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TÖÖJÕU PINGUTUSTE HALDAMISE TEHNIKA MÕJU KVALITEEDIJUHTIMISSÜTEEMILE, TOOTMISPROTSESSIDE KASUMLIKKUSELE JA TOOTE KVALITEEDILE NAZGOL ETTEVÕTTE BAASIL

HUMAN EFFORT ENGINEERING IMPACTS ON TQM, OPERATIONAL BENEFITS AND PRODUCT QUALITY WITHIN NAZGOL COMPANY

MAGISTRITÖÖ/ MASTER THESIS

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Tallinn 2021

(On the reverse side of title page)

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THESIS TASK

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Thesis topic:

(in English) *HUMAN EFFORT ENGINEERING IMPACTS ON TQM, OPERATIONAL BENEFITS AND PRODUCT QUALITY WITHIN NAZGOL COMPANY*

(in Estonian) TÖÖJÕU PINGUTUSTE HALDAMISE TEHNIKA MÕJU KVALITEEDIJUHTIMISSÜTEEMILE, TOOTMISPROTSESSIDE KASUMLIKKUSELE JA TOOTE KVALITEEDILE NAZGOL ETTEVÕTTE BAASIL

Thesis main objectives:

1. Review Human Engineering impact on TQM, Operational benefits, product quality
2. Design hypotheses and conduct questionnaire
3. Analyze findings and propose solutions

Thesis tasks and time schedule:

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1.	Review of Human Effort Engineering, TQM and Industrial Engineering techniques	15.03.2021
2.	Review of Human Effort Engineering impact on TQM, operational benefits, product/service quality	25.03.2021
3.	Design hypotheses and conduct questionnaire	01.04.2021
4.	Analyze findings and propose solutions	10.04.2021

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PREFACE

The topic of the thesis was initiated by the company demand for improvement in quality management; manufacturing processes, workplace managing processes and human-factor engineering including Ergonomics, staff training and integrating program for new comers.

This thesis is highlighting the importance of Human Effort Engineering to improve quality management in NAZGOL manufacturing company of sunflower oil, associated with Total Quality Management (TQM) principles, and in compliance with ISO standards. This integration guarantees better conditions for WORKFORCE, better TQM implementation, continuous improvement in the company, and thus higher quality of product and satisfaction of costumers. NAZGOL company is aiming to improve quality management through/within improvement of workforce, making sure the employees are safe, comfort and tasks are well-harmonized with their physical/physiological abilities. This thesis also includes the concept of Process Automation as a potential approach to systemizing the workplace, and ensuring the systems runs smoothly and efficiently. The ultimate task is to emphasize the relationship between the employees' contentment and company's objectives.

With deep gratitude, I acknowledge the valuable guidance and constant support, patiently provided by my supervisor, Lecturer PhD Alina Sivitski.

I would also like to thank Professor Kristo Karjust, Head of Department of Mechanical and Industrial Engineering of Tallinn University of Technology, for helping and guiding me in difficulties throughout my studies at Tallinn University of Technology.

Keywords: Human Effort Engineering, Total Quality Management (TQM), Operational objectives, ISO, Ergonomics, Process Automation, Master thesis.

List of abbreviations and symbols

TQM	Total Quality Management
IE	Industrial Engineering
JIT	Just in Time
IoT	Internet of Things
KPI	Key Performance Indicator
ISO	International Organization for Standardization
M2M	Machine to Machine
SQC	Statistical Quality Control
VSM	Value Stream Map
WIP	Work in Process

1. INTRODUCTION

The subject of this paper is highlighting the importance and impacts of Human Effort Engineering philosophy in succeeding Total Quality Management (TQM) and its reflection on operational benefits and/or on a high quality of products produced/services offered within NAZGOL manufacturing company of sunflower oil.

Our focus is the employees' satisfaction and its relations with company's performance in order to ensure the quality of product meets the customers' requirements. Human Effort Engineering is a comprehensive discipline of placing the employees in the center of attention, considering how ergonomic, safe, comfort and harmonized the workplace is, considering the employees' physical-intellectual abilities.

This thesis also includes the philosophy of Process Automation as a strategic approach to systemizing the workload, simplifying the work complexity and bringing comfort, safety and workflow efficiency to the employees involved.

On the hand, our third focus is the company current situation and ultimate objectives. This includes operational benefits such as reduced manpower, enhanced work accuracy, effective communication among business partners and reduced operational costs—initially introduced by Nigel Slack [1]—quality of product/service, and TQM implementation. To that sense, we design a questionnaire survey and number of hypotheses to analyze input data and propose solutions. Throughout the survey, the company Quality, Production, and Project managers participated in the study to contribute the thesis findings.

Thesis structure

- In the Literature Review, the role of Industrial Engineering in relation with Human Effