suited for factory use [3].

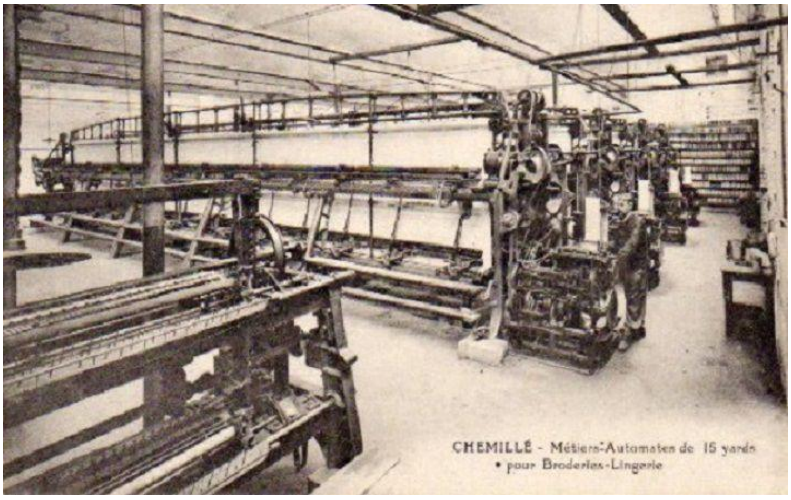


Figure 1.17 Workshop with Schiffli embroidery machines [3]

In the Figure 1.17 photo from year 1905 a Shiffli machine workshop is depicted. On the left-hand side, it has a punched card system, replacing the pantograph. The machine is fully automated and only one person is needed to operate it.
Despite the considerable age of the Schiffli embroidery machines, they still exist and continue to be used in production (the modernised versions, of course). The machine can be 18 meters long and have 1000 needles (Figure 1.18). They produce various types of whole cloth embroidery, including lace [3].


Figure 1.18 Automatic Schiffli machine [3]

After the invention of computerised tools, automatic machines started creating the embroidery from start to finish, with the hoop moving in accordance with the program embedded in paper punched cards, which looked like holes arranged in a certain order (Figure 1.179). Punched cards continued to be used until the 1970s [3].

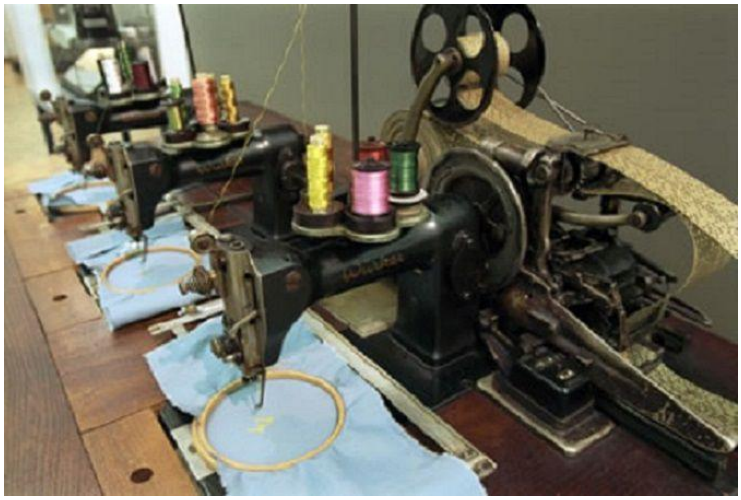


Figure 1.19 Embroidery machine with punched cards [3]

The technology of machine embroidery is continuosly improved (Figure 1.20). New ideas, machines, design transfer methods, and, of course, the skill of the designer, creating beautiful patterns for future embroidery. And as a result, modern embroidery machines can embroider almost everything.

Figure 1.20 Computerized Brother PR1000E Entrepreneur Pro 10 needle embroidery machine [19]

# 3 TYPES OF EMBROIDERY MACHINES

Embroidery is a decorative needlework. Nowadays embroidery can be done with both hand and machine. In machine embroidery either a sewing or embroidery machine is utilized to make patterns on clothing materials. It is generally used in decorative purposes [20]. The embroidery machines can be split by several categories free-motion, combined sewing and computerized machine embroidery. All pictures of embroidery machines are shown in Appendix1 (Table A1.1). Computerized machine embroidery can be split accordingly to the number of needles and number of heads [21].

## 3.1 Free-motion machine embroidery

A general form of a zigzag sewing machine may be used for a production of embroided design, when dealing with free-motion machine embroidery. The fabric material tightly banded needs to be placed under a needle in order to create a decoraction using this type of machine embroidery. The embroidery needs to be continued manually, so that an operator uses the settings of a machine; the stitches must be tight and must create an image or a design on a fabric.The machine types stated above have only one needle, so an operator needs to stop at some point and rethread for each colour manually when dealing with multi-colour design, which takes a long time. Each design made with this type of machine is a unique one since it is rather a manual process than a system of digital production and thus can not be reproduced which makes it different from computerized embroidery [20].

## 3.2 Embroidery/ Combined sewing machine

This machine is created to be used at home. It can provide two different functions: to work as a sewing or embroidery machine. The combined sewing machine are computerized ones. The machine is provided with the screen which displays the selected embroidery design. Being a single needle this machine requests the change of the thread each time when change the colour is needed [22].

## 3.3 Computerised machine embroidery

Nowadays, embroidery machines can be used only for embroidery and normally controlled by a computer. The embroidery machines usually have a frame holding the framed piece of fabric, having a tension under a sewing needle and moves it

automatically in order to create a pre-programmed decoration that will be saved within the machine. Founded on it is abilities, it needs multiple forms of an input from the user in specific digital format suitable for creating embroidery designs [23].

Computerized machine embroidery functions [23]:

- creating / achieving digitised design file,
- editing embroidery designs,
- loading the final version of embroidery file into the machine,
- stabilising the fabric material with sufficient tension and place it on the machine.

## 3.4 Single-needle embroidery machines

This type of machines is the most common. It looks like traditional machines, since it has a flat-bed and an embroidery unit that can be removed. Single-needle machines are simple to use and are a good fit for common stitching, making intricate stitches, or creating embroidery designs on computerized machines. Single-needle machines have a single head only. The head consists of a needle, a thread, a bobbin, and other accessories related to the machine. When the machine is in the process of embroidering, the needle is still stationary at the moment when the embroidery arm replaces the computerized design's appearance. There is on hoop attachment point in a single-needle machine. This kind of machine has a smaller range of hoop abilities than a multi-needle one. Usually, a single-needle embroidery machines can make 300-1000 stitches per minute as a minimum [22].

## 3.5 Multi-needle embroidery machines

Normally, there are around 4-10 needles in multi-needle machines. Every machine is capable to hold its own color of a thread. A multitude of machine embroidery threads provide the advantage of changing the color, in a difference from single-needle machines. Single-needle ones need to be taken out and then the color thread needs to be replaced, which often takes a long time. Multi-needle embroidery machines are functioning with a 400-1000 stitches speed. In a difference from single-needle machines. That is why it has a universal selection range in cases of embroidering hoops put on the clothing [22].

## 3.6 Single head embroidery machine

The single-head embroidery machine is a good fit for using it in small productions and workshops offering an opportunity to add beautiful and interesting design embroideries for different types of clothes and accessories such as: handbags, hats and different logos on accessories [24].

## 3.7 Double-head embroidery machines

Double-head embroidery machine consists of 2 sewing heads and was invented specially for small and middle productions giving an opportunity to produce 2 products at the same time. This type of embroidery machine allows producing difficult, interesting and non-standard embroidery [24].

## 3.8 Multi-head embroidery machine

The multi-head embroidery machine can include multiple sewing heads, all of which are able to sew exactly the same design on a garment concurrently that is separate. This kind of a machine can have twenty heads or more, all having fifteen needles or more. A head can normally produce a great number of a fabric's special effects, such as chain stitch embroidery, satin stitch embroidery, appliqué, sequins and cutwork [25].

## 3.9 Beads(Pearl) embroidery machine

Beads embroidery machine form a specific type of embroidery machine within the area of a textile machinery. It may be used in multiple types of areas, for instance, textiles, garment, art craft etc. The beads embroidery machine is the best and fastest way to decorate clothes with beads.

## 3.10 Coloreel unit

One of the biggest last years innovations in embroidery technology was presented in 2009 by Swedish company Coloreel. Coloreel has started producing its innovative technology of thread colouring enabling an instant high-quality textile thread colouring during the embroidery process. It is thread colouring unit which can work with each and every industrial embroidery machine (Figure 1.21) colouring white-base thread. Coloreel provides absolute liberty in creating one kind of embroidery with an unlimited

choice of colours. This innovative technology is a  fit for using within the fields of industrial embroidery, knitting, sewing, weaving etc [26].


Figure 1.21 Coloreel unit [26]

# 4 NEEDLES OF EMBROIDERY MACHINE

The needle is an important part of the embroidery machine. It can directly affect the quality of the embroidery. Needles of embroidery machines are divided into two categories by needle size (number) and by point type. The choice of the needle depends on the kind and thickness of the fabric, using of backing/stabilizer and thread type see Appendix 4 (Table A4.1). The selection of the wrong needle may result in fabric deformation, thread spinning, or break or make a large hole in the fabric. All this shows the importance of the right needle for the work.

## 4.1 Needle parts

Needle consist of: butt, shank, blade, long groove, scarf, eye, point and tip [27]. Needle anatomy is shown in Figure 1.22.

- The shank- is the thick upper part, which is inserted into the needle bar and held in place with a clamp with a screw. The industrial needle has a round shank, while the household needle shank has one flat section
- The blade- is the needle's narrow part that passes through a fabric. The diameter of the blade determines the needle size/number.
- The butt- is the blunt top end of the needle.
- The tip- is the sharp end of the needle blade.
- The point- is a part of the needle between the eye and the tip.
- The eye- is the hole perpendicular to the blade through which the thread passes. Embroidery needles have larger eyes than regular sewing needles. Thus, the thread goes through this hole more freely, thereby reducing the number of threads spinnings and breaks, consequently.
- The scarf - is a short bowl-shaped indentation on the backside of the needle's blade, just above the ear, which allows the hook to pass near the centerline of the needle. In this place the hook passes closely gets close to the eye and picks up the upper thread to form a loop and create a stitch. The size of the scarf varies with different needle types.
- The long groove- is along the front of the needle blade, going from the shank to the eye. Its width is about 40% of the needle diameter, which limits the size of the thread that can be used with a certain needle size. The groove leads the thread into the eye and lets it pass quickly and easily.

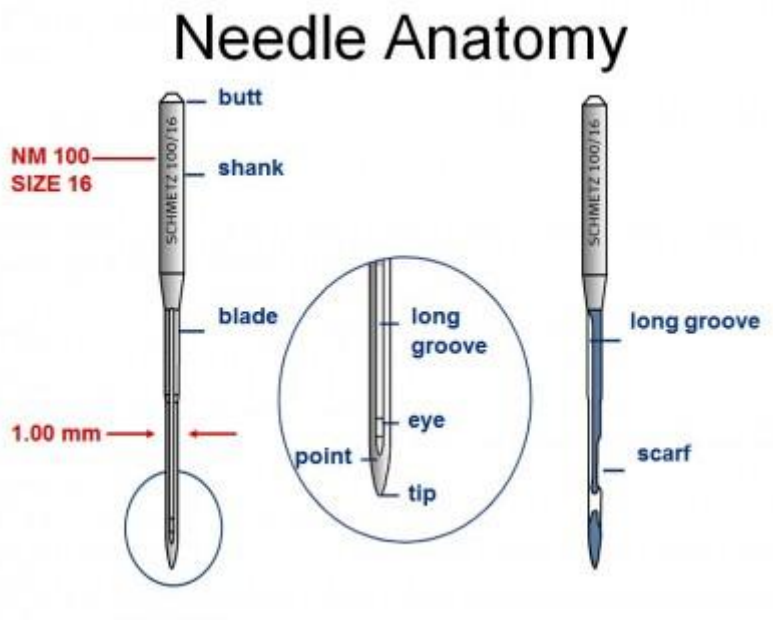



Figure 1.22 Needle Parts [28]

## 4.2 Basic technical features of the needles

A sewing machine needle is identified with three parameters, which are as follows:

- system,
- size,
- point type (needle type).

It is essential to know these features not only to put the right needles in the machine, but also to consider the thread type and the properties of a fabric on which the design will be embroidered with these needles [29].

## 4.3 Needle system

The needle system indicates physical sizes [29]:

- needle length,
- shank length and diameter,
- distance from the butt to the eye,
- bevel shape.

Some of these sizes determine the class of sewing machines to which a needle should be inserted, and others indicate the needle features. All these indicators are encrypted with numbers and letters. For example, DB x 1, DB x K5. Sometimes there are several nomenclature systems on the package. Historically, these nomenclatures show a trend

towards the standardization of sewing machine manufacturers. Each of these nomenclature systems will identify the same needle, which can be inserted into one machine [29].

## 4.4 Needle size (number)

Most needles are labelled with 2 numbers at once: one number refers to the European metric system and another to its equivalent, the American needle sizing system (Singer). Usually, they are separated by a slash "/", like 90/14, 80/12, etc. The true needle diameter is determined by the European number metric: 75/100 = 0.75 mm. European needle sizes range from 55 to 130 [29].

## 4.5 Point type

Point is an important part of the needle. Needle points have a special indifications. Needle point indification is shown in Appendix 2 (Figure A2.1) [27].

- **Set (Sharp) point** - is used for most fabrics except knitted materials.
- **Acute/Slim set point (SPI)** - is very sharp. It is recommended to be used for leather, densely woven fabrics and materials of rough texture.
- **Sharp point (no designation or K)** - is one of the most commonly used industrial needles. It is recommended to be used for woven materials or dense non-ladder fabrics. It goes well for caps. The sharp point cuts fibers, which provides a smaller pull&push deformation.
- **Normal round point (R)**
- **Ball point** - is used for most fabrics except knitted materials.
- **Light ball point (SES)** - is also one of the most commonly used needles. The tip is slightly rounded and therefore this needle can be used not only for woven materials, but also for knitwear due to the fact that the point does not leave holes around the embroidery, as it separates the cloth fibers, rather than cuts them.
- **Mediun ball point (SUK)** - is a rounded point that is intended to be used with coarse knitwear and elastic fibers.
- **Heavy ball point (SKF)** - is a rounded blunt point. It is intended to be used with elastic fibers.
- **Wedge point** - is used for genuine and artificial leather.

- **Narrow wedge (cutting) point (P)** - is used for leather, vinyl and closely woven fabric. Leaves not a hole, but a slot, so it is better to use it with bonded materials.
- **Cross point (CR)**
- **Reverse twist point (RTW)**
- **Triangular point (TRI)**
- **Square point (SQ)**

## 4.6 Needles identification

Some manufacturers offer Teflon coated needles, which are intended to be used for closely woven or abrasive fabrics, as well as for waterproof cloth. The needles coated with titanium nitride are also available on the market. They are designed for high-density fabrics. Such needles can be used for embroidery with adhesive materials. This coating prevents the glue from sticking to the needle and heats up less than regular needles.

In recent years, needle manufacturers label the needle shanks with alphabetical marking and color coding to specify which fabrics and types of work a needle is intended for. For example: blue band on the needle shank means denim needle; purple color – microtex needle; yellow color means that the needle is designed for knitwear; red color indicates that the needle is intended to be used for embroidery. So, the embroidery needles are identified by a red band on the needle shank and alphabetical marking H - E, where the letter H means that this needle is universal (regular) and the letter E indicates that it is designed for embroidery. This needle type is intended to be used for embroidery with special embroidery threads. Embroidery needles have a special notch and a slightly rounded tip, and their eye hole is slightly larger so as not to damage the material or thread [29].

## 4.7 Needle choice

Needles are chosen depending on the thickness and structure of the fabrics and threads [30]. The table with needle figures shown in Appendix 3 (Table A3.1).

- **Universal needle for machine embroidery** - Good for most embroidery
- **Needle for decorative threads** - The embroidery needle with an enlarged eye. Such a needle has a very large eye and a large groove so that the

decorative thread (usually it is thick enough to be clearly seen, for example, metallic or woolen yarn like Lana) can freely fit and pass through it.

- **Needle for embroidery on delicate fabrics** - This needle has a thin elongated point. It makes a minimal hole in the fabric. Such a needle can be used for embroidery on leather.
- **Needle for embroidery on knits and elastic fabrics** - This needle features by a small rounded point. It easily separates the cloth fibers and loops and thereby passes between the threads, excluding damage to fabric
- **Needle for embroidery on loose knitwear and rough elastic fabric** -This needle has a medium rounded tip, which does not damage the fabric structure.
- **Needle for embroidery on leather (genuine and artificial leather)** - This needle has an acute wedge point. There are cutting point needles marked with letters H-LR, where the letter L (i.e. LEATHER) means that they are designed for sewing with leather. The incision is made at an angle of 45 degrees to the direction of the seam. The result is a decorative seam, the stitches of which are slightly sloped.
- **Needle with crochet hook end** -These needles come with a regular or short crochet hook end. Needles with a regular crochet hook end are designed for chain stitch embroidery, spiral and ribbon embroidery. And those that have a short crochet hook end are designed for raised embroidery.
- **Needle for cutwork (boring) embroidery** - It's a knife-shaped needle that does not need a thread. It cuts holes of various shapes respecting the embroidery design, which are then welted by another, regular embroidery needle.

## 4.8 Reasons to change a needle

Several problems can occur while embroidering. Often the reason is not a suitable needle. For example: bad choice of a needle may result in problems with tension. The choice of large size needle could lead to the thread spinning and break. A thick needle makes unnecessarily large holes or cut through the fabric, which could cause the formation of gaps between the embroidery stitches while the bad choice of a point may result in fiber cutting, fabric deformation, and blurred embroidery edges. In the case of the thin needle and thick thread, the abrasion will cause the break of the thread. Using a thick needle and thin thread can result in a loop formation. The cause is the movement of the thread without sufficient reliance on the groove [29].

# 5 THREADS FOR EMBROIDERY MACHINES

Embroidery thread is a yarn for stitching designs or patterns on the textile. It adds exclusivity and value to textiles [25]. To create embroidery on computerized embroidery machines, a lot of different threads can be used, some samples are shown in Appendix 5 (Table A5.1). The choice of thread for embroidery depends on embroidery design, aim and place. Depending of the fiber content, the thread can have different features: different strength, flexibility, it can be shiny or matt. Some threads have high tensile strength which means that high speed can be used for embroidering and some threads being low strength request a lowest speed. Not all threads are suitable for every fabric type.

Embroidery threads are marked by numbers. Embroidery threads are numbered from size 100 to 12, where a larger number shows a smaller thread size. The number of embroidery thread marked shows how many kilometers of the thread are included in one kilogram of threads [31].

## 5.1 Viscose embroidery thread

Viscose embroidery threads are 100% viscose ones. This thread type gives embroidery natural sheen and silk effect. These are soft embroidery threads, which lie down freely in any direction, do not form loops and settle on the fabric better than polyester of the same thickness. The surface embroidered with viscous is uniform and calm. Viscose threads are best suited to embroidery. The silk shine of viscose embroidery thread changes according to the lighting but natural viscose retains its bright colours in the embroidered product. It withstands the high-speed stitching. Even 1200 stitches per minute is possible. Soft viscose threads protect needles and thread knives from premature aging [32].

Viscose thread features [32]:

- soft,
- shiny surface,
- a wide selection of colors and shades, including multicolour,
- do not form loops during the embroidery process,
- easier to use than polyester,
- threads with different number are available: from No. 12 to No. 60,
- washable (may be washed in hot water at temperatures of up to 95°C degrees using ordinary detergents),

- may be dry cleaned,
- may be ironed at temperatures of up 150°C on the back of the embroidery.

## 5.2 Polyester embroidery thread

Polyester embroidery threads are 100% polyester. Polyester embroidery threads are chlorine-resistant. They are therefore ideal for embroidery on products subjected to hard and frequent washing and disinfection, like sports goods, childrens cloths, work wear, cook uniform and hotel linen [32].

Polyester thread features [32]:

- ordinary polyester threads are shinier than viscose,
- stronger than viscose,
- withstands bleaching and other chemical agents,
- polyester thread is more elastic than viscose.Therefore, looping is possible during the embroidery possible,
- polyester thread deforms embroidery more than viscose,
- washable at 100 °C degrees (boiling is possible) with ordinary and harsh detergents; bleaching and chloring are permitted,
- withstands repeated washing and cleaning,
- may be ironed at temperatures of up 150°C on the back of the embroidery.

## 5.3 Cotton embroidery thread

Cotton threads can be 100% cotton ones or consist of 50% cotton and 50% acryl. Cotton threads are a bit shiny and have almost matte finish. They are therefore commonly used to create various effects. Cotton threads can not be bleached, but they withstand frequent washings. One of the main disadvantages of cotton threads is a small choice of colors [32].

Cotton thread features [32].

- natural fiber,
- matte finish,
- a small choice of colors,
- washable,
- can not be bleached,
- threads with different number are available: from No. 30 to No.120,

- it makes the looper dirty when working, because it is not as smooth as synthetic thread.

## 5.4 "Wool" effect embroidery thread

So-called „wool" embroidery threads or acrylic threads, which are also known as crewel, consist of 50% wool and 50% acrylic thread. They are used to create wool-like effect and are ideal for machine embroidery on both knitted and textile cloths [32].

"Wool" effected embroidery thread features [32]:

- durability and wear resistance. Even after prolonged wearing, it does not break, but keeps the shape, and as a result does not deform the embroidery,
- gives embroidery a voluminous and slightly fluffy structure,
- does not require the use of special machine embroidery needles, unlike metallic threads,
- bright saturated colors.

## 5.5 Metallic embroidery thread

Metallic threads are used to create an unique texture and certain special effects, and consequently, they are not classified as universal. Three types of metallic threads are distinguished, which are quite different by appearance: they can be flat, twisted or wrapped. The foil is used to produce metallic threads. The most common is the wrapped thread, which consists of a polyester thread wrapped with metal foil. It provides a smooth and shiny embroidery surface [32].

Metallic thread features [32]:

- shiny surface,
- textured surface is available,
- less flexible than polyester or viscose threads,
- not suitable for every fabric type,
- can be twisted when getting off the reel during the embroidery process,
- a threads with different number are available: from No.15 to No.50,
- a small color range,
- can not be bleached,
- slow speed should be used for embroidering.

## 5.6 Supertwist embroidery thread

This textured thread gives embroidery a very spectacular look and can enrich even the simplest design. Due to the fact that this thread consists of 30% metallized polyester and 70% polyamide, the embroidered products can be washed at a temperature of 60°C. This thread is available in 2 thread thicknesses: No.30 and No.12. Therefore, an embroidery may be thinner or thicker [32].

Supertwist thread features [32]:

- strong nylon core and genuine metallic base,
- less flexible than polyester or viscose threads,
- shiny surface,
- washable,
- gives embroidery a designs dimension and a unique textured effect,
- not suitable for every fabric type,
- a big color range.

## 5.7 Glow in the dark embroidery thread

Glow in the dark embroidery thread includes microparticles of glass lenses with a high retroreflective coefficient. In daylight, such embroidery has a matte coating, but in the dark it starts to glow. 15-20 minutes it is enough time for light absorption, and embroidery will be shining in the dark. The thread consists of 60% polybutylene terephthalate (PBT) and 40% polypropylene (PP). These threads are often used to embroider contour designs on a black background, mainly on T-shirts [32].

Glow in the dark thread features [32]:

- glows in the dark,
- washable,
- not suitable for every fabric type,
- slow speed should be used for embroidering,
- a small color range.

## 5.8 Fire-retardant embroidery thread

Fire-retardant machine embroidery threads, which are simply indispensable for embroidering motorcycle sportswear, working and protective clothing [33]. A 40 weight fire-retardant embroidery thread is also used to embroider airline seat cushions

and is excellent for use where safety matters are paramount. They are recyclable and comply with the international standards ISO 6941:2003 Textile fabrics — Burning behavior — Measurement of flame spread properties of vertically oriented specimens and ISO 15025:2016 Protective clothing — Protection against flame — Method of test for limited flame spread. The thread is made of 100% aramid fibers [32].

Fire-retardant thread features [32]:

- flame resistant,
- does not melt or drip and will self-extinguish without the heat source,
- chemically treated for self-extinguish,
- washable,
- colour range available,

## 5.9 Multi-colour or Astro colour embroidery thread

MULTI-COLOUR 100% viscose filament viscose is the perfect thread for machine embroiderers. High tensile strength and good colour fastness of this high-quality thread will provide the embroidery with a silky luster and consistent appearance. Its special dyeing process produces outstanding and ever-changing colors throughout the whole spool, as a result, every embroidery will be unique and different from any other. It is ideal for decorative stitching, quilting and embellishment on all fabrics as for finest silk and for denim and toughest leather. Only viscose embroidery is soft to the touch and has a natural sheen [32].

Multi-colour or astro colour thread features:

- soft,
- shiny surface,
- high tensile strength,
- do not form loops during the embroidery process,
- threads with different number are available: from No.12 to No.60,
- washable (may be washed in hot water at temperatures of up to 95°C degrees using ordinary detergents),
- may be dry cleaned,
- may be ironed at temperatures of up to 150°C on the back of the embroidery),
- a wide selection of colours.

# 6 EMBROIDERY BACKINGS AND TOPPINGS

Backings and toppings are non-stretchable non-woven textile materials. These materials are needed to reduce the deformation of the fabric during embroidering. Embroidery backings and toppings have to be chosen based on fabric properties, threads and density or size of stitches.

## 6.1 Backings (stabilizers)

Backings (also called stabilizers) are special materials, often non-woven, which are placed under the fabric (Figure 1.23). They serve the purpose to support and stabilize the fabric during the embroidery process, prevent puckering, deformation and stretching, both when embroidering and washing or cleaning [34].


Figure 1.23 Backing for embroidery [35]

There are several types of backings [34]:tearaway,cutaway, adhesive, soluble, fusible.

### 6.1.1 Tearaway stabilizers

This type of stabilizer is good for the natural fabrics and provides only a temporary support. This kind of stabilizer is easily removed and can be successfully used on products where the back of embroidery is seen (towels, blankets, scarves and so on). It is also widely used with non-transparent light-colored fabrics and durable closely woven fabrics made of natural fibers like denim. Not recommended to use with any kinds of knits. Tearaway stabilizers usually consist of paper of varying thickness [36].

### 6.1.2 Cutaway stabilizers

Cutaway stabilizers are used to stabilize highly stretchable fabrics and they provide constant support during the embroidery process. They are urgently needed to embroider a design with a lot of stitches, in order to prevent fabric from volumetric deformation (waviness, hogging or concavity) even after several washes. A cutaway stabilizer is always thicker than a tearaway. As a rule, it consists of a non-woven material made of long fibers on the basis of polyester or viscous. The way the fibers are arranged inside a stabilizer is also crucial. If the fibers are mainly arranged in one direction, it stretches and tears only in this direction. Therefore, to stabilize the fabric properly it is necessary to use two layers of backing, placing them perpendicularly to each other. Such backings are available in different densities. If the fibers in a non-woven fabric are arranged in random order, then a stabilizer has an unsmooth spotted structure – random thickenings and hardenings. This inhomogeneity may result in reducing the quality of fabric support and stabilizing. But such material is still suitable for embroidery and often used because of its cheapness. Such stabilizers are also available in various densities.

If a wet lay-up technique is used in production, then by bonding short polyester, viscose, cellulose fibers and binders, a non-woven fabric of high quality will be produced, which has a smooth surface, does not stretch in any direction and is soft like a tearaway stabilizer. This stabilizer can be of varying density, and just one layer of it is sufficient. It is considered to be the best embroidery stabilizer because it does not add extra volume to the embroidery and is not visible through the fabric.

Among the cutaway stabilizers, stands out the stabilizer, which is produced with spunbond method. It is a thin, very soft material that resembles a waffle. This kind of backing is good because it does not stretch at all, it provides constant support and it is not visible through the fabric [36].

### 6.1.3 Adhesive stabilizers

These are glued to the back of embroidered product, thus increasing the fabric stability. There are several types of adhesive stabilizers. First of all there ia an ordinary adhesive stabilizer which has glue on one side. The embroidered product is attached to this backing with an iron. Secondly there ia a type od adhesive paper which has one sticky side covered with a protective layer. This paper is necessary when embroidering tricky fabrics, such as velvet, cashmere, leather, which are not recommended to be hooped, as well as for the products that are hard to hoop: collars, cuffs, small details. An adhesive paper is placed in the hoop with a sticky side facing

up, then the protective layer is removed, and the product is placed on top. Having embroidered the product, the paper needs to be teared away [34].

### 6.1.4 Soluble stabilizers

A water-soluble fabric-like interlining and water-soluble films of varying density are considered to be soluble stabilizers. They are used for stabilizing the embroidery when it is necessary to remove the backing without traces, for example, for organza, transparent fabrics, and cutwork [36].

### 6.1.5 Fusible stabilizers

They are used when it is necessary to stabilize the fabric, which should not get wet while removing the backing leftovers. They can be successfully used for creating water-soluble film. As a rule, fusible stabilizers are removed with a very hot iron (no less than 120°C) or by pressing through the ordinary paper. The steam should be used with fusible stabilizers [36].

## 6.2 Toppings

**Toppings** are special materials placed on the fabric.

Figure 1.24 Topping for embroidery [37]

They are necessary to prevent the stitches from sinking into the pile, loops, fur and other piled materials, as well as with loosely woven fabrics and knits (Figure 1.24). Gelatin-based toppings are most commonly used, as they can be easily solved in water. They are called water-soluble toppings (or wash-away toppings). There are two types of them: thin and thick (dense). Thin topping is used practically in almost all cases, but thick one – only with a very high pile.

Another kind of topping is a fusible topping (heat-away topping, heat-soluble topping). They are used in cases when the fabric cannot be washed, and consequently, the use of water-soluble film is not possible. As a rule, fusible toppings are removed with a very hot iron (no less than 120°C) or by pressing through the ordinary paper. The steam should by no means used with fusible toppings [36].

General rules for using stabilizers [36]:

- for thick, heavyweight fabrics use thick backings; for thinner, lightweight fabrics, lightweight backing will work better.
- denser your embroidery design is, and the more stitches it has, the heavier backing is required to stabilize the fabric.
- when embroidering with metallic threads, synthetic backings should be avoided and embroidery stabilizers with natural components, such as cotton or viscose. This is necessary because natural machine embroidery stabilizers are usually softer and they create less friction with embroidery needle and thread. As a result, the number of thread breaks reduces and the needle heats up less.

# 7 TYPES OF EMBROIDERY SOFTWARE

Automated embroidery machines have greatly expanded the ability to process more complex designs in a very short time. The software in embroidery is used to create designs, edit them, convert files from one format to another. Such a process is known as embroidery punching or embroidery digitizing. Digitized file is easily readable by computerized embroidery machines, which embroiders the pattern on the product [38].

There are many different programs for embroidery which have various levels: professional, semi-professional, and converter [39]. It should be mentioned that embroidery software is quite expensive. So, it is important to be familiarized with the various options provided by software before buying it. It is important to find out which program suits the best and what features are needed to make the work process fast, convenient and time-saving. Yet it is important to remember that regardless of the embroidery digitization software that will finally be chosen it will be always a compromise between the performance and price.

## 7.1 Wilcom software

Wilcom has released a series of digitization softwares designed for both beginners and professionals. They provide software for embroidery digitizing, apparel decoration design, editing of embroideries and creation of labels. The range of functions and ease of use is impressive. Wilcom's website contains many educational and training materials, as well as local support and training resources which can help also beginners.

Wilcom Embroidery software was developed for a Windows operating system, still with the loading of some additional settings it can be used also on Mac computers. 30 Day Free Trial version is available. Participation in different pieces of training also requests registration [38]. Wilcom EmbroideryStudio E4 software consists of several parts: Editing, Lettering, Decorating and Designing.

**The program software levels:**

- **Wilcom EmbroideryStudio E4 Editing –** this level of software allows: to recognize and open more than 35 file formats, edit native Wilcom.EMB files or stitch files such as .dst, flip, rotate and reflect objects, fix problems and improve stitch quality and control over the underlay and pull compensation [40].

- **Wilcom E4 EmbroideryStudio Lettering -** this level of software allows: to choose from satin, zig-zag or fill stitch letters, sew on the arc, circle or any shaped baseline, change the direction the text, sews from left, right or center out for caps, control over underlay and pull compensation to suit any fabric and preview designs on fabric backgrounds and garments [40].

- **Wilcom's E4 EmbroideryStudio Decorating -** Includes all from the Wilcom lettering and editing features, plus basic digitizing tools that allow to create embroidery designs. It is coupled with CorelDRAW® Graphics Suite X8, which helps to convert common image files like jpg or png vector graphics into embroidery or appliqué form [40].

- **Wilcom's E4 EmbroideryStudio Designing -** it is Wilcom's high-level embroidery software. It allows creating any type of embroidery design starting from a corporate logo up to a complex fashion piece [40].

## 7.2 Hatch by Wilcom

This embroidery software is designed specifically for hobbyists, small, and home businesses. It has all functions and tools needed to create or edit an embroidery design. This program allows manual digitization but is also equipped with tools to perform tasks such as auto digitizing, lettering, monogramming and applications for creating embroidery designs. The program allows to resize or recolor the design, create offset outlines, re-sequence the stitch-out. To get familiar with interface and features, Hatch offers a free unlimited 30-day access to the software with no registration [41]. The software is supported by the web page with a lot of videos with step by step education of the program.

Hatch Embroidery software is developed for a Windows operating system, yet with loading some applications it becomes useful for Mac computers. Hatch Embroidery software is splitter to several parts: organizer, personalizer, composer, and digitizer.

**Hatch Embroidery software levels:**

- **Hatch Embroidery Organizer** - this program is able to organize files with design manager, convert files to machine formats, change design color, resize and customize designs, show virtual sewing and designs, allow finishing of the design [42].

- **Hatch Embroidery Personalizer -** this program includes all of Hatch Organizer features, plus gives a possibility to create/add lettering, create monograms and change blocks of colors [42].

- **Hatch Embroidery Composer -** Composer includes all of Hatch Organizer and Personalizer features and has auto-digitizing (7 methods), multi-hooping, edit design objects, layout tools, sequence tools and creative tools [42].

- **Hatch Embroidery Digitizer -** Hatch Digitizer has manual and auto-digitizing (10 methods), powerful editing with endless layout options, appliqué, photo flash,resizing,recoloring,multi-hooping,creating offset outlines, monogramming, sequencing, world-class lettering up to a complex fashion piece [42].

## 7.3 Drawings

DRAWings® is an embroidery software that allows creating original designs for embroidery, print, cut, or stencil. It is suitable for business operators who supply machine embroidery, rhinestone/crystal templates and services, applique, stencil printing and cutting, vinyl signage and heat-press, printable graphics and more all in the one powerful and simple to use application. The program does not have a free 30 days trial version. It is the ideal software for screen printing businesses, promotion companies and small embroidery operators who are currently using CorelDRAW® or Adobe Illustrator®.

The software works on MAC OS and Windows 7, 8 and 10. Program is divided into several levels: DRAWINGS X PRO, Creative DRAWINGS, Wings modular 6 embroidery software, and Embroidery Effect [43].

**DRAWings® software levels:**

- **DRAWings® version X PRO -** is a multi-functional software with a fully customizable interface and an impressive list of features, designed to be used in graphics designing, textile and screen printing, embroidery, computerized quilting, crafting with cuts and stencils as well as fabric painting. It automatically calculates the embroidery parameters such as underlay, compensation, tacking, branching, thread trimming, etc. This software level fit for screen printing businesses, promotion companies, and small embroidery operations [43].

- **Creative DRAWings® -** this software level allows creating a design easy and fast, either from scratch or by using vector images or even bitmap images and

stitch files. Creative DRAWings® can be used for graphics designing, textile and screen printing, embroidery, monogramming as well as computerized quilting. Creative DRAWINGS have a bit fewer functions than DRAWINGS X PRO [43].

- **DRAWings X & Wings modular 6 -** in the DRAWings X package, the Wings 6 modular embroidery software comes with the basic, text, and editing modules. Inside the modular 6 Wings it is possible to have stitch editing abilities, combine embroidery designs by copy and pasting parts of different designs, re-sequence objects, use pre-digitized fonts to add text on path or inside the envelope, change entry and exit points of a design, adjust advanced embroidery parameters such as density, underlay, fix and lock stitches, change corner style, adjust compensation, add half-pitch compensation and variable pitch on stitch objects. In addition, Wings modular Wings module includes over 3,000 free embroidery designs. DRAWings X package, the Wings 6 is only available for Windows and NOT for MAC OS [43].

- **DRAWings Embroidery Effect -** can convert any vector/bitmap graphic into an embroidery-like image quickly and easily [43].

## 7.4 Melco DesignShop V10

Melco is the only company in the United States which engineers and manufactures embroidery machines and software. Melco Design Shop V10 is another high-end software that can be easily used to solve the most complex digitization tasks. It allows easy conversion of vectors to stitches and ensures retention of colors during copying and pasting. Auto-digitizing is easy to use for digitizers. The features like auto underlay with various options and customization allow creating clean digitized files.

Melco Design Shop V10 software is not provided with a free 30 days trial version.The company website comes with loads of teaching and free training resources. On the Internet, they have a complete program guide. Melco Design Shop V10 software is fully compatible with Windows 7, Windows 8, Windows 8.1, and Windows 10 [38].

**The program software levels:**

- **DesignShop V10 Lite -** affordable lettering abilities for the beginner and enthusiast. The level includes: random stitch length for fills, auto select stitch type, envelope for lettering, control point editing, scale, rotate and slant

individual letters, multi-color symbol and monogramming, change the color of individual letters, auto fabric adjustment, auto underlays [44].

- **DesignShop V10 -** full-scale lettering, editing and sizing with basic digitizing. Ideal for users who want basic-to-advanced capabilities. Includes all of DesignShop V10 Lite plus give a possibility to: hybrid digitizing mode, enhanced symbols/auto shapes, advanced copy/paste, edge fill, on-screen digitizing, user-defined pattern fills, scan images, expanded stitch editing, measurement capabilities, read .bmp files and read/Write: .pcx, .tif, .png, .jpg files [44].

- **DesignShop V10 Pro** - Complete digitizing, lettering, editing, and sizing capabilities with auto digitizing. Includes all of DesignShop V10 Lite and V10, plus give a possibility to: Custom digitized tie in & tie-offs, appliqué tool, auto digitizing (.pcx, .bmp, .tif and .jpg), trapunto effects, decorative stitch [44].

- **DesignShop V10 Pro+ -** This is Melco high-level software. This level allows for creating any type of embroidery design. Professional digitizing, lettering, editing, and sizing [44].

## 7.5 Overview of software prices

It should be mentioned that embroidery software prices are pretty high. It is highly recommended to get familiar with as much software as possible to choose which will fit the needs the best. The Table 1.1 gives the overview of different software prices.

Table 1.1 The prices of different software

| No | Levels | Wilcom | Hatch by Wilcom | Drawings | Melco DesignShop V10 |
|---|---|---|---|---|---|
| 1 | Basic | 561 € | 135 € | Free | 570 € |
| 2 | Advanced | 1010 € | 228 € | 275 € | 910 € |
| 3 | Professional | 2134 € | 457 € | 828 € | 2115 € |
| 4 | High - professional | 3371 € | 1006 € | 1599 € | 4229 € |

# 8 THE PRODUCT DEVELOPMENT PROCESS OF EVENING GOWN AND BELTS

Product development process of evening gown and belts consist of the following steps: evening gown - product design, choose of the fabrics, fabrics testing, measurements taking, pattern making, sewing technology description and sewing. The belts - embroidery design, choose threads, embroidery testing, pattern making, embroidering and sewing.

Product design is the first part of the Product development process. It is very important part of product development process as the final product has to meet the client's expectations in terms of garment purpose, needs and fit. Evening gown design was made by using Kaledo Style software. Kaledo is a textile /fashion software that is created by a leading CAD/CAM company named Lectra. The software includes Kaledo Collection, Kaledo Print, Kaledo Knit and Kaledo Weave for designing prints, knits, and yarn-dyed woven fabric collections. It allows making a quick check of design without the cost of the material [45]. Kaledo also enables data sharing in real-time. So this itself enables, more efficient communication amongst design teams and fastens product development cycles. The textile software enables designers to design collections quicker. Materials, components, and combinations of styles are saved automatically and will be reflected throughout the collection [46].

## 8.1 Technical drawing of the evening gown

Kaledo Style v4r1 program was used for composing the technical drawings. Designed evening gown presents a classical one-shoulder dress with the long right sleeve. The dress is a floor-length evening gown, see Figure 1.25 and Figure 1.26. This dress can be worn on special occasions like weddings, going to the theatre, graduations, and receptions. There are bust and waist darts and a slit on the front of the dress. The concealed zipper is sewn to the left sideseam. Two waistline darts are on the back details of the dress. Five different belts were chosen to become an interchangeable accessory which can be changed or just taken off depending on the mood and the need of the wearer.

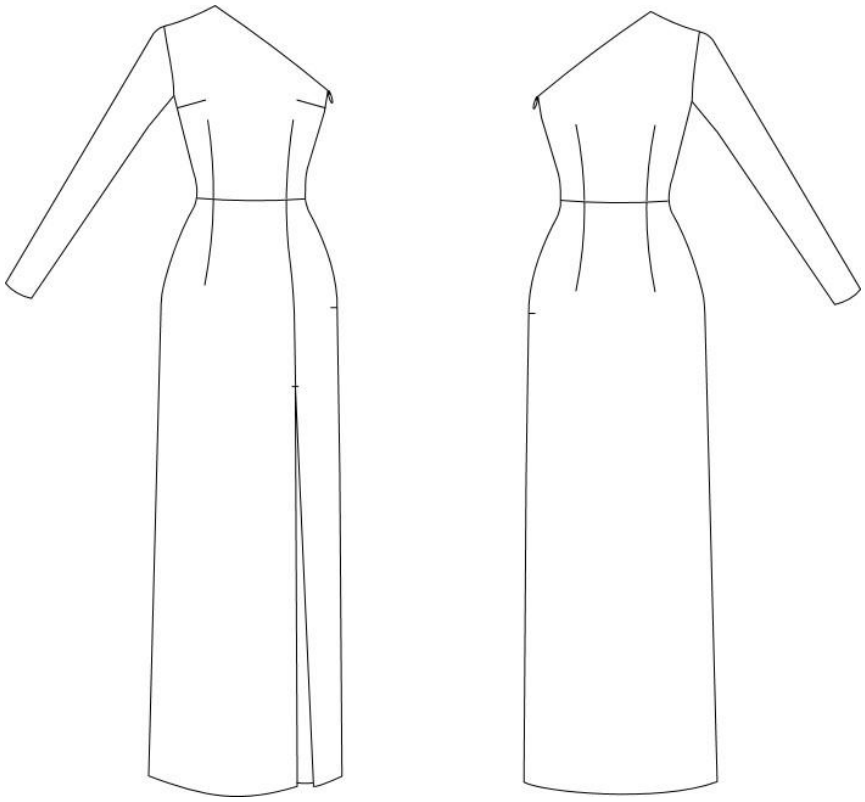


Figure 1.25 Technical drawing of classical one shoulder evening gown

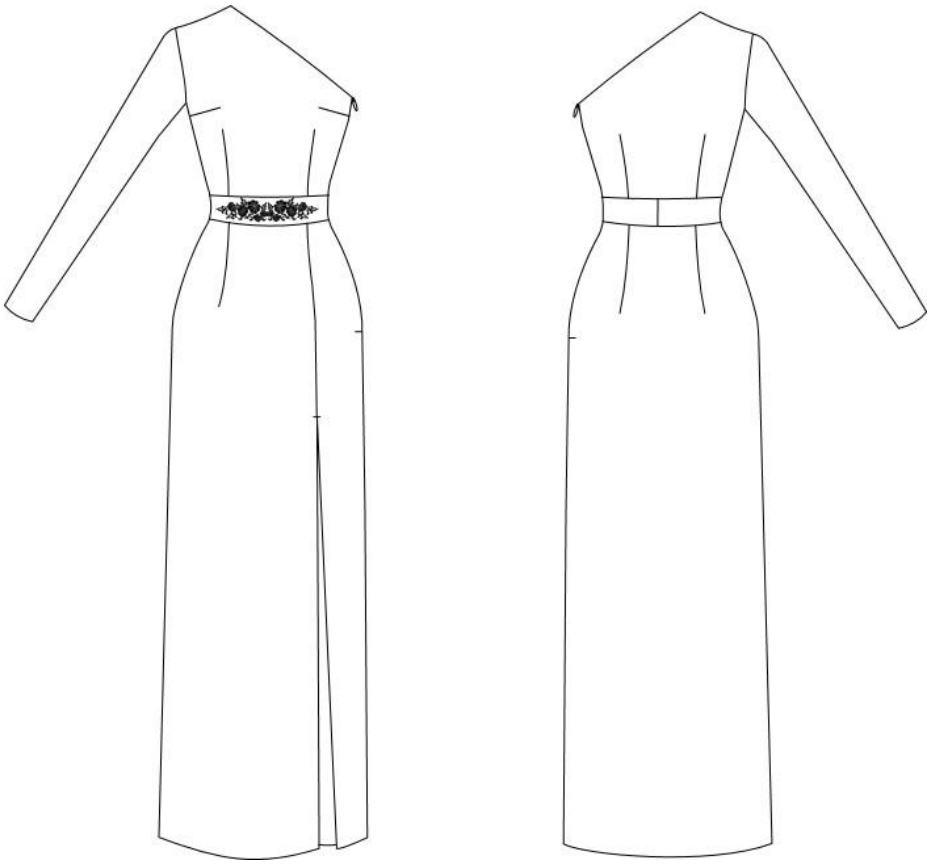


Figure 1.26  Technical drawing of classical one shoulder evening gown with the belt

## 8.2 Technical drawings of the belts

Kaledo style v4r1 program was used to make the technical drawings of the belts. Figure 1.27 presents 5 different interchangeable belts for an evening gown. The belts can be worn with an evening gown or some other garment item like a casual dress, jacket, or shirt. Belts consist of front and back details. Embroideries were done in the middle of the front detail of the belts. The belt closes with metallic snap fasteners, which were sewn on the sides of the belts. 4 belts have a different width. The widest is Luna belt being 13 cm high in the middle and 7 cm on the sides. The belt is 83 cm long. Gold and Flower belts have dimensions of 9 cm x 86 cm, Blue belt 7 cm x 86 cm. The silver belt is the narrowest, its dimensions are 86 x 5 cm.

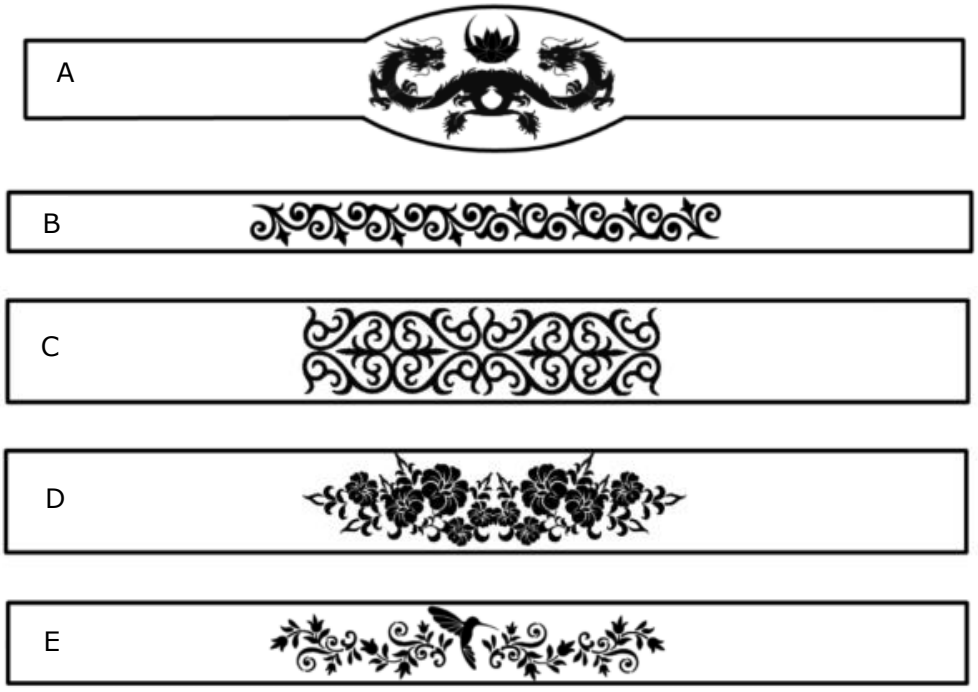



Figure 1.27 Technical drawings of the belts A - luna belt, B - silver belt, C - gold belt, D - flower belt, E- Blue belt

# 9 TESTING METHODS OF MATERIALS FOR EVENING GOWN AND BELTS

## 9.1 Testing methods of evening gown and belts fabrics

Testing is a good opportunity to control the fabric quality and its help to choose fabrics with the best features. There are many test methods for textiles testing, but tests should always be selected according to the use of the product.

The fabrics made by different producers can vary in the way of production and quality. For clothing manufactures it is important to get products with stable and expected quality. Using textile products, consumers want to be sure that they will get a good touch, good appearance, durability, and the confidence that the clothes do not contain harmful substances [47]. Special textile tests have been developed to achieve those demands.

Textile testing is an important part of product development process. It helps to evaluate whether the quality of textile materials meets the requirements of the specified standards [47]. The standards help to ensure that products, regardless of where they were made, are safe, reliable, and of acceptable quality.

For the textile test, four different black fabrics were purchased in order to test them and select a fabric with the best features to be used for sewing a evening gown and belts. All four fabrics have a plain weave construction. 3 fabrics were 100 % PES/(PL) (Fabric nr.1 Solveig;  Fabric nr.2 Leedi AV and Fabric nr.4 ), Fabric nr.3 Abakhan composition was 97 % PL and 3% EL/(EA). Charactererization of fabrics are shown in Appendix 6 (Table A6.1).

Four methods for textile testing were used: determination of fabrics mass per unit area, colour fastness to rubbing, colour fastness to domestic and commercial laundering and determination of fabric propensity to surface fuzzing and pilling. The embroiderys were tested for: fuzzing and pilling resistance and resistance to laundering. Before testing all specimens were kept in the standard testing atmosphere according to ISO 139:2005 Textiles — Standard atmospheres for conditioning and testing.

### 9.1.1 Determination of fabrics mass per unit area

The standard EVS-EN 12127:2000 Textiles – Fabrics – Determination of mass per unit area using small samples was used. The method can be applied to woven and knitted fabrics as also for other fabrics [48].

To make the test the ruler, balance Mettler AE200 (Figure 1. 28) and pin were used. 5 specimens of a minimum of 100 $cm^2$ ( 10 x10 cm) have to be cut out from the fabric. The width and the length of each specimen should be measured 3 times and rounded to the nearest 1 mm. Then the cut area of each specimen should be calculated using mean values of length and width, rounding the result to three significant figures. The next step is to weight every specimen and round the result to the nearest 1 mg and record each value. For each specimen, the mass per unit area should be calculated using the formula (9.1):

$$M = \frac{(m \cdot 10\,000)}{A} \qquad (9.1)$$

**Where:**

**M –** mass per unit are in $g/m^2$

**m -** is the mass of a test specimen in grams

**A -** is the area of the same test specimen in square centimeters

Figure 1.29 Balance Mettler AE200 [49]

### 9.1.2 Colour fastness to rubbing

Colour fastness rubbing is done according to the following standard ISO 105-X12:2016 Textile-Tests for colour fastness- Part X12: Colour fastness to rubbing. The method can be applied to different types of textile materials. During the test, the specimens of the textile were rubbed with dry rubbing cloth and with a wet rubbing cloth [50].

To make the test a grey scale, textile rubbing cloth from company SDC Enterprises Limited (accordingly to the standard ISO 105 - F09), colour assessment cabinet VeriVide and Crockmeter M238AA (Figure 1.30) were used. To make a test 4 specimens of a minimum of 5x 14 cm, two specimens in the warp direction, and 2 in the weft direction, should be cut out from the same fabric. For making a dry rubbing test the specimens (1 specimen in the warp direction and 1 in the weft direction) and white standard fabric were fixed to the chrockmeter and rubbed at a rate of one cycle per second, rub to and fro in a straight line 20 times, 10 times forward, and 10 times back.

To make a wet rubbing test the standard fabric should be soaked with distilled water (water take-up should be 95% to 100%) then fixed to the chrockmeter with the specimens and rubbed at a rate of one cycle per second, rub to and fro in a straight line 20 times, 10 times forward, and 10 times back. Then leave the white standard fabrics to dry in the drying cabinet. When standard fabrics would dry up, evaluate visually dry and wet rubbing standard fabrics placing three layers of standard fabric under the rubbed ones and using greyscale in colour assessment cabinet [50].

Figure 1.30 Crockmeter M238AA [51]

### 1.1.3 Colour fastness to domestic and commercial laundering

The standard ISO 105-C06 Textiles – Tests for colour fastness – Part C06: Colour fastness to domestic and commercial laundering. This test is carried out to determine the colour fastness to domestic and commercial laundering. The test defines methods

for determining the colour fastness of fabrics of all kinds and in all forms to the procedure of domestic or commercial laundering used for normal household articles with the use of a reference detergent while industrial and hospital articles can be a subject for more sever special laundering procedures [52].

To proceed with the test colour assessment cabinet VeriVide, grey scale, teflon balls, containers, multiadjacent fabric from company SDC Enterprises Limited (accordingly to the standard ISO 105 F10), laboratory laundry machine Linitest (Figure 1.31) and standard detergent (SDC ECE NON-PHOSPHATE REFERENCE DETERGENT) were used. To do the test cut out 2 specimens (size 100x40mm) from each fabric and 8 specimens from multifibre adjacent fabric, sew white and colour fabric specimens together from the shorter side of the specimen. Prepare a washing solution adding 4,8 g of standard detergent to 1200 ml of distilled water, pour the solution into containers of the laundry machine and add 4 Teflon balls to each container (8 containers in total). Close the containers and place them into the laundry machine. Wash at washing temperature 40 ° C and washing time 30 min. Rinse the specimens under 40 ° C water. Place the specimens to the drying cabinet and keep until they will be dry. Use colour assessment cabinet and greyscale to compare the colour fastness.

Figure 1.31 Laundry machine Linitest

### 9.1.3 Determination of fabric propensity to surface fuzzing and pilling

The standard EVS-EN ISO 12945-2:2000 Textiles – Determination of fabric propensity to surface fuzzing and to pilling – Part 2: Modified Martindale method. This test was carried out for the determination of the resistance to pilling and surface change of textile fabrics using the Martindale method. Pills are formed when fibers on a fabric surface "tease out" and become entangled during wear. Such surface deterioration is

undesirable, the level of pilling will depend on the fabric, the garment type, and textile end-use [53].

To make a test a colour assessment cabinet VeriVide, James Heal Mini-Martindale machine (Figure 1.32), sample cutter and auxiliary materials: felt from company James Heal (accordingly ISO 12947-1, and, abradant fabric from company James Heal (accordingly ISO 12947-1) were used. For making the test need to cut out 3 circular specimens of each fabric (4 different fabrics). Then cut out 3 circular specimens from auxiliary materials: felt, abradant (use special sample cutter). After that need to fix the auxiliary materials to the lower circular bases. The 3 test specimens of each fabric are attacking to the circular specimen holder and secured with special rubber bands. The next step is to mount the test specimen on the pilling table. For making the test needs to choose the right category for the pilling test. Categories of pilling test depend on textile and abradant type. Table 1.2 shows the category of pilling test. When these steps are ready to run the test until reaching the end of the first rubbing stage. Carry out the first assessment without removing the test specimen from the specimen holder and without clearing away parts of the surface for the purpose assessment. Use a color assessment cabinet to evaluate the surface of the fabrics. Continue the test, assessing at each stage of rubbing, until the end of the last stage of rubbing is reached.

Table 1.2 Category of pilling test [53]

| **Category** | **Textile type** | **Abradant type** | **Loading weight g** | **Assessment stage** | **Number Of rubs** |
|---|---|---|---|---|---|
| 2 a | Woven fabrics (except upholstery fabrics) | Woven fabric under test (face/face) or wool fabric | 415 ± 2 | 1 | 125 |
| | | | | 2 | 500 |
| | | | | 3 | 1 000 |
| | | | | 4 | 2 000 |
| | | | | 5 | 5 000 |
| | | | | 6 | 7 000 |

Figure 1.32 James Heal Mini-Martindale machine [54]

## 9.2 Testing methods of embroidery

Five different embroidery threads were selected for decorating the belts. Characteristics of the of the chosen threads are shown in Appendix 7 (Table A7.1). The quality of the threads directly affects the quality of the embroidery. For this reason two different tests were carried out with the embroideries: determination of embroidery propensity to surface fuzzing and pilling and embroidery resistance to laundering. The specimens for the test were cut out from the main material (evening gown fabric) on which the square shape embroideries with each chosen thread were done. All embroideries were done with computerized embroidery machine TEXI IRIS 10. For more information about TEXI IRIS 10 embroidery machine look in the part 12.2.

### 9.2.1 Determination of embroidery propensity to surface fuzzing and pilling

This test was carried out to determination of embroidery propensity to surface fuzzing and pilling. It is important to know the propensity to avoid the damage of embroidery while wearing, which can be caused by the rubbing by the bag or the hands of the wearer.

As for the test the bigger surface was needed the standard EVS-EN ISO 12945-2:2000 Textiles – Determination of fabric propensity to surface fuzzing and to pilling – Part 2: Modified Martindale method was chosen [53].

To make a test a colour assessment cabinet VeriVide, James Heal Mini-Martindale machine, sample cutter and Auxiliary materials: felt, abradant were used. This test was performed in exactly the same way as for testing the fabrics for evening gown and belts. The only difference in the test was that 5x5 cm square embroidery was made on the test specimens. To support and stabilize the fabric during the embroidery process, prevent puckering, deformation and stretching backings/ stabilizers of non-woven material were used. After the embroidery was done the leftover of backing/ stabilizer material was removed by tearing.

### 9.2.2 Embroidery resistance to laundering

This test was carried out to determine the fastness of embroideries to domestic laundering. The test allows controlling the resistance of evening gown fabric to colour loss and the influence of evening gown fabric colour to the colours of embroidery. The

test also provides a good opportunity to control if the care instructions given to the threads are correct.

To make a test home laundry machine Blomberg LWF294411 (Figure 1.33) and standard detergent (SDC ECE NON-PHOSPHATE REFERENCE DETERGENT)was used.

The laundering test was done twice according to laboratory method: first, at 30 °C washing temperature and the secondly at 40 °C. To make the test 2 specimens for each thread (10 in total) were cut off from the main material (evening gown fabric). On the specimens were embroidered square embroidery measuring 6x6 cm. To support and stabilize the fabric during the embroidery process, prevent puckering, deformation and stretching backings/ stabilizers of non-woven material were used. After the embroidery was done the leftover of backing/ stabilizer material was removed by tearing. To get the rubbing the corner of the specimens was sewed to the piece of the linen fabric. The linen with the test specimens was placed in the washing machine with dark clothes. The washing machine had about 4-5 kg of laundry. The garments were washed with 100 ml (40 g) of standard detergent, washing temperature 30 ° C and washing time 30 min. Then the specimens were rinsed under 30 ° C water and left for drying. When the specimens were dry visual evaluation of the embroidery surface was done. After the evaluation was done the piece with the specimens was placed in the washing machine again and this time laundered at washing temperature 40 ° C and washing time 30 min. Then the specimens were rinsed under 40 ° C water and left for drying. Visual evaluation of the embroidery surface was done after the specimens dried.

Figure 1.33 Laundry machine  Blomberg LWF294411 [55]

# 10 THE TESTS RESULTS

## 10.1 The evening gown and belts fabrics tests results

### 10.1.1 The Determination of mass per unit area test results

For this test the standard EVS-EN 12127: 2000 Textiles - Fabrics - Determination of mass per unit area using small samples was used [48]. With this test a mass per unit area for 4 different fabrics was calculated. Calculations of fabrics mass per unit area were done on dimensions of samples and average area calculations, which can be seen in Appendix 8 (Table A8.1) accordingly to the equation (9.1). The result of the test shown in the Table 1.3.

Table 1.3 The Determination of mass per unit area test results

| No | Mass per Unit Area, g/m$^2$ | | | |
|---|---|---|---|---|
| | **Fabric nr 1 Solveig** | **Fabric nr 2 Leedi AV** | **Fabric nr 3 Abakhan** | **Fabric nr 4 Trendtekstiil** |
| 1 | 293 | 277 | 133 | 295 |
| 2 | 294 | 276 | 134 | 295 |
| 3 | 301 | 281 | 135 | 291 |
| 4 | 294 | 271 | 132 | 293 |
| 5 | 288 | 269 | 133 | 293 |
| **Average** | **294** | **275** | **133** | **293** |
| **Standard deviation** | **5** | **5** | **1** | **2** |

The results show that fabric nr 3 (Abakhan) was lighter than the other ones. Mass per unit area value of Fabric nr 3 was only 133 g/m$^2$ with standard deviation (133±1) g/m2. Fabric nr 2 (Leedi AV) was heavier than fabric nr 3 (Abakhan) with mass per unit area value of 275 g/m$^2$ with standard deviation (275±5) g/m$^2$, but lighter than fabric nr 1. The heaviest fabric was fabric nr 1 (Solveig) it has a mass per unit area value of 294 g/m$^2$ with standard deviation (294±5) g/m$^2$. Fabric nr 4 (Trendtekstiil) has almost the same value of mass per unit area with 293 g/m$^2$ with standard deviation (293±2) g/m$^2$.

Due to the fact that fabrics nr 1 (Solveig) and nr 4 (Trendtekstiil) are the heaviest, they are best suited for sewing the evening gown and the belts. Because of the weight of the fabrics, they provide a good fabric drap. Also, the thickness of the material, makes them most convenient to embroidery patterns on them.

### 10.1.2 Test results of colour fastness to rubbing

For this test the standard Textile-Tests for colour fastness- Part X12: Colour fastness to rubbing (ISO 105-X12:2016) was used [50]. This test was carried out to determine the resistance of the colour to rubbing off and staining other materials. In this test, the specimens were rubbed with dry rubbing cloth and with a wet rubbing cloth using the white standard fabric. The test result was visually evaluated in colour assessment cabinet by using grayscale where 5 was the best result and 1 was the lowest. The test results are shown in Table 1.4.

Table 1.4 Visual evaluation of colour fastness by using greyscale

| No | Tested fabric | Grey scale grade |
|---|---|---|
| | **Fabric nr 1 Solveig** | |
| 1 | Dry rubbing weft | 2 |
| 2 | Wet rubbing weft | 5 |
| 3 | Dry rubbing warp | 2/3 |
| 4 | Wet rubbing warp | 5 |
| **Fabric nr 2 Leedi AV** | | |
| 1 | Dry rubbing weft | 5 |
| 2 | Wet rubbing weft | 4 |
| 3 | Dry rubbing warp | 5 |
| 4 | Wet rubbing warp | 4/5 |
| **Fabric nr 3 Abakhan** | | |
| 1 | Dry rubbing weft | 4 |
| 2 | Wet rubbing weft | 4/5 |
| 3 | Dry rubbing warp | 4/5 |
| 4 | Wet rubbing warp | 4/5 |
| **Fabric nr 4 TrendTekstiil** | | |
| 1 | Dry rubbing weft | 4/5 |
| 2 | Wet rubbing weft | 4/5 |
| 3 | Dry rubbing warp | 4/5 |
| 4 | Wet rubbing warp | 4/5 |

Fabric nr 1 (Solveig) had the best result of colour fastness to wet rubbing in both warp and weft direction (grade 5) and the lowest result to dry rubbing in both weft and warp with (grade 2 and 2/3 repectively). Fabric nr 2 (Leedi AV) showed the best result at dry rubbing weft and warp with result 5 and little bit lower result showed at wet rubbing to warp and weft. Fabric nr 3 (Abakhan) had the same result at wet rubbing weft, warp and dry rubbing warp. A little bit lower result showed at dry rubbing weft. The Fabric nr 4 (TrendTekstiil) had the same result everywhere with result 4/5.

Overall, the best result in colour fastness to rubbing showed the fabric nr 2 (Leedi AV) and the second one was fabric nr 4 (TrendTekstiil). The lowest result in colour fastness to rubbing showed the fabric nr 1 (Solveig). According to this test the best fabrics for sewing, the evening gown and the belts should be fabric nr 2 (Leedi AV) or fabric nr 4 (TrendTekstiil) which had a little bit lower result.

### 10.1.3 Test results of colour fastness to domestic and commercial laundering

For this test the standard ISO 105-C06 Textiles – Tests for colour fastness – Part C06: Colour fastness to domestic and commercial laundering was used [52]. This test was carried out to determine colour fastness to domestic and commercial laundering for staining other materials. In the test, specimens (sp) were sewn together with multifibre adjacent fabric and washed using the standard detergent. The test results were visually evaluated in colour assessment cabinet by using grayscale where 5 is the best result and 1 is the lowest. The result of the test shown in the Table 1.5.

Table 1.5 Colour fastness test results

| **No** | **White standard fabric** | **Fabric nr.1 Solveig** | | **Fabric nr.2 Leedi AV** | | **Fabric nr.3 Abakhan** | | **Fabric nr.4 Trend Tekstiil** | |
|---|---|---|---|---|---|---|---|---|---|
| | | *Sp 1* | *Sp 2* | *Sp 1* | *Sp 2* | *Sp 1* | *Sp 2* | *Sp 1* | *Sp 2* |
| 1 | Filament Triacetate | 4/5 | 4/5 | 4 | 4 | 3 | 3 | 4/5 | 4/5 |
| 2 | Bleached Cotton | 4/5 | 4/5 | 4 | 4 | 4/3 | 4/3 | 4/5 | 4/5 |
| 3 | Spun Polyamide (Nylon 6.6) | 3 | 3 | 2 | 2 | 1/2 | 1/2 | 2 | 2 |
| 4 | Spun Polyester (Dacron 54) | 4/5 | 4/5 | 4/5 | 4/5 | 3 | 3 | 4 | 4 |
| 5 | Spun Polyacrylic (Orlon 75) | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| 6 | Spun Viscose | 5 | 5 | 4 | 4 | 4/5 | 4/5 | 4/5 | 4/5 |
| | **Dress fabric** | **3/4** | **3/4** | **5** | **5** | **5** | **5** | **5** | **5** |

Test for colour fastness to domestic and commercial laundering showed that all four fabrics were staining at washing temperature 40 °C. All four fabrics showed different shades on multifibre adjacent fabric. Fabric nr 1 (Solveig) gave the best result in colour fastness to domestic and commercial laundering. Fabric nr 3 (Abakhan) gave the worst result, this fabric gave the most dye after washing. Fabric nr 4 (Trend Tekstiil) showed a slightly worse result than Fabric nr.1 (Solveig), but better than Fabric nr 2 (Leedi AV) and Fabric nr 3 (Abakhan). On a multifibre adjacent fabric, the best result showed fiber Spun Polyacrylic (Orlon 75) and the worst result showed fiber Spun Polyamide (Nylon 6.6). Also, a good result was shown by Spun Viscose fiber.

The test result showed that all four fabrics do not have a good colour fastness to washing. Although Fabric nr 1 (Solveig), showed the best result in colour fastness to domestic and commercial laundering, it was the only fabric which lost its brightness after the washing. Because of that, the best fabric was fabric nr 4 (Trend Tekstiil).

### 10.1.4 Determination of fabric propensity to surface fuzzing and pilling test results

The standard EVS-EN ISO 12945-2:2000 Textiles – Determination of fabric propensity to surface fuzzing and to pilling – Part 2: Modified Martindale method [53]. This test was carried out for the determination of the resistance to pilling and surface change of textile fabrics using the Martindale method. In this test, specimens and auxiliary materials were fixed on the pilling table. Test specimens had 6 assessment stages starting from 125 to 7000 rubs. For the test was used loading weight 415 ± 2. The test result was visually evaluated in the color assessment cabinet by using the visual assessment table from a standard where 5 is meaning no change in surface and 1 that pills covering the whole surface of the fabric. The result of the test shown in the Table 1.6.

Table 1.6 Pilling test results

| **No** | **Number of rubs** | **Loading weight,g** | **Fabric nr 1 Solveig** | | | **Fabric nr 2 Leedi AV** | | | **Fabric nr 3 Abakhan** | | | **Fabric nr 4 Trend Tekstiil** | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | *Sp 1* | *Sp 2* | *Sp 3* | *Sp 1* | *Sp 2* | *Sp 3* | *Sp 1* | *Sp 2* | *Sp 3* | *Sp 1* | *Sp 2* | *Sp 3* |
| 1 | 125 | 415 ± 2 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| 2 | 500 | | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| 3 | 1000 | | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| 4 | 2000 | | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| 5 | 5000 | | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| 6 | 7000 | | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |

Determination of fabric propensity to surface fuzzing and pilling test showed that all 4 fabrics are resistant to pilling. After 7000 rubs, all fabrics had a clear surface with no pills. At the same time, the surface of Fabric nr 1 (Solveig) after 7000 rubs became lighter. The fabric lost its brightness. It feels like the dye has worn off although the auxiliary materials have no changes. Fabric nr 3 (Abakhan) after the test became darker, even the auxiliary material looked the same after the test as at the beginning. The test showed that the best fabrics for sewing a evening gown and belts would be fabric nr 2 (Leedi AV) or Fabric nr 4 (Trend Tekstiil).

## 10.2 The embroidery tests results

### 10.2.1 Determination of embroidery propensity to surface fuzzing and pilling test results

This test was carried out to determine the resistance of embroidery to surface fuzzing and pilling. To know the resistance is important to avoid the damage of embroidery while wearing which can be caused by the rubbing by the bag or the hands of the wearer. As for the test the bigger surface was needed the standard EVS-EN ISO 12945-2:2000 Textiles – Determination of fabric propensity to surface fuzzing and to pilling – Part 2: Modified Martindale method was chosen. Test specimens had 6 assessment stages starting from 125 to 7000 rubs. For the test was used loading weight 415 ± 2. The test result was visually evaluated in the colour assessment cabinet by using the visual assessment table from a standard where 5 is meaning no change on the surface and 1 when pills covering the whole surface of the fabric. The test result is shown in the Table 1.7.

Table 1.7 Test results of determination of embroidery propensity to surface fuzzing and pilling

| **No** | **Number of rubs** | **Loading weight** | **Metallic embroidery thread FS No. 40** | | | **Embroidery Thread Luna** | | | **CLASSIC embroidery thread No.40** | | | **Astro Color embroidery thread CLASSIC No.40** | | | **Polyneon embroidery thread No.40** | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | *Sp 1* | *Sp 2* | *Sp 3* | *Sp 1* | *Sp 2* | *Sp 3* | *Sp 1* | *Sp 2* | *Sp 3* | *Sp 1* | *Sp 2* | *Sp 3* | *Sp 1* | *Sp 2* | *Sp 3* |
| 1 | 125 | 415 ± 2 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| 2 | 500 | | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| 3 | 1000 | | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| 4 | 2000 | | 5 | 5 | 5 | 4 | 4 | 4 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| 5 | 5000 | | 5 | 5 | 5 | 4 | 4 | 4 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| 6 | 7000 | | 5 | 5 | 5 | 4 | 4 | 4 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |

The test showed that except Luna all threads have great abrasion resistance. Luna thread after 2000 rubs had some pills on the surface of embroidery. Other threads after 7000 rubs do not have any changes or pills on the surface. The test showed that all threads are suitable for creating high-quality embroideries. As Luna thread surface showed some changes, it is better to use the embroidery with this thread in garment areas with minimum abrasion.

### 10.2.2 Embroidery resistance to laundering test results

This test was carried out to determine embroidery resistance to domestic laundering and the influence of the laundering on embroidery surface. The test also helped to check whether the colours of basic material can influence and/or change the embroidery colour while laundering. It also gave possibility to control if announced threads care instructions meet the stated ones. The laundering test was done 2 times: first with 30 °C washing temperature and secondly at 40 °C. The test results were visually evaluated with a scale where 5 means no change on the surface and 1 when the surface shows changes, some threads are torn or come out. The test results are shown in the Table 1.8.

Table 1.8 Embroidery resistance to washing test results

| | **Type of thread** | **Washing 30 ° C** | **Washing 40 ° C** |
|---|---|---|---|
| Standard detergent 100 ml /40 g 5l water 4-5 kg of clothes | Metallic embroidery thread FS No. 40 | 5 | 5 |
| | Embroidery Thread Luna | 5 | 5 |
| | CLASSIC embroidery thread No.40 | 5 | 5 |
| | Astro Color embroidery thread CLASSIC No.40 | 5 | 5 |
| | Polyneon embroidery thread No.40 | 5 | 5 |

The test showed that the embroidery threads are high quality ones and are resistant to laundering. The laundering did not influence the brightness of the threads. The tests showed that the thread cares instruction meet the stated ones. The embroideries done with the threads were resistant to laundering too showing no changes in the colours or on the surface. However, it is important to mention that the embroidery curled up after the washing and needed the ironing.

# 11 PATTERNMAKING OF EVENING GOWN

Body measurements play an important role in the best fit of clothes for the human body. It is very important for the designer or tailor to know the anatomy of the body as well as the correct procedure of body measuring [56]. Body measurements and recommended allowances were taken according to M.Müller & Sohn Metric Patternmaking for Dresses & Blouses [57]. All measurements were taken strictly according to the instructions to avoid possible mistakes. Figure dimensions are shown in Appendix 9 (Table A9.1). Also, some measurements can be calculated. Calculations of measurements allow to over check if the dimensions were taken in a correct way. Calculated measurements can be seen in the Appendix 9 (Table A9.2). Recommended close-fitted dress allowances for ease are shown in the Appendix 9 (Table A9.3).

## 11.1 The evening gown pattern construction

A basic pattern can be constructed in any three ways, flat pattern made manually or with the help of computer software or draped on the stand [56]. It is considered that the fastest and most convenient way to design patterns is with the help of computer programs/softwares. It is much faster and easier to make changes in the computer if needed, although the patterns constructed manually or by draping the fabric on the model, are usually more creative, accurate and get a better fit on the body.

Patterns were constructed and modelled according to book M.Müller & Sohn Metric Patternmaking for Dresses & Blouses. The body dimensions are shown in the Appendix 9 (Table A9.1) were used for pattern constructing. First, the patterns were constructed on paper, after corrections made, patterns were digitized in Lectra Modaris software with the help of a digitizing table CALCOMP model no. 34600 and then redraw in the Kaledo Style software.

### 11.1.1 Construction of basic and modelled patterns

Initially, basic patterns were made on the paper manually. Basic patterns are shown in Appendix 10 (Figure A10.1) and Appendix 11 (Figure A11.1). After the basic pattern constructions were ready, the patterns were copied to another paper for modeling the dress. While modeling the bust dart was rotated from shoulder seam to side seam. The dress neckline was changed to asymmetrical (such neckline is called a One-shoulder neckline). The front and back were divided into 2 parts: upper and lower ones. Front lower detail was divided into 2 parts too. On one side, the dart was lengthened and another one was used for making a slit. On the back detail, the darts

were not moved, they maintained in the same place as on the base pattern construction. Modelled dress patterns are shown in Appendix 12 (Figure A12.1). The sleeve of the dress did not need changing. The base pattern construction was used. The pattern of the sleeve is shown in Appendix 13 (Figure A13.1). After the patterns were completed, the sample was sewn.

### 11.1.2 Corrections of the patterns

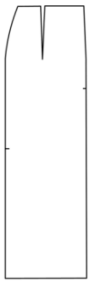
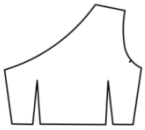
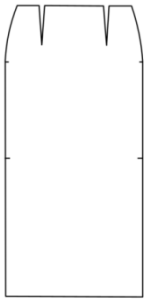
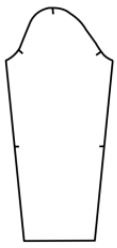
With the use of modelated patterns, a sample evening gown was sewed. The sample was tried on a model to check the fit and proportions of the style. Some changes were required: front and back shoulder seams and both side seams were taken in 1 cm. The shoulder lines were shortened by 2,5 cm. The waistlines of all lower details were taken in 1 cm. The side seams of the sleeve were taken in 1 cm. All changes that were done on the patterns are shown in Appendix 14 (Table A14.1). After the patterns were corrected, they were digitized to the Lectra Modaris program. The real evening gown was sewn based on corrected patterns. The list of those patterns are shown in Table 1.9.

## 11.2 The belts pattern construction

Patterns for the belts were created using the measurement of the waist taken from the figure for dress patterns construction.
First, the patterns were constructed on paper, when the patterns were ready, the measurements of the patterns were controlled on the figure. When all patterns were controlled, they were redrawn in Lectra Modaris software, and later redrawn again in Kaledo Style software. The list of belts patterns are shown in Table 1.10.

Table 1.9 List of the patterns and number of pattern pieces of the evening gown

| No | Pattern name | Pattern images | Quantity of patterns | Quantity of pieces |
|---|---|---|---|---|
| **Main material** | | | | |
| 1 | Front upper detail |  | 1 | 1 |

| No | Pattern name | Pattern images | Quantity of patterns | Quantity of pieces |
|---|---|---|---|---|
| 2 | Front lower detail side 1 |  | 1 | 1 |
| 3 | Front lower detail side 2 |  | 1 | 1 |
| 4 | Back upper detail |  | 1 | 1 |
| 5 | Back lower detail |  | 1 | 1 |
| 6 | Sleeve |  | 1 | 1 |
| **Lining** | | | | |
| 7 | Front upper detail |  | - | 1 |

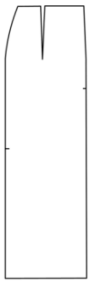
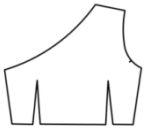
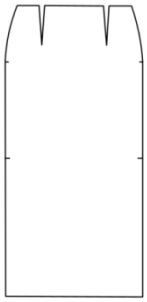
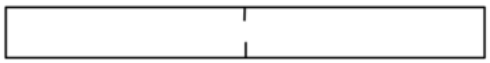
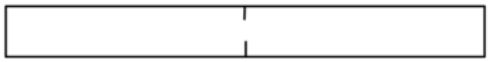
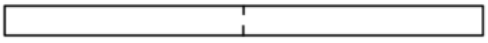
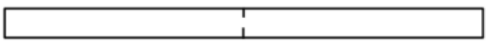
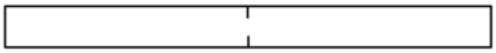
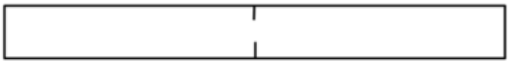
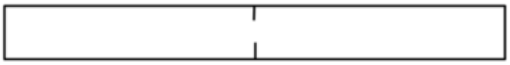
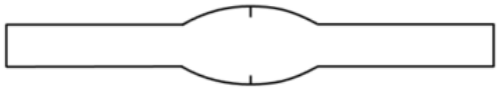
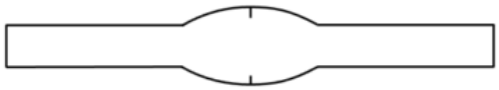
| No | Pattern name | Pattern images | Quantity of patterns | Quantity of pieces |
|---|---|---|---|---|
| 8 | Front lower detail side 1 |  | - | 1 |
| 9 | Front lower detail side 2 |  | - | 1 |
| 10 | Back upper detail |  | - | 1 |
| 11 | Back lower detail |  | - | 1 |

Table 1.10 List of the patterns and number of pattern pieces of the belts

| No | Pattern name | Pattern images | Quantity of patterns | Quantity of pieces |
|---|---|---|---|---|
| **Gold belt** | | | | |
| 1 | Front detail |  | 1 | 1 |
| 2 | Back detail |  | 1 | 1 |
| **Silver belt** | | | | |
| 3 | Front detail |  | 1 | 1 |
| 4 | Back detail |  | 1 | 1 |
| **Blue belt** | | | | |

| No | Pattern name | Pattern images | Quantity of patterns | Quantity of pieces |
|---|---|---|---|---|
| 5 | Front detail |  | 1 | 1 |
| 6 | Back detail |  | 1 | 1 |
| **Flower belt** | | | | |
| 7 | Front detail |  | 1 | 1 |
| 8 | Back detail |  | 1 | 1 |
| **Luna belt** | | | | |
| 9 | Front detail |  | 1 | 1 |
| 10 | Back detail |  | 1 | 1 |

# 12 BELTS EMBROIDERING

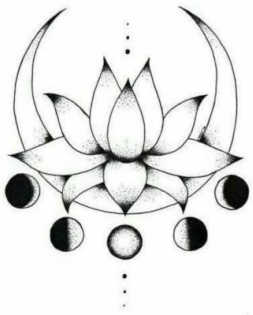
## 12.1 Embroidery design of the belts

To decorate the belts, five designs for embroidery were developed. The inspiration for embroidery designs appeared in viewing the collections of famous designers. The embroidery designs were made with a combination of different styles and patterns, and have a slight Oriental influence. The patterns are shown in the Table 1.11.

After the patterns were selected, they were imported into Kaledo Style software, where all the patterns were redrawn and combined with each other. When the designs for the embroidery were ready they were saved in jpg format. Then all the designs were imported to Hatch By Wilcom embroidery software and redrawn in a special embroidery format .emb file. After that, the embroidery files were exported to .dst file which is needed for working with embroidery machine.

Table 1.11 Patterns for belts

| Belt No. | Belts Type | Pattern 1 | Pattern 2 |
|---|---|---|---|
| 1 | Gold belt |  Pattern for Gold belt [58] | |
| 2 | Silver belt |  Pattern for Silver belt [59] | |

| Belt No. | Belts Type | Pattern 1 | Pattern 2 |
|---|---|---|---|
| 3 | Flower belt |  Pattern for Flower belt [60] | |
| 4 | Blue belt |  Pattern1 for Blue belt [61] |  Pattern2 for Blue belt [62] |
| 5 | Luna Belt |  Pattern 1 for Luna belt [63] |  Pattern 2 for Luna belt [64] |

## 12.2 Belts embroidering using TEXI IRIS 10 embroidery machine

All five belts were embroidered with TEXI IRIS 10 embroidery machine. TEXI IRIS 10 is a single head computerized embroidery machine. The machine has 10 needles which allow to use different threads for embroidery. A multitude of machine embroidery threads provides an advantage of changing the color. This machine can make 1000 stitches per minute. TEXI IRIS 10 embroidery machine has a touch panel with

functions needed (Start, Stop, Auto thread trimming, Color change, Embroidery status, Numerical keys for needle choice, Frame move). The machine is equipped with additional functions like the possibility of the editing, copying, scaling of the design on the panel's screen, and erasing. The progress of the embroidery can be followed from the panel's screen in real-time.

The embroidery machine has a multilingual menu, which makes using the machine much more convenient. It has a USB port for importing the designs to embroidery machine. TEXI IRIS 10 embroidery machine supports different embroidery file formats: Tajima, Barudan, ZSK (.dst, .dsb, .fdr). The machine has 5 different hoops: 1 x oval 70 x 50 mm, square 110 x 110 mm, rectangular 190 x 140 mm, rectangular 310 x 210 mm and cap frame [65]. TEXI IRIS 10 embroidery machine is shown in Figure 1.34.


Figure 1.34 TEXI IRIS 10 embroidery machine

## 12.3 Embroidering of the belts

All embroideries were embroidered on the fabric nr.4 (Trend Tekstiil). Fabric composition was 100% polyester (PES /PL). The fabric has a plain weave construction. It was decided not to use backing or stabilizer for the embroidery. Instead, the fabric was strengthened with one-sided cotton interlining which helped to support and stabilize the fabric during the embroidery process.

Five different embroideries were designed for the belts. Five different Madeira threads were used for the embroidery: metallic, silver, luna, astro color, classic, and polyneon.

- Metallic embroidery thread FS No. 40 was used to embroider Gold and Silver belts. The threads consist of 40 % met.PES, 35 % PA, and 25% cellulose. Metallic thread is very sensitive to the needle size, tension, and speed. It is advised to use the lowest possible speed for embroidery because of the delicate structure and easy breaking of metallic thread. A 75/11 needle was used for embroidering, the machine had the lowest speed of 300 stitches per minute, and the thread tension was set to minimum. The design choused for embroidering with golden metallic embroidery thread is shown in Figure 1.35 and for embroidering with silver metallic thread on Figure 1.36.

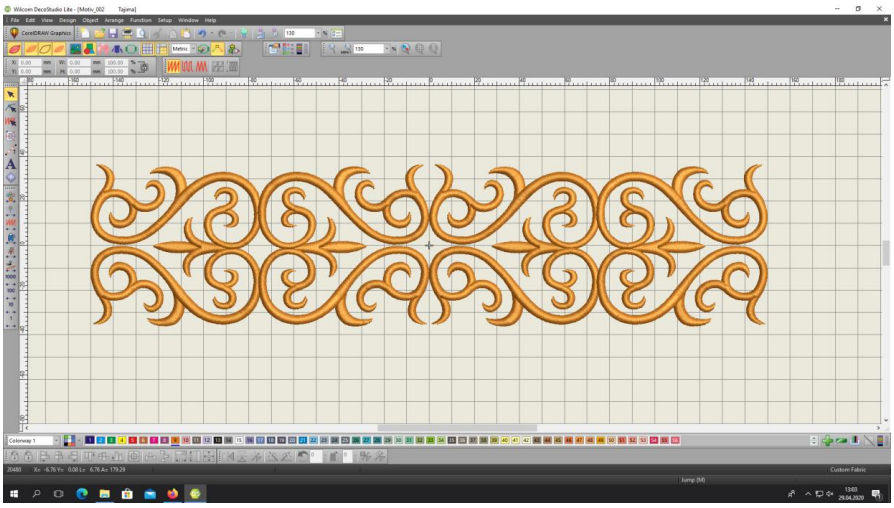


Figure 1.35 Embroidery design for gold belt in .dst file

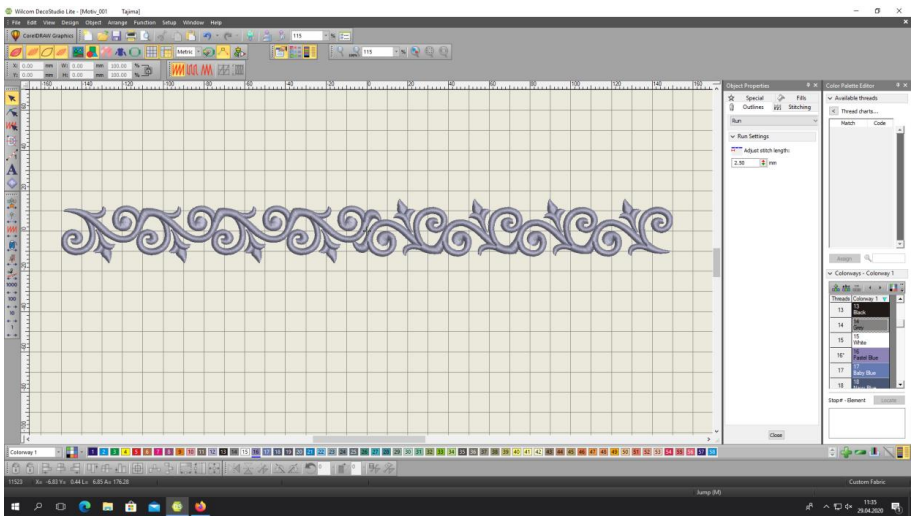


Figure 1.36 Embroidery design for silver belt in .dst file

- A Luna thread was used to embroider a Luna belt. LUNA is a glowing in the dark embroidery thread. It consists of approx. 60% polybutylene terephthalate (PBT) and 40 % polypropylene (PP). Luna thread is sensitive to the tension and speed. While embroidering with Luna thread, the lowest possible speed for embroidery is advised because the thread can constantly be broken and knotted on the fabric. The embroidery was created at the speed 300 stitches per minute, with medium thread tension and the needle number 75/11. Embroidery design for Luna belt a shown in Figure 1.37.

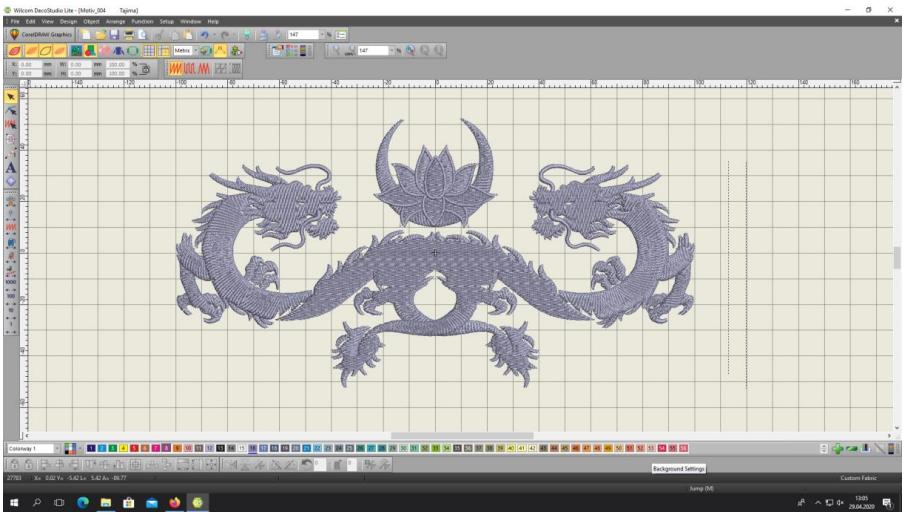


Figure 1.37 Embroidery design for Luna belt in .dst file

- For Blue belt embroidering Astro Color embroidery thread, CLASSIC No.40 was used. It consists of 100% viscose. Astro Color special dyeing process produces outstanding and ever-changing colours throughout the whole spool, as a result, embroidery will be unique. Astro Color is soft embroidery thread, which lies down freely in any direction, do not form loops, and settle on the fabric better than the same thickness polyester thread. The surface embroidered with viscous is uniform and calm. The thread withstands the high-speed stitching. A 75/11 needle was used to create for the embroidery, the machine had high speed 700 stitches per minute, and the thread strong tension was used. Embroidery design for Astro Color (Blue belt) a shown in Figure 1.38.

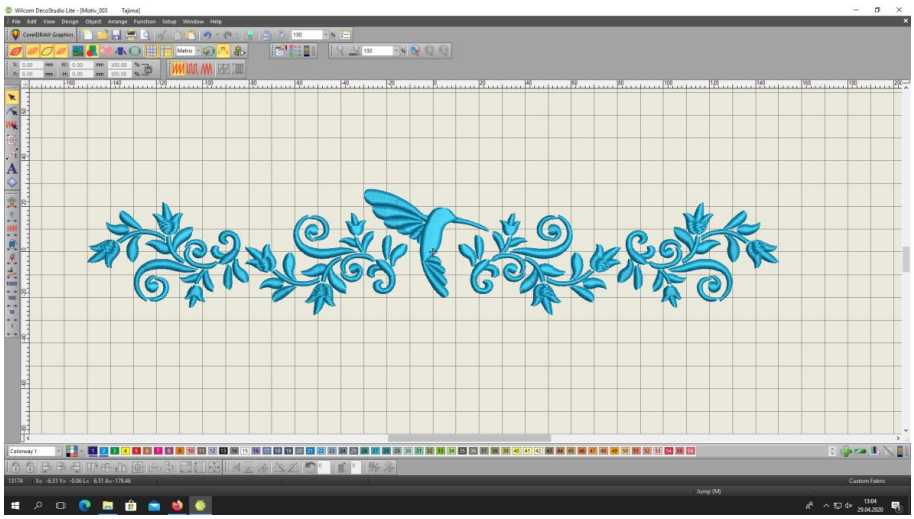


Figure 1.38 Embroidery design for Blue belt in .dst file

- Flower belt was embroidered with CLASSIC embroidery thread and Polyneon embroidery thread No.40. CLASSIC embroidery thread consists of 100% viscose and Polyneon embroidery thread of 100% PES/PL. CLASSIC embroidery thread No.40 has the same properties as an Astro Color embroidery thread CLASSIC No.40. Polyneon embroidery thread is stronger and shinier, elastic than viscous thread. This thread withstands the high-speed stitching too. The embroidery was created at the speed 700 stitches per minute, the thread tension was strong, and the needle number was 75/11. Embroidery design for polyneon and Classic threads (flower belt) is shown in Figure 1.39.

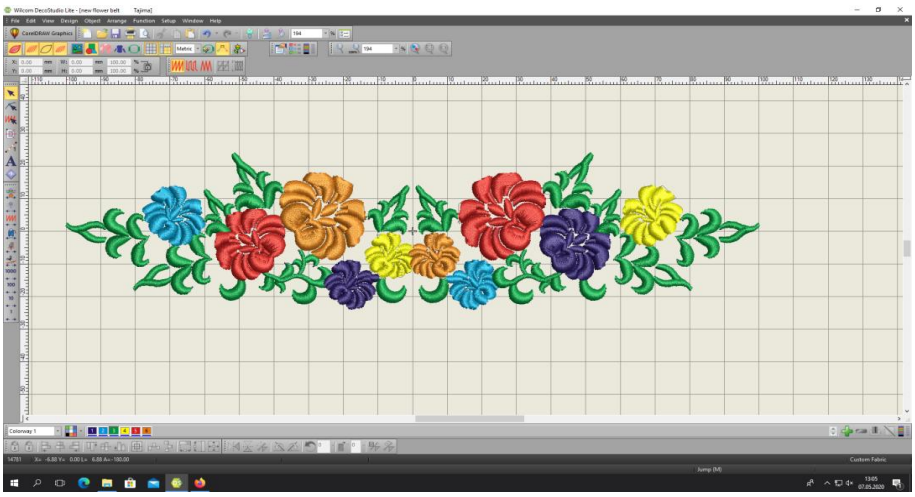


Figure 1.39 Embroidery design for Flower belt in .dst file

# 13 SEWING TECHNOLOGY OF EVENING GOWN AND BELTS

## 13.1 Equipment used for sewing of the evening gown and belts

During the sewing, several sewing machines, fusing press machine and steam iron were used. The choice of sewing machines depends on sewing technology and product.  Fusing press machine and steam iron characteristics can be seen in Table 1.13.

Table 1.12 shows the sewing machines used and their technical parameters. Fusing press machine and steam iron characteristics can be seen in Table 1.13.

Table 1.12 Choice of sewing machines and their technical parameters

| No | Machine type | Machine name | Max.Sewing speed | Technical parameters | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | Stitch name | Stitch type | Stitch length | Thread No. | Needle No. |
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| 1 | Universal sewing machine | BROTHER S-7000DD-403 | 5000 | Lock stitch | 301 | 1-5 | 120 | R90 |
| 2 | Overlock sewing machine | BROTHER EF4-N21-37-5 | 6500 | Overedge stitch | 504 | 1-4 | 120 | R90 |
| 3 | Invisible Seam/Blind Hem Sewing Machine | Maier 251 | 3000 | Blind Stitch | 103 | 3-8 | 200 | 80 |

Table 1.13 Used pressing equipment and its characterization

| No | Machine type | Machine name | Technical parameters | | | |
|---|---|---|---|---|---|---|
| | | | Temperature C° | Pressure (N/cm2) | Speed (m/min) | Voltage |
| | 1 | 2 | 3 | 4 | 5 | 6 |
| 1 | Fusing press machine | Meyer RPS-L400 | 0 - 400 | 0-50 | 1 - 9 | 230 |
| 2 | Steam iron | HD 202 Iron | 0 - 260 | - | - | 220 |

## 13.2 Sewing technology description and order of processing steps

Sewing technology depends on product design and materials. The sewing technology description is a detailed overview of the sewing process, where each operation has a detailed explanation. It includes machine type and sectional drawings, provides details of the operations, use of exact needles, threads and stitch density [66].Description of sewing technology and order of processing steps of the evening gown and the belts are shown in Appendix 15 (Table A15.1) and Appendix 16 (Table A16.1). Sectional drawings explanations are shown in Appendix 17 (Table A17.1).

## 13.3 Specification sheets for the evening gown and belts

Specification sheet is a technical document, which includes a sketch to give a visual impression of front and back details, a fabric sample to show the fabric chosen for the garment, a list of materials used, as also the main sewing parameters to sew the garment. Product specification sheet is used in production to have an overview of the garment concept and it is a basic document reflecting the main points of production parameters [67]. The specification sheets of the evening gown and it`s belts are shown in Appendix 18 - Appendix 23.

# 14 Discussion of product development process of evening gown

The development process of an evening gown and embroidered belts took more time and effort than expected. In the beginning, it was necessary to figure out which product would be completed in the course of the master thesis. The product was supposed to be suitable and fit the person who will wear it. It has to highlight the pros and hide the cons of the figure. Finally, classical one shoulder evening gown with a slit was designed. It was also necessary to concider how to decorate the evening gown with embroidery. The belts were designed as an interchangeable accessory and vary by embroidery design and threads used for embroidery. All belts are removable and they can be changed depending on mood or occasions.

In order to start designing an evening gown, it was important to find the right fabric for the evening gown and belts. The fabric has to be with good drap and with enough thickness for embroidering, also with good colour fastness to rubbing and laundering, and resistant to fuzzing and pilling. It was also important to find threads with suitable properties for the belts embroidering. The threads should be abrasion resistance and resistant for fuzzing and pilling, and laundering.

When fabrics and threads were chosen, it was necessary to design a pattern for the evening gown and it's belts. The basic pattern of the dress was used to make a prototype and modeled after the trial dress was tried on. Pattern construction for the belts was easy and fast.

Some problems were faced while sewing the evening gown. Because of the weight of the fabric, the seams on the dress
were out of place for 1- 1,5 cm and needed to be moved to the right place. The lack of experience created a problem while sewing a slit. It took time to find the right technological solution to sew it. The rest sewing of evening gown went smootly. Ready evening gown is shown on Figure 1.40.

The embroidery took a lot of time and effort because it was a lot of work with finding correct thread tension to prevent the thread breaks and to get uniformed and nice embroidery. The sample embroideries were done with every chosen thread to ensure the quality of embroidery and avoid the loose of the main material. Three embroideries were done smoothly, but two of them needed special attention. One of

the problematic thread was Luna thread, it requested the lowest speed (300 stitches per minute) and teared often. A flower (multi-color) belt also created a problem: the threads of different colours were used for that belt. It was not easy to find the right configuration of the embroidery machine to put it to change the threads in correct order. Embroidery with Luna and multi colour threads was very time consuming.

The development of any product is a time-consuming process basic knowledge and efforts are required to succeed. To work with an embroidery machine, it is necessary to get acquainted with the world of embroidery and learn not only how to manage the machine, but also how to choose the right needles, threads and fabrics. A lot of tests are required to be successful with embroidery. The photo of embroidered belts is shown on Figure 1.41 and photos of the evening gown with different belts in Appendix 24 - Appendix 28.

Figure 1.40 Evening gown

Figure 1.41 Embroidered belts

# SUMMARY

Embroidery is one of the most common types of folk and applied arts. It came into existence with the first stitch made by prehistoric humans. Sewing first appeared as a necessity and quickly developed to embroidery. Many centuries the embroidery showed the status of the wearer.

Before the beginning of the 19th-century embroidery was done by hand, it took a lot of experience, time and patience to make it. The first embroidery machine was invented at the beginning of the 19th-century and from that on the development of embroidery machines began. Nowadays there are different versions of computerized embroidery machines and software for them. Embroidery machines can do almost anything. They are fast and convenient. Everyone can choose the machine and software depending on their needs: a small atelier up to big factories for mass production.

Wool, linen, and silk have been used for embroidering for thousands of years. Today embroidery threads are manufactured in cotton, viscose, polyester and novelty yarns like fire resistance or Luna, a thread shining in dark, as well as in traditional wool, linen, and silk. Coloreel is the latest invention of one of the Swedish companies. It is an added device that allows to colour a white thread at any colour at the moment of embroidering. Thanks to technological advances, embroidery is nowadays a computerized process of decorating, elegant, sophisticated and sought-after.

The aim of this master thesis was to explore the possibilities of embroidery in modern product development. An evening gown was chosen to explore how different embroideries with different types of threads can influence the perception and the mood of the gown. The belts were chosen to become interchangeable embroidered accessories. One important aim was to design not an expensive luxury gown, but develop an affordable evening gown for a local consumer.

During the work, an evening gown with 5 belts was developed. The dress is a floor-length evening gown. This dress can be worn on special occasions like weddings, going to the theatre, graduations, and receptions. Five different belts were chosen to become an interchangeable accessory which can be changed, just taken off or used with other clothes depending on the mood and the need of the wearer. Embroideries were done in the middle of the front detail the belts. The belt closes with metallic snap fasteners, which were sewn on the sides of the belts.

Different textile tests were carried out to choose the fabric for the evening gown and belts. Colour fastness to rubbing, colour fastness to laundering, fuzzing and pilling resistance tests were performed. The fabric with the best features was chosen for the evening gown. The material for the evening gown have to have a good drapability and have enough thickness for embroidering as the belts were done with the same fabric as the evening gown. As the threads mainly define the embroidery resistance to the wear, sample embroideries with threads chosen for embroidering were prepared and tested for fuzzing and pilling and laundry resistance. All embroideries showed very good test results.

TEXI IRIS 10 embroidery machine was used for embroidering the belts. TEXI IRIS 10 is a single head computerized embroidery machine. The machine has 10 needles which allow using different threads for embroidery. Five different types of Madeira threads were used for the embroidery: metallic, silver, Luna, Astro color, Classic, and Polyneon. Those threads were chosen to bring out the diversity of available threads and embroideries done with them.

The master thesis enabled to become familiar with product development, embroidery and embroidery machines history and fabric testing. It gave knowledge and experience of product development from idea to finished product with accompanying documentation included. Also it gave a wide and varied experience of working with a modern embroidery machine, brought out the necessity of getting acquainted with the world of embroidery, taught not only how to manage the embroidery machine, but also the importance of choosing the right needles, threads and fabrics. A lot of exercises are required to be successful with embroidery. It is important to know the materials, equipment, software, and technology of the product development process to ensure the quality of the product.

The Master thesis was written in English, include 132 pages, consist of 14 parts, 41 pictures and 13 tables.

# KOKKUVÕTE

Tikkimine on üks levinumaid rahva- ja tarbekunsti liike, mis sai alguse meie esivanemate esimestest kaunistuspistetest. Esialgu õmmeldi vaid vastavalt vajadusele, kuid kiiresti arenes välja ka rõivaste kaunistamine tikkimise näol. Mitmete sajandite vältel on tikand näidanud kandja staatust.

Enne 19. sajandi algust tikiti käsitsi, see eeldas kogemusi, aega ja kannatust. Esimene tikkimismasin leiutati 19. sajandi alguses ja sellest ajast on tikkimismasinad läbinud suure arengu. Tänapäeval on võimalik soetada paljusid erinevaid arvutipõhiseid tikkimismasinaid ning saadaval on ka hulgaliselt erinevaid tikkimisfailide loomise tarkvarasid. Kiirete ja mugavate tikkimismasinate abil on võimalik teostada peaaegu kõike. Masina ja tarkvara saab igaüks valida vastavalt vajadusele: olgu siis väikese ateljee või masstootmise tarbeks suures tehases.

Villa, lina ja siidi niite on tikkimisel kasutatud tuhandeid aastaid. Tänapäeval toodetakse tikkimisniite puuvillast, viskoosist, polüestrist ja ka uudsematest kiududest (saades näiteks tulekindlaid niite või pimedas helendavat niiti Luna), samuti traditsioonilisest villast, linast ja siidist. Samas on tänapäeval võimalik tikkida värviliselt ka ainult valget niiti kasutades. Coloreel on ühe Rootsi ettevõtte välja töötatud lisaseade, mis võimaldab tikkimise ajal värvida valget niiti mis tahes värvitooni. Tänu tehnoloogia arengule on tikandid muutunud elegantseks, keerukaks ja ihaldatud kaunistuselemendiks.

Käesoleva magistritöö eesmärk oli uurida tikkimise võimalusi tänapäevases tootearenduses. Õhtukleit valiti selleks, et uurida, kuidas erinevat tüüpi niitidega tikandid mõjutavad kleidi tajumist ja meeleolu. Vööd valiti vahetatavateks tikitud aksessuaarideks. Üks oluline eesmärk oli kujundada mitte kallist luksusrõivast, vaid välja töötada kohalikule tarbijale taskukohane õhtukleit.

Töö käigus arendati välja viie erineva vööga pikk õhtukleit. Seda kleiti saab kanda erilistel puhkudel, näiteks pulmades, teatrisse minnes, kooli lõpetamisel ja vastuvõttudel. Vahetatavaks aksessuaariks valiti viis erinevat vööd, mida saab vastavalt tujule ja kandja vajadusele muuta, lihtsalt ära võtta või muude rõivastega kasutada. Tikandid tehti vööde paremale poole. Vöösid saab kinnitada metallist trukkidega.

Õhtukleidi ja vööde kanga valimiseks viidi läbi erinevad materjali katsetused. Teostati värvipüsivus hõõrdumise, ning pesemise toimele. Määrati ka materjalide pillingukindlus. Õhtukleidiks valiti parimate omadustega kangas. Õhtukleidi materjal peab olema hästi drapeeruv ja tikkimiseks piisavalt paks, kuna vööd tehti samast kangast nagu õhtukleit. Kuna tikandite kulumiskindluse määravad peamiselt niidid, valmistati ette tikkimiseks valitud niidiga tikandite proovid ja katsetati nende hõõrde- ja pillingukindlust ning pesukindlust. Kõik tikandid andsid väga häid testitulemusi.

Vööde tikkimiseks kasutati TEXI IRIS 10 tikkimismasinat, mis on ühe peaga arvutipõhine tikkimismasin. Masinal on 10 nõela, mis võimaldavad tikkimiseks kasutada erinevaid niite. Tikanditeks kasutati viit erinevat tüüpi Madeira niiti: metallik, hõbe, Luna, Astro color, Classic ja Polyneon, mis valiti selleks saadaolevate niitide ja nendega tikitavate tikandite mitmekesisuse esile toomiseks.

Magistritöö võimaldas tutvuda tootearenduse, tikkimise ja tikkimismasinate ajaloo ning kangaste testimisega. See andis teadmisi ja kogemusi tootearendusest ideest valmistooteni koos tootmiseks vajaliku dokumentatsiooni koostamisega. Samuti andis see laia ja mitmekesise kogemuse kaasaegse tikkimismasinaga töötamisel, tõi välja vajaduse tutvuda tikkimismaailmaga, õpetas mitte ainult tikkimismasinaga töötamist, vaid ka õigete nõelte, niitide ja kanga valimise olulisust. Õnnestunud tikandi saavutamine nõuab palju harjutamist. Toote kvaliteedi tagamiseks on tootearendusprotsessis oluline teada  materjale, seadmeid, tarkvara ja tehnoloogiat.

Magistritöö on kirjutatud inglise keeles, sisaldab 132 lehekülge, koosneb 14 osast, 41 pildist ja 13 tabelist.

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# APPENDICES

## Appendix 1 Types of embroidery machines

Table A1.1 Different types of embroidery machines [68], [69], [70], [71], [72], [73], [74], [75], [76]

| No | Type of embroidery machines | Pictures of embroidery macines |
|---|---|---|
| 1 | Free-motion machine embroidery |  |
| 2 | Computerised machine embroidery |  |
| 3 | Combined sewing/embroidery machines |  |
| 4 | Single-needle embroidery machines |  |
| 5 | Multi-needle embroidery machines |  |

| No | Type of embroidery machines | Pictures of embroidery macines |
|---|---|---|
| 6 | Single- head embroidery machine |  |
| 7 | Double-head embroidery machines |  |
| 8 | Multi- head embroidery machine |  |
| 9 | Beads(Pearl) embroidery achine |  |

## Appendix 2 Needle point identification

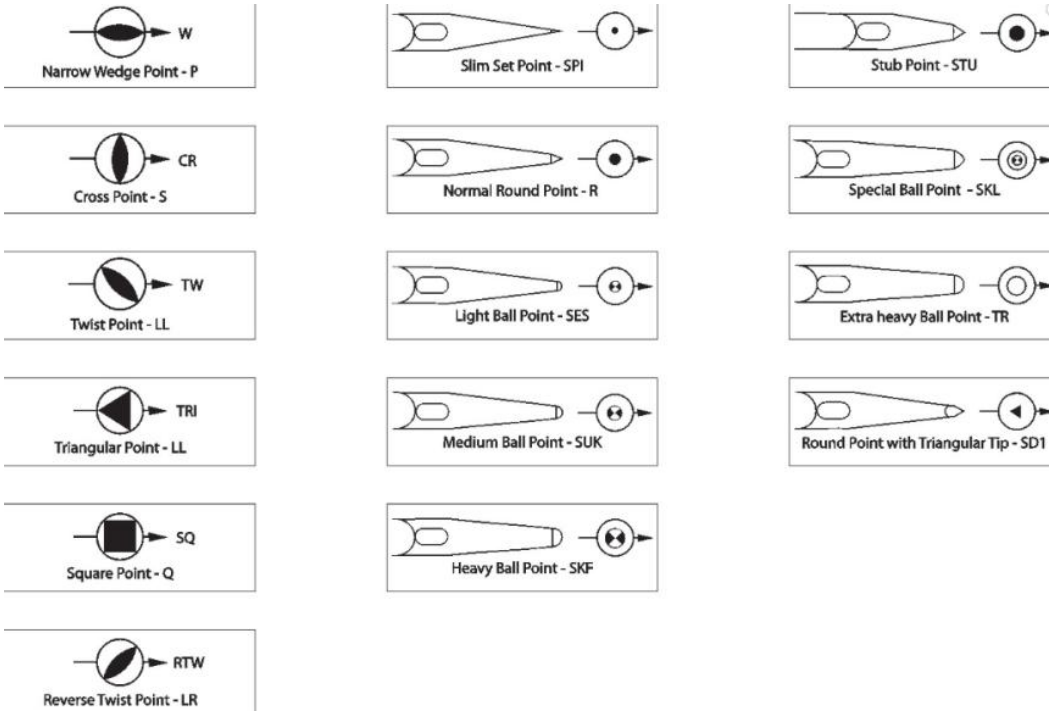



Figure A2.1 Needle point identification [30]

## Appendix 3 Needle point for different materials

Table A3.1 Embroidery needle points for different materials [30]

| No | Materials | Pictures of embroidery needle point |
|---|---|---|
| 1 | Universal needle for machine embroidery |  |
| 2 | Needle for decorative threads |  |
| 3 | Needle for embroidery on delicate fabrics |  |
| 4 | Needle for embroidery on knits and elastic fabrics |  |
| 5 | Needle for embroidery on loose knitwear and rough elastic fabric |  |
| 6 | Needle for embroidery on leather (genuine and artificial leather) |  |
| 7 | Needle with crochet hook end |  |
| 8 | Needle for cutwork (boring) embroidery |  |

## Appendix 4 Relation of fabrics type with needle points and needle sizes

Table A4.1 Relation of fabrics type/needle points/needle sizes [29]

| No | Fabric Type | Needle Point | | Needle Size | |
|---|---|---|---|---|---|
| | | Household Needles | Industrial Needles | Household Needles | Industrial Needles |
| 1 | Thin satin | H-M, H, H-J | SPI | 70-75 | 65-70 |
| 2 | Lycra, spandex, fabric stretching in all directions | HE, H-SUK | SES/SUK | 70-75 | 65-75 |
| 3 | Broadcloth, poplin with spandex | H-M, H, H-J | SPI | 70-75 | 70-75 |
| 4 | Thin genuine leather | H-J | SPI/R | 70-80 | 70-80 |
| 5 | Soft genuine leather | H-E | SES | 75-80 | 75-80 |
| 6 | Thin vinyl | H-J | R | 70-80 | 70-80 |
| 7 | Thick vinyl | H-E | SES | 75-80 | 75-80 |
| 8 | Transparent natural/synthetic fabrics | H-M, H, H-J | SPI | 65-75 | 65-70 |
| 9 | Single knit | H-E | SES | 70-75 | 70-75 |
| 10 | Double knit | H-SUK | SUK | 70-75 | 70-75 |
| 11 | Organza | H, H-J | R/SES | 70-75 | 70-75 |
| 12 | Thin nylon | H, H-J, H-E | R/SES | 70-75 | 70-75 |
| 13 | Thick nylon | H-J, H-E | R | 90 | 80-90 |
| 14 | Taffeta | H, H-E | SES | 70-75 | 70-75 |
| 15 | Corduroy, velvet | H-E | SES | 75 | 75 |
| 16 | Terrycloth | H-E | SES | 75 | 75 |
| 17 | Furry fleece | H-E | SES | 75 | 75 |
| 18 | Fake fur | H-E | SES | 75 | 75 |

## Appendix 5 Different threads for embroidery machine

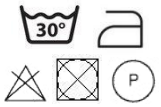
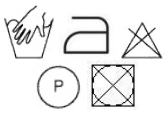
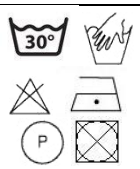
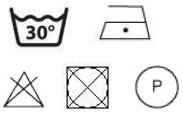
Table A5.1 Different threads for embroidery machine [77], [78], [32], [79], [80], [81], [82]

| No | Embroidery threads | Pictures of embroidery threads |
|---|---|---|
| 1 | Viscose embroidery thread |  |
| 2 | Polyester embroidery thread |  |
| 3 | Cotton embroidery thread |  |
| 4 | "Wool" effect embroidery thread |  |
| 5 | Metallic embroidery thread |  |

| No | Embroidery threads | Pictures of embroidery threads |
|---|---|---|
| 6 | Supertwist embroidery thread |  |
| 7 | Glow in the dark embroidery thread |  |
| 8 | Fire-retardant embroidery thread |  |
| 9 | Multi-colour or Astro Color embroidery thread |  |

## Appendix 6 Evening gown and belts fabrics characteristics

Table A6.1 Characterization of fabrics

| No | Fabric number | Fabric article | Width of fabric cm | Fabric construction | Fabric composition | Price of fabric /m | Care instruction |
|---|---|---|---|---|---|---|---|
| 1 | Fabric nr1 Solveig | 956-59 | 146 cm | Plain weave | 100% PES (PL) | 26 € |  |
| 2 | Fabric nr2 Leedi AV | 145-67M | 144 cm | Plain weave | 100% PES (PL) | 34 € |  |
| 3 | Fabric nr3 Abakhan | P62901 40VER4 | 140 cm | Plain weave | 97% PL 3% EL (EA) | 7.70 € |  |
| 4 | Fabric nr4 Trend-tekstiil | LS44 | 150 cm | Plain weave | 100% PES (PL) | 26 € |  |

## Appendix 7 Embroidery threads characteristics

Table A7.1 Characterization of embroidery threads

| No | Type of thread | Art. No | Thread length on the cop | Thread composition | Thread linear density, dtex | Care instruction |
|---|---|---|---|---|---|---|
| 1 | Metallic embroidery thread FS No. 40 | 985 | 1000 m | 40% met.PES 35% PA 25% cellulose | 220 |  |
| 2 | Embroidery Thread Luna | 996 | 750 m | 60% PBT 40% PP | 150 |  |
| 3 | CLASSIC embroidery thread No.40 | 911 | 1000 m | 100% viscose | 135 |  |
| 4 | Astro Color embroidery thread CLASSIC No.40 | 911-2016 | 1000 m | 100% viscose | 135 |  |
| 5 | Polyneon embroidery thread No.40 | 919 | 1000 m | 100% PES (PL) | 135 |  |

## Appendix 8 Mass per unit area calculations

Table A8.1 Dimensions of samples and average area calculations

| **Fabric nr.1 Solveig** | m - 2,9501 g | | | m - 2,9381 g | | | m - 3,0084 g | | | m - 2,9500 g | | | M - 2,9205 g | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Sample 1 | | | Sample 2 | | | Sample 3 | | | Sample 4 | | | Sample 5 | | |
| No | L | W | Area | L | W | Area | L | W | Area | L | W | Area | L | W | Area |
| 1 | 9,8 | 10,2 | | 9,9 | 10,2 | | 10,2 | 9,8 | | 10,1 | 10 | | 9,8 | 10,2 | |
| 2 | 10 | 10 | | 9,8 | 10,2 | | 10 | 10 | | 10 | 10 | | 9,9 | 10,2 | |
| 3 | 10,1 | 10,1 | | 9,9 | 10 | | 10 | 10 | | 10 | 10 | | 10,1 | 10,2 | |
| Mean | 9,96 | 10,10 | **100,60** | 9,86 | 10,13 | **99,88** | 10,06 | 9,93 | **99,90** | 10,03 | 10 | **100,30** | 9,93 | 10,2 | **101,29** |
| **Fabric nr.2 Leedi AV** | m - 2,7702 g | | | m - 2,7544 g | | | m - 2,8066 g | | | m - 2,7575 g | | | m - 2,7144 g | | |
| | Sample 1 | | | Sample 2 | | | Sample 3 | | | Sample 4 | | | Sample 5 | | |
| No | L | W | Area | L | W | Area | L | W | Area | L | W | Area | L | W | Area |
| 1 | 10 | 9,9 | | 10 | 10 | | 10 | 10,1 | | 10 | 10,2 | | 10,1 | 10 | |
| 2 | 10 | 10 | | 10 | 10,1 | | 10 | 10 | | 10,1 | 10 | | 10 | 10 | |
| 3 | 10,1 | 10 | | 9,9 | 10 | | 9,9 | 10 | | 10 | 10,2 | | 10,1 | 10 | |
| Mean | 10,03 | 9,96 | **99,90** | 9,96 | 10,03 | **99,90** | 9,96 | 10,03 | **99,90** | 10,03 | 10,13 | **101,60** | 10,04 | 10,06 | **101,00** |
| **Fabric nr.3 Abakhan** | m - 1,3330 g | | | m - 1,3310 g | | | m - 1,3314 g | | | m - 1,3275 g | | | m - 1,3250 g | | |
| | Sample 1 | | | Sample 2 | | | Sample 3 | | | Sample 4 | | | Sample 5 | | |
| No | L | W | Area | L | W | Area | L | W | Area | L | W | Area | L | W | Area |
| 1 | 10 | 10,1 | | 9,8 | 10 | | 9,8 | 9,9 | | 10 | 10,1 | | 9,8 | 10,1 | |
| 2 | 9,9 | 10 | | 10 | 10 | | 10 | 10 | | 10 | 10 | | 9,9 | 10 | |

| **Fabric nr.1 Solveig** | m - 2,9501 g | | | m - 2,9381 g | | | m - 3,0084 g | | | m - 2,9500 g | | | M - 2,9205 g | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Sample 1 | | | Sample 2 | | | Sample 3 | | | Sample 4 | | | Sample 5 | | |
| 3 | 9,9 | 10,1 | | 10,1 | 9,9 | | 10, 2 | 9,8 | | 10 | 10,1 | | 10 | 10,1 | |
| Mean | 9,93 | 10,06 | **99,90** | 9,96 | 9,96 | **99,20** | 10 | 9,9 | **99** | 10 | 10,06 | **100,60** | 9,9 | 10,06 | **99,59** |
| **Fabric nr.4 Trend-tekstiil** | m -2,9354 g | | | m – 2,9638 g | | | m – 2,9473 g | | | m – 2,9670 g | | | m – 2,9501 g | | |
| | Sample 1 | | | Sample 2 | | | Sample 3 | | | Sample 4 | | | Sample 5 | | |
| No | L | W | Area | L | W | Area | L | W | Area | L | W | Area | L | W | Area |
| 1 | 9,8 | 9,9 | | 10 | 10,1 | | 10,2 | 9,9 | | 10,1 | 10 | | 10 | 9,9 | |
| 2 | 10,1 | 10 | | 10 | 10,1 | | 10,2 | 10,1 | | 10,2 | 10,1 | | 10,1 | 10,1 | |
| 3 | 10 | 10 | | 10,1 | 9,9 | | 10,1 | 9,9 | | 10,1 | 9,9 | | 10,1 | 10 | |
| Mean | 9,97 | 9,97 | **99,40** | 10,03 | 10,03 | **100,60** | 10,17 | 9,97 | **101,40** | 10,13 | 10 | **101,3** | 10,06 | 10 | **100,6** |

## Appendix 9 Figure measurements taken for pattern construction

Table A9.1 Figure measurements

| No | Description | Figure measurements, cm | 1/2 of the measurment, cm | 1/4 of the measurment, cm | 1/8 of the measurment, cm |
|---|---|---|---|---|---|
| 1 | Height | 171 | 86 | 43 | |
| 2 | Bust | 88 | 44 | 22 | 11 |
| 3 | Waist | 72 | 36 | 18 | |
| 4 | Hips | 99 | 49.5 | | |
| 5 | Sleeve length | 63 | | | |
| 6 | Armscye depth | 19.3 | | | |
| 7 | Nape to waist | 41.75 | | | |
| 8 | Waist to hip | 61 | | | |
| 9 | Dress Length | 155 | | | |
| 10 | Top arm | 29 | | | |
| 11 | Wrist | 16 | | | |
| 12 | 1/2 Neck width | 6.4 | | | |
| 13 | Bust depth | 26 | | | |
| 14 | Front length | 45.75 | | | |
| 15 | 1/2 Back width | 16.5 | | | |
| 16 | Shoulder | 12 | | | |
| 17 | 1/2 Chest width | 18 | | | |
| 18 | Armhole width/ Armscye width | 9.5 | | | |

Table A9.2 Calculated measurements

| No | Measurements obtained by calculations | |
|---|---|---|
| 1 | Armscye depth | 1/10 Bust +10.5 |
| 2 | Nape to waist | 1/4 Height -1 cm |
| 3 | Waist to hip | Armscye depth + Nape to waist |
| 4 | 1/2 Neck width | 1/20 Bust+ 2 cm |
| 5 | Bust depth | 1/4 Bust + 3...5 cm |
| 6 | Front length | Nape to waist + 4 cm (if Bust= 80-90 cm) |
| 7 | | Nape to waist + 4,5 cm (if Bust= 91-100 cm) |
| 8 | | Nape to waist + 4.5 +1/10x (if Bust= 101-110 cm) |
| 9 | | Nape to waist +5 +1/10x (if Bust= 111-120 cm) |
| 10 | | Nape to waist +5.5 +1/10x (if Bust= 121-130 cm) |
| 11 | | Nape to waist +6 +1/10x (if Bust= 131-... cm) |
| 12 | 1/2 Back width | 1/8 Bust + 5.5 cm |
| 13 | Armhole width/ Armscye width | 1/8 Bust - 1.5 cm |
| 14 | 1/2 Chest width | 1/4 Bust - 4 cm |

Table A9.3 Recommended ease for close-fitted dress construction

| Description | Ease in cm | 1/2 |
|---|---|---|
| Bust | 7 | 3,5 |
| Waist | 4 | 2 |
| Hips | 4 | 2 |
| Armscye depth | 1 -1.5 | |
| 1/2 Bakc width | 1 -2 | 0.5- 1 |
| Armhole width/ Armscye width | 1.5 -2 | |
| 1/2 Chest width | 3 | 1.5 |
| Shoulder | 05 -1.5 | |

## Appendix 10 Basic pattern construction of the close-fitted evening gown

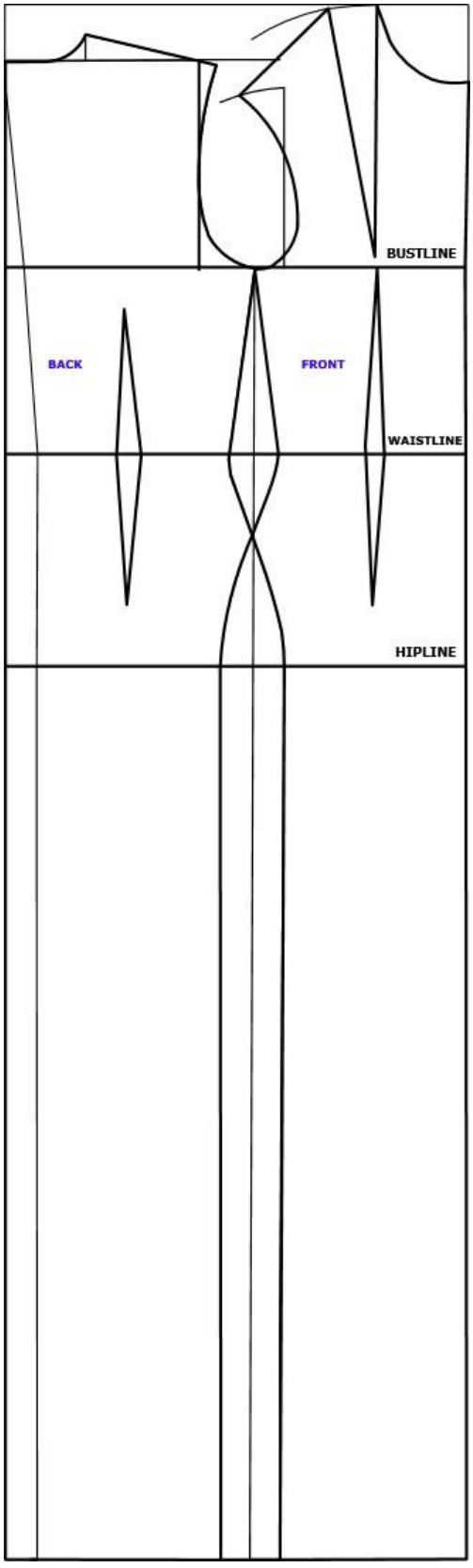



Figure A10.1 Basic pattern construction for the close-fitted evening gown

## Appendix 11 Basic pattern construction of the evening gown sleeve

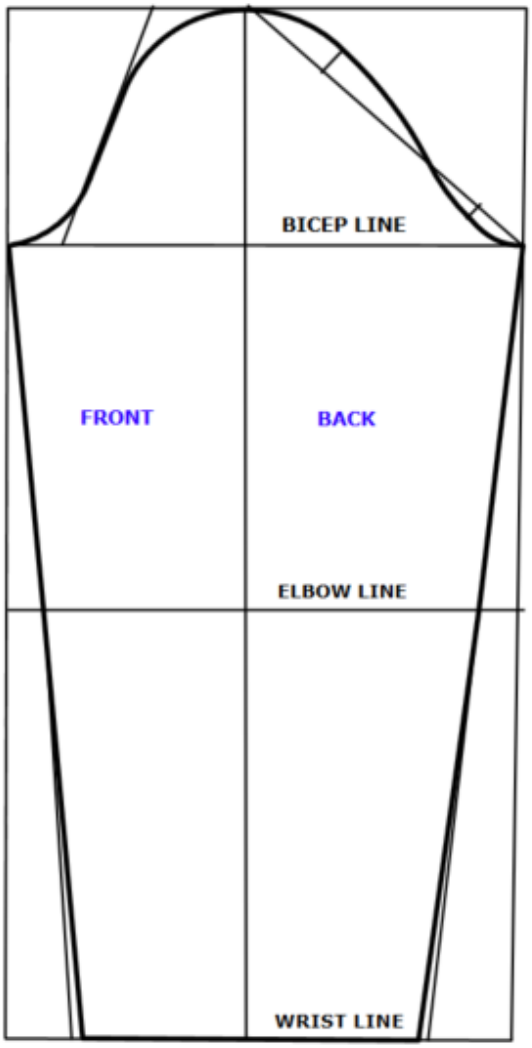



Figure A11.1 Basic pattern construction for the evening gown sleeve

## Appendix 12 Modeled evening gown patterns

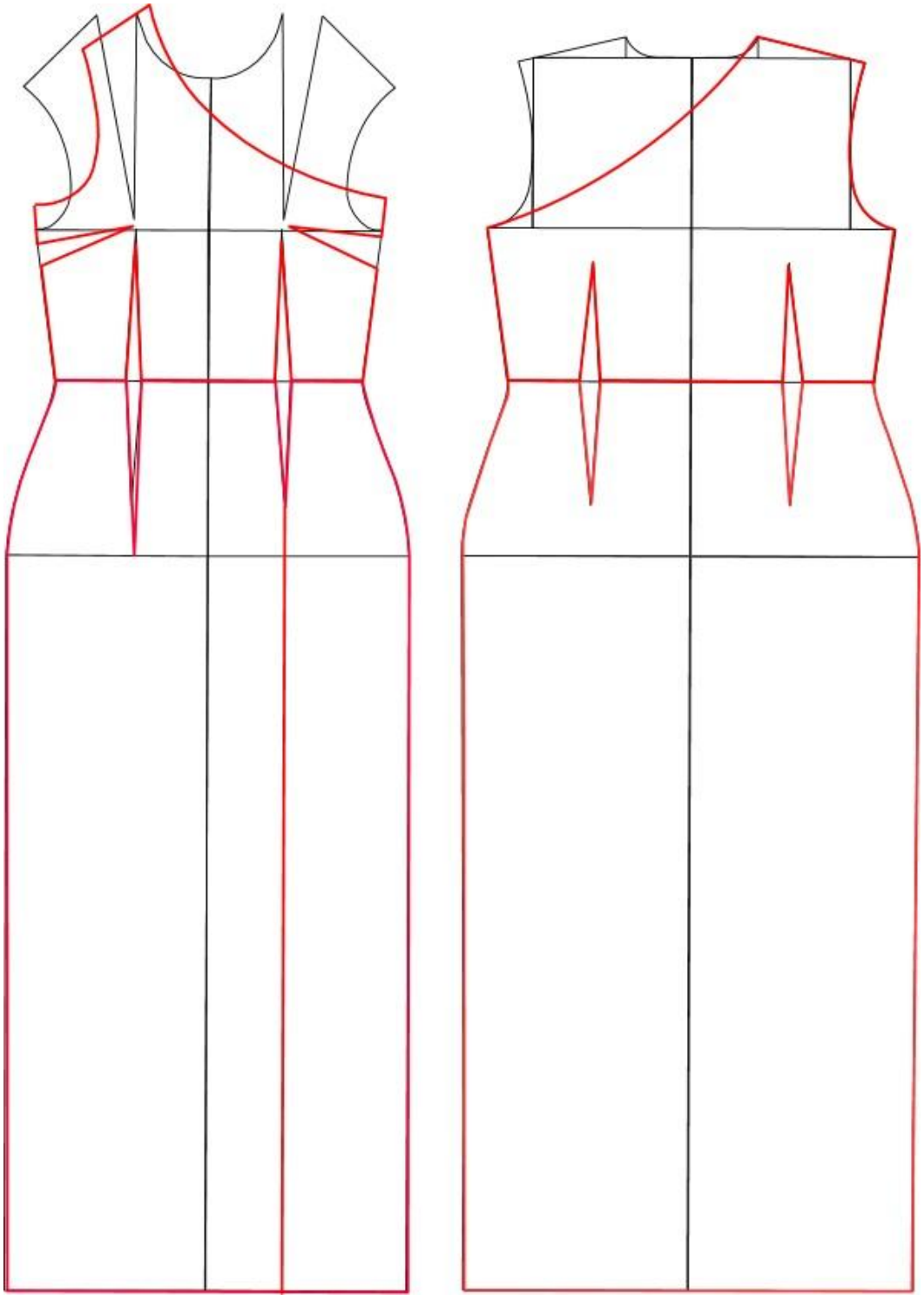


Figure A12.1 Modeled evening gown patterns

## Appendix 13 Sleeve pattern of the evening gown

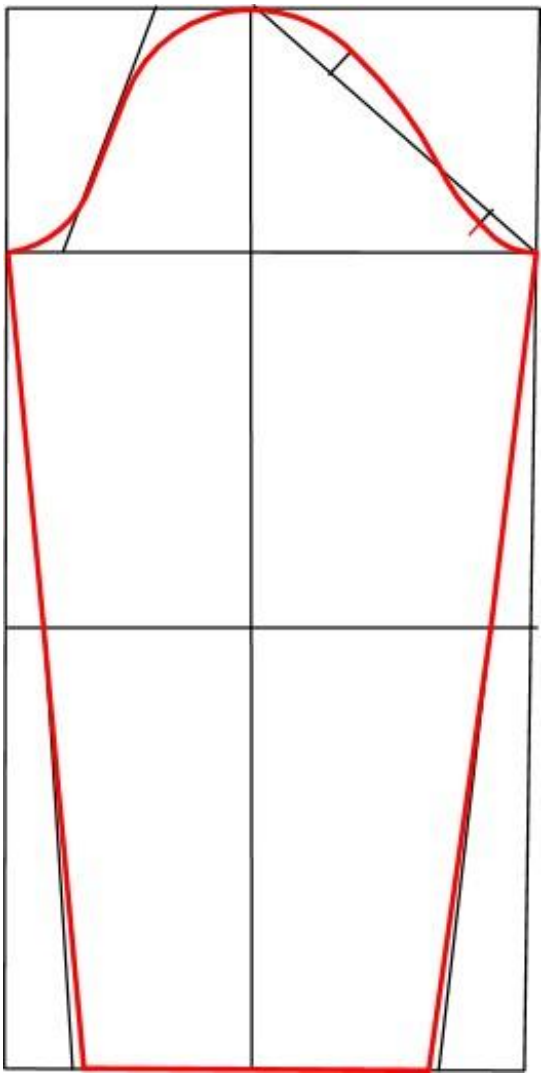
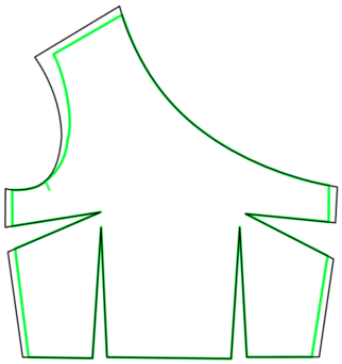
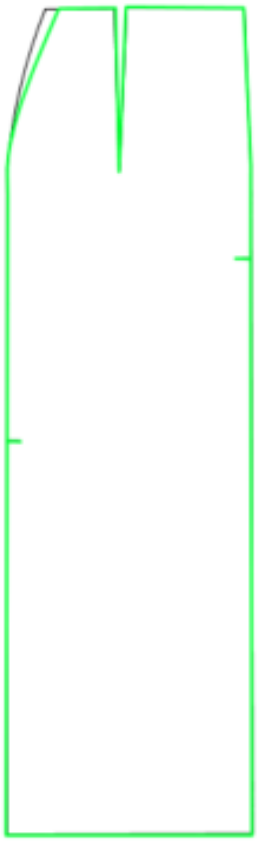
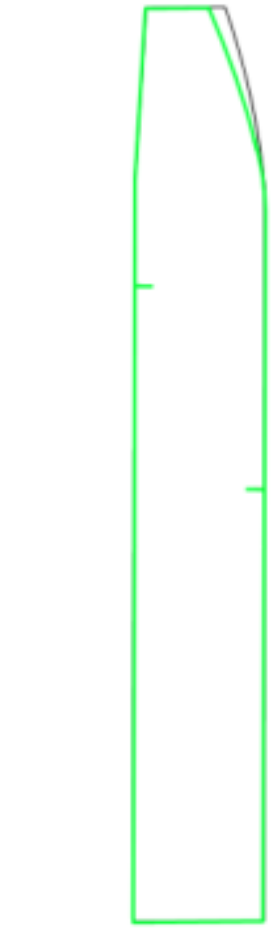
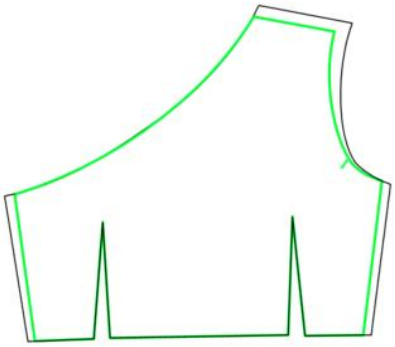


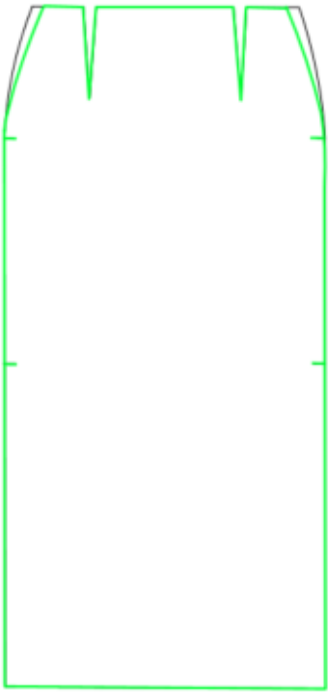
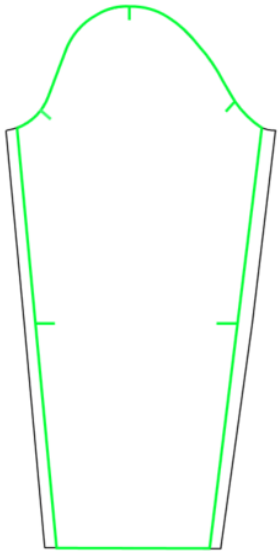
Figure A13.1 Sleeve pattern of evening gown

## Appendix 14 Evening gown patterns corrections

Table A14.1 Corrections of the patterns

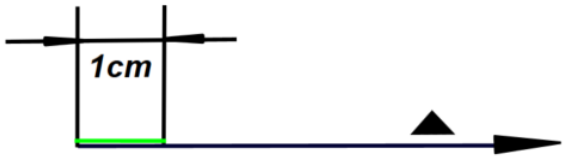
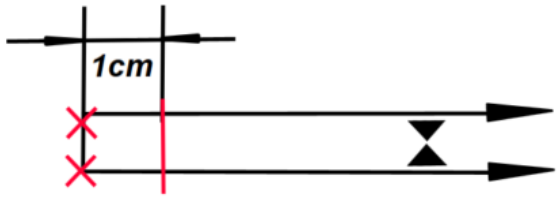
| Details No | Patterns names | Patterns images | Changes |
|---|---|---|---|
| 1 | Front upper detail |  | Shoulder seam - was taken in 1 cm<br>Side seam - was taken in 1 cm<br>Shoulder line - shortened by 2,5 cm |
| 2 | Front lower detail side 1 |  | Waist - was taken in 1 cm |

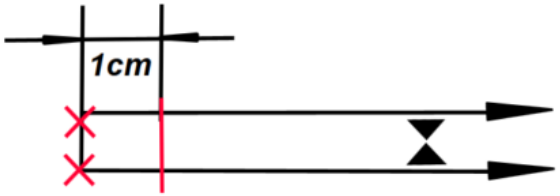
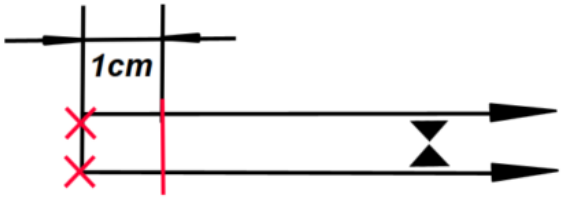
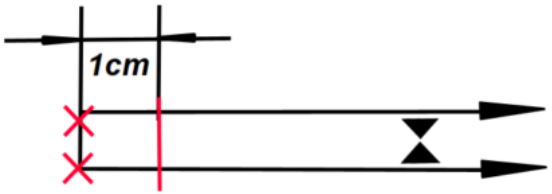
| Details No | Patterns names | Patterns images | Changes |
|---|---|---|---|
| 3 | Front lower detail side 2 |  | Waist - was taken in 1 cm |
| 4 | Back upper detail |  | Shoulder seam - was taken in 1 cm<br>Side seam - was taken in 1 cm<br>Shoulder line - shortened by 2,5 cm |

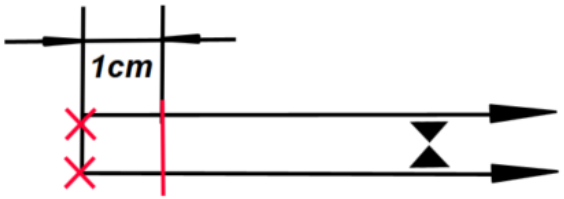
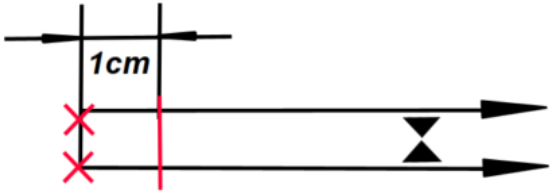
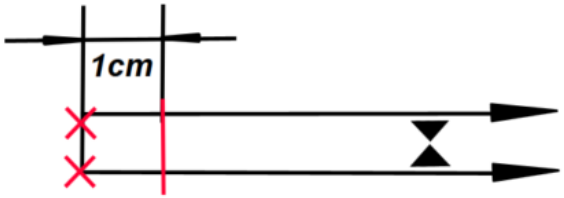
| Details No | Patterns names | Patterns images | Changes |
|---|---|---|---|
| 5 | Back lower detail |  | Waist - was taken in 1 cm |
| 6 | Sleeve |  | Side seam - was taken in 1 cm |

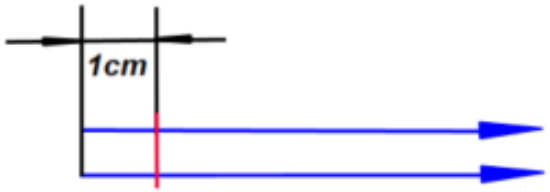
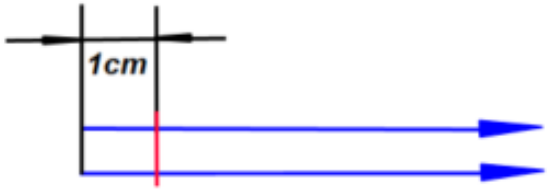
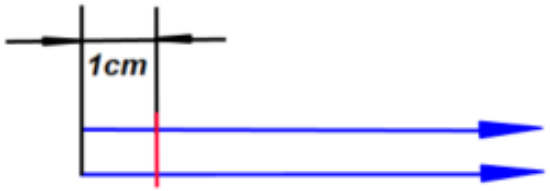
## Appendix 15 Sewing technology description of the evening gown

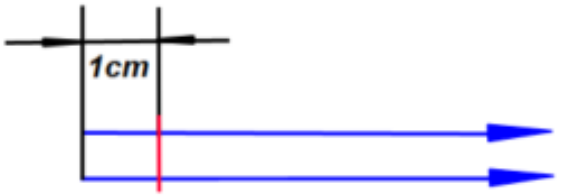
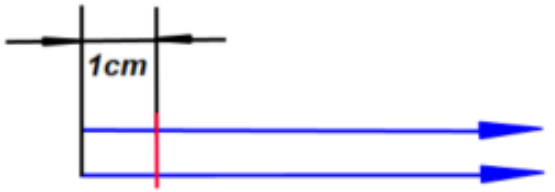
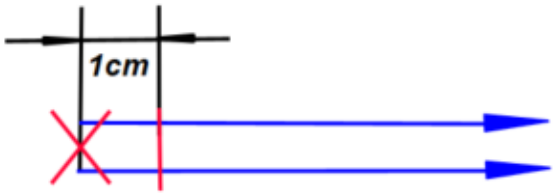
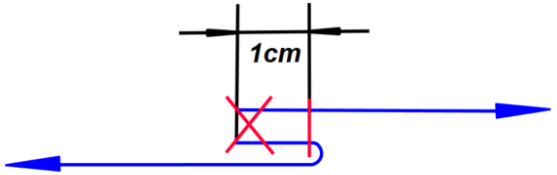
Table A15.1 Sewing technology description and order of processing steps of the evening gown

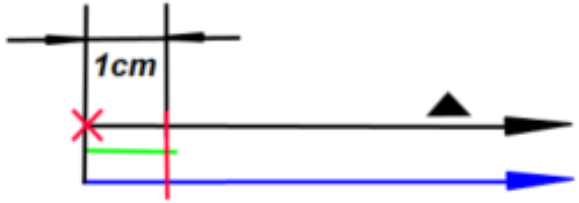
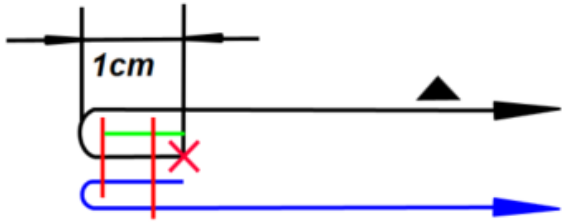
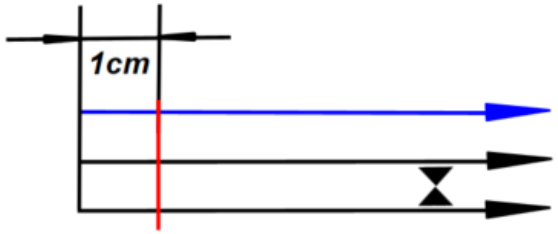
| No | Description of the operation | Technical conditions | Machine type | Machine name | Sectional drawing (location of needle penetration or passage) |
|---|---|---|---|---|---|
| 1 | Cut out details | | By hand | | |
| 2 | Attach the fusible bias stay tape to the top edge of the front and back detail | Fusible bias stay tape width 1 cm Temperature 140 C° | Iron | HD 202 Iron |   |
| 3 | Overlock main material details except armscye depth and sleeve cap | Needle nr. R90 Thread nr. 120 | Overlock sewing machine | BROTHER EF4-N21-37-5 |  |
| 4 | Stitch the darts of the front upper detail | Needle nr. R90 Thread nr. 120 Stitch density 5 stitch/cm | Universal sewing machine | BROTHER S-7000DD-403 |  |
| 5 | Stitch the dart of front lower detail side 1 | Needle nr. R90 Thread nr. 120 Stitch density 5 stitch/cm | Universal sewing machine | BROTHER S-7000DD-403 |  |
| 6 | Stitch together front lower details 1 and 2 till the slit | Needle nr. R90 Thread nr. 120 Stitch density 5 stitch/cm | Universal sewing machine | BROTHER S-7000DD-403 |   |

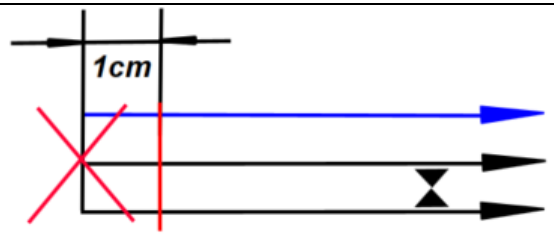
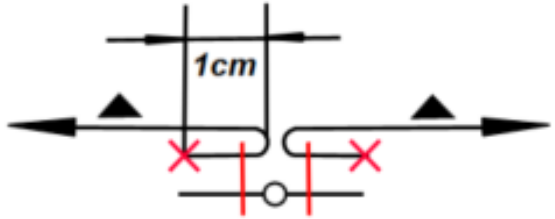
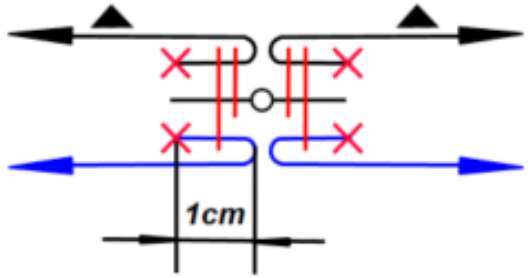
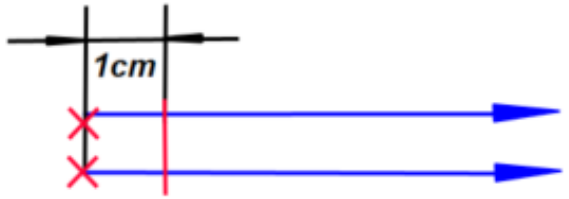
| No | Description of the operation | Technical conditions | Machine type | Machine name | Sectional drawing (location of needle penetration or passage) |
|---|---|---|---|---|---|
| 7 | Stitch the darts of the back upper detail | Needle nr. R90<br>Thread nr. 120<br>Stitch density<br>5 stitch/cm | Universal sewing machine | BROTHER S-7000DD-403 |  |
| 8 | Stitch the darts of the back lower detail | Needle nr. R90<br>Thread nr. 120<br>Stitch density<br>5 stitch/cm | Universal sewing machine | BROTHER S-7000DD-403 |  |
| 9 | Stitch together the front upper and front lower details | Needle nr. R90<br>Thread nr. 120<br>Stitch density<br>5 stitch/cm | Universal sewing machine | BROTHER S-7000DD-403 |  |
| 10 | Stitch together the back upper and back lower details | Needle nr. R90<br>Thread nr. 120<br>Stitch density<br>5 stitch/cm | Universal sewing machine | BROTHER S-7000DD-403 |  |
| 11 | Stitch the shoulder seam | Needle nr. R90<br>Thread nr. 120<br>Stitch density<br>5 stitch/cm | Universal sewing machine | BROTHER S-7000DD-403 |  |

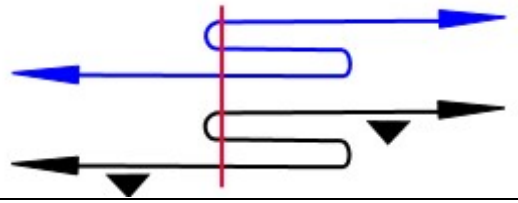
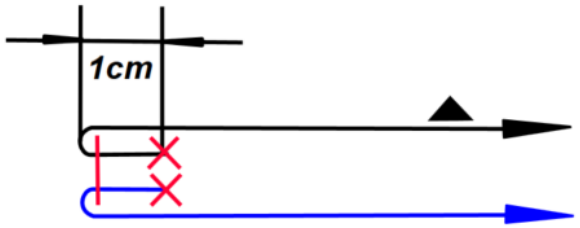
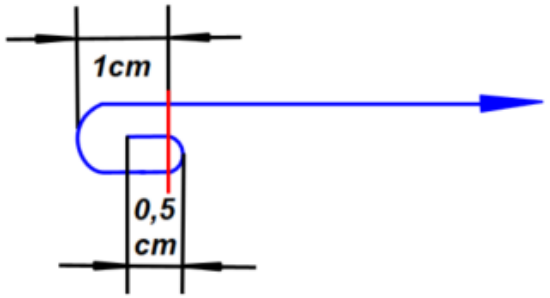
| No | Description of the operation | Technical conditions | Machine type | Machine name | Sectional drawing (location of needle penetration or passage) |
|---|---|---|---|---|---|
| 12 | Stitch together the right side | Needle nr. R90<br>Thread nr. 120<br>Stitch density<br>5 stitch/cm | Universal sewing machine | BROTHER S-7000DD-403 |  |
| 13 | Stitch the left side till the zipper | Needle nr. R90<br>Thread nr. 120<br>Stitch density<br>5 stitch/cm | Universal sewing machine | BROTHER S-7000DD-403 |  |
| 14 | Stitch the sleeve till armhole edges | Needle nr. R90<br>Thread nr. 120<br>Stitch density<br>5 stitch/cm | Universal sewing machine | BROTHER S-7000DD-403 |  |
| 15 | Press seam allowances open | Temperature<br>140 C° | Iron | HD 202 Iron |  |
| 16 | Stitch the darts of the lining front upper detail | Needle nr. R90<br>Thread nr. 120<br>Stitch density<br>3 stitch/cm | Universal sewing machine | BROTHER S-7000DD-403 |  |
| 17 | Stitch the dart of the lining front lower detail side 1 | Needle nr. R90<br>Thread nr. 120<br>Stitch density<br>3 stitch/cm | Universal sewing machine | BROTHER S-7000DD-403 |  |

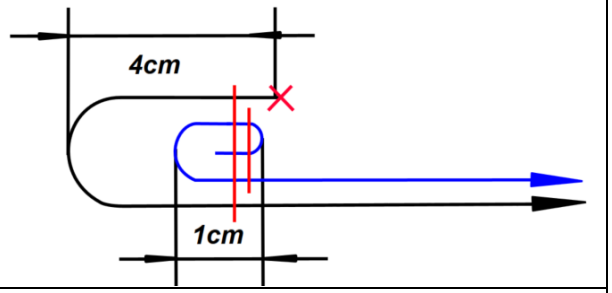
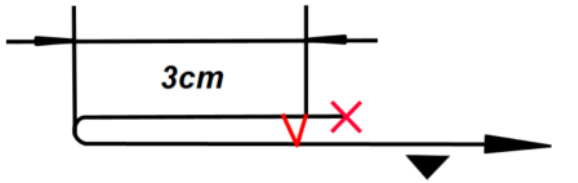
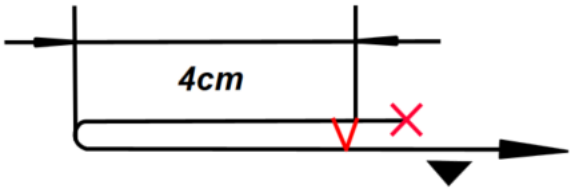
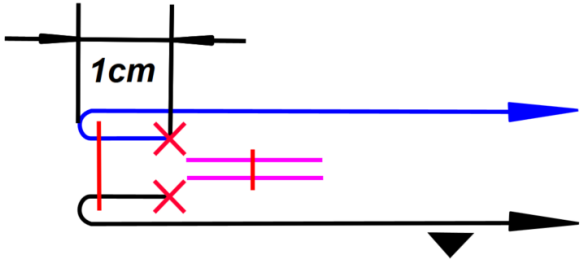
| No | Description of the operation | Technical conditions | Machine type | Machine name | Sectional drawing (location of needle penetration or passage) |
|---|---|---|---|---|---|
| 18 | Stitch together lining front lower details 1 and 2 till the slit | Needle nr. R90<br>Thread nr. 120<br>Stitch density<br>3 stitch/cm | Universal sewing machine | BROTHER S-7000DD-403 |  |
| 19 | Stitch the darts of the lining back upper detail | Needle nr. R90<br>Thread nr. 120<br>Stitch density<br>3 stitch/cm | Universal sewing machine | BROTHER S-7000DD-403 |  |
| 20 | Stitch the darts of the lining back lower detail | Needle nr. R90<br>Thread nr. 120<br>Stitch density<br>3 stitch/cm | Universal sewing machine | BROTHER S-7000DD-403 |  |
| 21 | Stitch together the lining front upper and front lower details | Needle nr. R90<br>Thread nr. 120<br>Stitch density<br>3 stitch/cm | Universal sewing machine | BROTHER S-7000DD-403 |  |
| 22 | Stitch together the lining back upper and back lower details | Needle nr. R90<br>Thread nr. 120<br>Stitch density<br>3 stitch/cm | Universal sewing machine | BROTHER S-7000DD-403 |  |

| No | Description of the operation | Technical conditions | Machine type | Machine name | Sectional drawing (location of needle penetration or passage) |
|---|---|---|---|---|---|
| 23 | Stitch the lining shoulder seam | Needle nr. R90<br>Thread nr. 120<br>Stitch density<br>3 stitch/cm | Universal sewing machine | BROTHER S-7000DD-403 |  |
| 24 | Stitch together the lining right side | Needle nr. R90<br>Thread nr. 120<br>Stitch density<br>3 stitch/cm | Universal sewing machine | BROTHER S-7000DD-403 |  |
| 25 | Overlock the connecting seam allowances of the lining | Needle nr. R90<br>Thread nr. 120 | Overlock sewing machine | BROTHER EF4-N21-37-5 |  |
| 26 | Overlock of the lining slit and left side edge | Needle nr. R90<br>Thread nr. 120 | Overlock sewing machine | BROTHER EF4-N21-37-5 |  |
| 27 | Press to one side the lining of the right side, shoulder, front and back seam allowances | Temperature<br>140 C$^{o}$ | Iron | HD 202 Iron |  |

| No | Description of the operation | Technical conditions | Machine type | Machine name | Sectional drawing (location of needle penetration or passage) |
|---|---|---|---|---|---|
| 28 | Press the lining slit and left side seam allowances open | Temperature 140 C° | Iron | HD 202 Iron |  |
| 29 | Treatment of upper detail of the top edge with the lining | Needle nr. R90<br>Thread nr. 120<br>Stitch density<br>5 stitch/cm | Universal sewing machine | BROTHER S-7000DD-403 |  |
| 30 | Topstitch of seam allowance from lining side | Needle nr. R90<br>Thread nr. 120<br>Stitch density<br>5 stitch/cm | Universal sewing machine | BROTHER S-7000DD-403 |  |
| 31 | Stitch the sleeve to the armhole edge | Needle nr. R90<br>Thread nr. 120<br>Stitch density<br>5 stitch/cm | Universal sewing machine | BROTHER S-7000DD-403 |  |

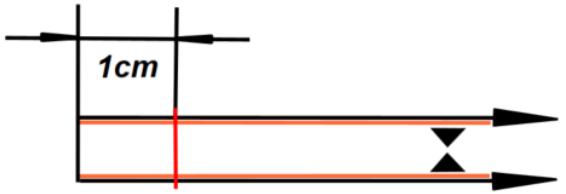
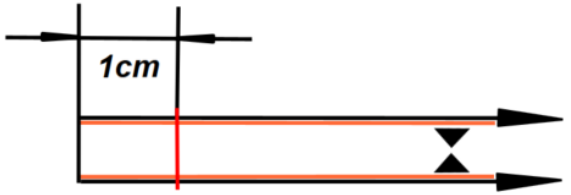
| No | Description of the operation | Technical conditions | Machine type | Machine name | Sectional drawing (location of needle penetration or passage) |
|---|---|---|---|---|---|
| 32 | Overlock the armhole edge | Needle nr. R90<br>Thread nr. 120 | Overlock sewing machine | 3 BROTHER EF4-N21-37-5 |  |
| 33 | Stitch invisible zipper with main material throughout 50 cm | Needle nr. R90<br>Thread nr. 120<br>Stitch density<br>5 stitch/cm<br>Invisible Zipper<br>60 cm | Universal sewing machine | BROTHER S-7000DD-403 |  |
| 34 | Stitch the lining with invisible zipper and main material throughout 52 cm | Needle nr. R90<br>Thread nr. 120<br>Stitch density<br>5 stitch/cm<br>Invisible Zipper<br>60 cm | Universal sewing machine | BROTHER S-7000DD-403 |  |
| 35 | Stitch left side of the lining starting from invisible zipper | Needle nr. R90<br>Thread nr. 120<br>Stitch density<br>3 stitch/cm | Universal sewing machine | BROTHER S-7000DD-403 |  |

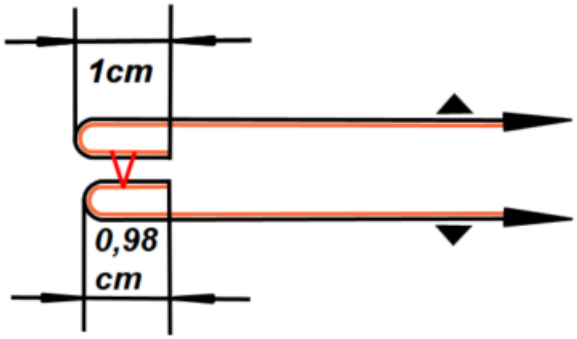
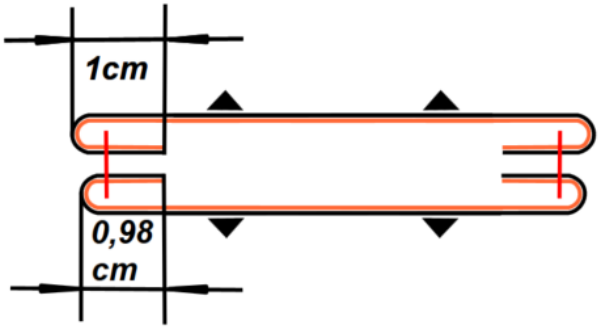
| No | Description of the operation | Technical conditions | Machine type | Machine name | Sectional drawing (location of needle penetration or passage) |
|---|---|---|---|---|---|
| 36 | Stitch auxiliary seam on the waistline of the main and lining material | Needle nr. R90<br>Thread nr. 120<br>Stitch density<br>5 stitch/cm | Universal sewing machine | BROTHER S-7000DD-403 |  |
| 37 | Stitch the slit/ the slit treatment | Needle nr. R90<br>Thread nr. 120<br>Stitch density<br>5 stitch/cm | Universal sewing machine | BROTHER S-7000DD-403 |  |
| 38 | Stitch of lining hem edge | Needle nr. R90<br>Thread nr. 120<br>Stitch density<br>3 stitch/cm | Universal sewing machine | BROTHER S-7000DD-403 |  |

| No | Description of the operation | Technical conditions | Machine type | Machine name | Sectional drawing (location of needle penetration or passage) |
|---|---|---|---|---|---|
| 39 | Slit bottom angles treatment | Needle nr. R90<br>Thread nr. 120<br>Stitch density<br>3 stitch/cm | Universal sewing machine | BROTHER S-7000DD-403 |  |
| 40 | Fix the sleeve hem with invisible seam/ blind | Needle nr. 80<br>Thread nr. 200 | Invisible Seam/Blind Hem Sewing Machine | Maier 251 |  |
| 41 | Fix the evening gown hem with invisible seam/ blind | Needle nr. 80<br>Thread nr. 200 | Invisible Seam/Blind Hem Sewing Machine | Maier 251 |  |
| 42 | Fix the lining slit to main material with transparent double-sided fusible interlining tape, hem tape | Transparent double-sided fusible interling tape, Hem tape width 2 cm | Iron | HD 202 Iron |  |
| 43 | Final ironing | Temperature 140 C° | Iron | HD 202 Iron | |

## Appendix 16 Sewing technology description of the evening gown belts

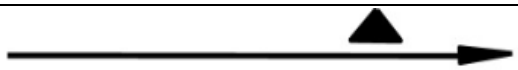
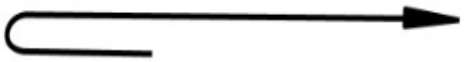
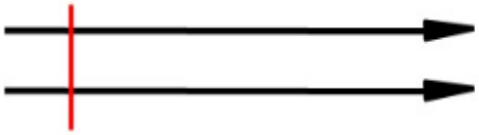
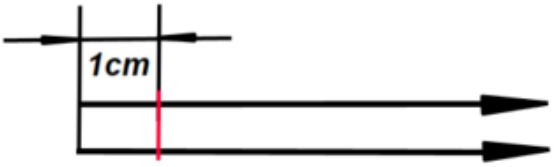
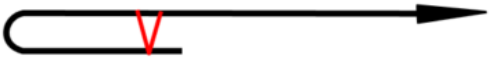
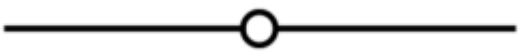
Table A16.1 Sewing technology description and order of processing steps of the belts

| No | Description of the operation | Technical conditions | Machine type | Machine name | Sectional drawing (location of needle penetration or passage) |
|---|---|---|---|---|---|
| 1 | Cutting out details | | By hand | | |
| 2 | Attach one-sided cotton interlining to the front and back details | Temperature 130 C$^{o}$ Speed 3 sek | Fusing press machine | Meyer RPS-L400 |  |
| 3 | Stitch the long sides of front and back details | Needle nr. R90 Thread nr. 120 Stitch density 4 stitch/cm | Universal sewing machine | BROTHER S-7000DD-403 |  |
| 4 | Stitch the right short side of ront and back details | Needle nr. R90 Thread nr. 120 Stitch density 4 stitch/cm | Universal sewing machine | BROTHER S-7000DD-403 |  |

| No | Description of the operation | Technical conditions | Machine type | Machine name | Sectional drawing (location of needle penetration or passage) |
|---|---|---|---|---|---|
| 5 | Stitch the left short side of front and back details | Thread nr. 120 | By hand | |  |
| 6 | Final ironing | Temperature 140 C° | Iron | HD 202 Iron |  |

## Appendix 17 Sectional drawings explanation

Table A17.1 Sectional drawings explanation

| No | Sectional drawing explanation | Sectional drawing |
|---|---|---|
| 1 | Main fabric |  |
| 2 | Lining |  |
| 3 | Fusible bias stay tape |  |
| 4 | One-sided cotton interlining |  |
| 5 | Transparent double-sided fusible interling tape, Hem tape |  |
| 6 | The direction of the material or detail and its continuation |  |
| 7 | Face side of fabric |  |
| 8 | Overlock stitch |  |
| 9 | Folded fabric |  |
| 10 | Folded fabrics of details |  |
| 11 | Plain seam |  |
| 12 | Seam allowance |  |
| 13 | Invisible Seam/Blind Hem Seam |  |
| 14 | Invisible Zippers |  |

**Appendix 18 Specification sheet of the evening gown**

# SPECIFICATION SHEET

| | | | |
|---|---|---|---|
| **Season:** | **SS 20** | **Article nr:** | **A.M.B-995** |
| **Product:** | **Dress** | **Order date:** | **06.04.20** |
| **Style:** | **Evening gown** | **Delivery Date:** | **26.04.20** |

**SKETCH**

**Main material**

Fabric composition: 100% PL
Fabric construction: Plain weave
Fabric width: 150 cm
Fabric article No: LS

**Lining**

Fabric composition: 100% Viscose
Fabric construction: Plain weave
Fabric width: 148 cm
Fabric article No: 100-250

Attach the fusible bias stay tape to the top edge of the front and back details
Needle and thread No:
Lock stitch 301- thread No. 120, needle No. R90
Overedge stitch 504 - thread No. 120, needle No. R90
Blind Stitch 103- thread No. 200 needle No. 80
Stitch density:
Main material - 5 stitch/cm
Lining - 3 stitch/cm
Seam allowances:
Connecting seam - 1 cm
Dress hem - 4 cm
Sleeve hem - 3 cm
Fix the hems with invisible seam/blind hem
Fix slit with transparent double-sided fusible interling tape/hem tape

**Auxiliary materials**

Black invisible zipper, 60 cm
Black fusible bias stay tape 1 cm
White transparent double-sided fusible interling tape/ hem tape width 2 cm

**Care instructions**


**Technologist:** Anna-Marie Badasjan **Date:** 03.04.2020

**Appendix 19 Specification sheet of the gold belt**

# SPECIFICATION SHEET

| | | | |
|---|---|---|---|
| **Season:** | **SS 20** | **Article nr:** | **A.M.B-996** |
| **Product:** | **Belt** | **Order date:** | **04.05.20** |
| **Style:** | **Gold belt** | **Delivery Date:** | **11.05.20** |

**SKETCH**

**EMBROIDERY**

**Main material**

Fabric composition: 100% PL

Fabric construction: Plain weave

Fabric width: 150 cm

Fabric article No: LS

**Thread**

Thread composition: 40 % Met.PES, 35 % PA, 25% Cellulose

Thread 10000 m weight in g: dtex 220

Thread 9000 m weight in g: den 200

Thread length on the cop: 1000 m

Thread article No: 985 4001

**Auxiliary materials**

Black one-sided cotton interlining

Interlining article No:1340

Black metallic snap fasteners ø12mm

Snap fasteners article No: KL0172

Attach one-sided cotton under-lining to the front and the back detail.

Embroidery:

Machine -TEXI IRIS 10

Threads - Metallic Gold FS No.40

Needle -75/11

Speed - Low (300)

Thread tension- Minimal

Sewing:

Lock stitch 301- thread No. 120, needle No. R90

Blind Stitch 103 - thread No. 120

Stitch density - 4 stitch/cm

Seam allowances - 1 cm, cut to 0,5 cm before turning out the belt.

**Care instructions**


**Technologist:** Anna-Marie Badasjan **Date:** 01.05.2020

**Appendix 20 Specification sheet of the silver belt**

# SPECIFICATION SHEET

| | | | |
|---|---|---|---|
| **Season:** | **SS 20** | **Article nr:** | **A.M.B-997** |
| **Product:** | **Belt** | **Order date:** | **04.05.20** |
| **Style:** | **Silver belt** | **Delivery Date:** | **11.05.20** |

**SKETCH**

**EMBROIDERY**

**Main material**

Fabric composition: 100% PL

Fabric construction: Plain weave

Fabric width: 150 cm

Fabric article No: LS

**Thread**

Thread composition: 40 % Met.PES, 35 % PA, 25% Cellulose

Thread 10000 m weight in g: dtex 220

Thread 9000 m weight in g: den 200

Thread length on the cop: 1000 m

Thread article No: 985 4010

Attach one-sided cotton under-lining to the front and the back detail.

Embroidery:

Machine -TEXI IRIS 10

Threads - Metallic Silver FS No.40

Needle -75/11

Speed - Low (300)

Thread tension- Minimal

Sewing:

Lock stitch 301- thread No. 120, needle No. R90

Blind Stitch 103 - thread No. 120

Stitch density - 4 stitch/cm

Seam allowances - 1 cm, cut to 0,5 cm before turning out the belt.

**Auxiliary materials**

Black one-sided cotton interlining

Interlining article No:1340

Black metallic snap fasteners ø12mm

Snap fasteners article No: KL0172

**Care instructions**


**Technologist:** **Anna-Marie Badasjan** **Date:** **01.05.2020**

**Appendix 21 Specification sheet of the luna belt**

# SPECIFICATION SHEET

| | | | |
|---|---|---|---|
| **Season:** | **SS 20** | **Article nr:** | **A.M.B-999** |
| **Product:** | **Belt** | **Order date:** | **04.05.20** |
| **Style:** | **Luna belt** | **Delivery Date:** | **11.05.20** |

**SKETCH**

**EMBROIDERY**

**Main material**

Fabric composition: 100% PL

Fabric construction: Plain weave

Fabric width: 150 cm

Fabric article No: LS

**Thread**

Thread composition: 60% PBT, 40% PP

Thread 10000 m weight in g:
dtex 150

Thread 9000 m weight in g:
den 135

Thread length on the cop: 750 m

Thread article No: 996

Attach one-sided cotton under-lining to the front and the back detail.

Embroidery:

Machine -TEXI IRIS 10

Threads - LUNA

Needle -75/11

Speed - Low (300)

Thread tension- Medium

Sewing:

Lock stitch 301- thread No. 120, needle No. R90

Blind Stitch 103 - thread No. 120

Stitch density - 4 stitch/cm

Seam allowances - 1 cm, cut to 0,5 cm before turning out the belt.

**Auxiliary materials**

Black one-sided cotton interlining

Interlining article No:1340

Black metallic snap fasteners ø12mm

Snap fasteners article No: KL0172

**Care instructions**


**Technologist:** **Anna-Marie Badasjan** **Date:** **01.05.2020**

**Appendix 22 Specification sheet of the blue belt**

# SPECIFICATION SHEET

| | | | |
|---|---|---|---|
| **Season:** | **SS 20** | **Article nr:** | **A.M.B-998** |
| **Product:** | **Belt** | **Order date:** | **04.05.20** |
| **Style:** | **Blue belt** | **Delivery Date:** | **11.05.20** |

**SKETCH**

**EMBROIDERY**

**Main material**

Fabric composition: 100% PL

Fabric construction: Plain weave

Fabric width: 150 cm

Fabric article No: LS

**Thread**

Thread composition: 100% Viscose

Thread 10000 m weight in g: dtex 135

Thread 9000 m weight in g: den 120

Thread length on the cop: 1000 m

Thread article No: 911-2016

**Auxiliary materials**

Black one-sided cotton interlining

Interlining article No:1340

Black metallic snap fasteners ø12mm

Snap fasteners article No: KL0172

Attach one-sided cotton under-lining to the front and the back detail.

Embroidery:

Machine -TEXI IRIS 10

Threads - Astro Colour CLASSIC No.40

Needle -75/11

Speed - High (700)

Thread tension- Strong

Sewing:

Lock stitch 301- thread No. 120, needle No. R90

Blind Stitch 103 - thread No. 120

Stitch density - 4 stitch/cm

Seam allowances - 1 cm, cut to 0,5 cm before turning out the belt.

**Care instructions**


**Technologist:** Anna-Marie Badasjan **Date:** 01.05.2020

**Appendix 23 Specification sheet of the flower belt**

# SPECIFICATION SHEET

| | | | |
|---|---|---|---|
| **Season:** | **SS 20** | **Article nr:** | **A.M.B-1000** |
| **Product:** | **Belt** | **Order date:** | **04.05.20** |
| **Style:** | **Flower belt** | **Delivery Date:** | **11.05.20** |

**SKETCH**

**EMBROIDERY**

**Main material**

Fabric composition: 100% PL

Fabric construction: Plain weave

Fabric width: 150 cm

Fabric article No: LS

**Thread**

CLASSIC thread composition: 100% Viscose

Polyneon thread composition: 100% PES (PL)

Threads 10000 m weight in g:

dtex 150

Threads 9000 m weight in g:

den 135

Thread length on the cops: 1000 m

CLASSIC thread article No: 911

Polyneon thread article No: 919

Attach one-sided cotton under-lining to the front and the back detail.

Embroidery:

Machine -TEXI IRIS 10

Threads - CLASSIC and Polyneon No.40

Needle -75/11

Speed - High (700)

Thread tension- Strong

Sewing:

Lock stitch 301- thread No. 120, needle No. R90

Blind Stitch 103 - thread No. 120

Stitch density - 4 stitch/cm

Seam allowances - 1 cm, cut to 0,5 cm before turning out the belt.

**Auxiliary materials**

Black one-sided cotton interlining

Interlining article No:1340

Black metallic snap fasteners ø12mm

Snap fasteners article No: KL0172

**Care instructions**


**Technologist:** Anna-Marie Badasjan **Date:** 01.05.2020

**Appendix 24 Evening gown with gold belt**

**Appendix 25 Evening gown with silver belt**

**Appendix 26 Evening gown with blue belt**

**Appendix 27 Evening gown with Flower belt**

**Appendix 28 Evening gown with Luna belt**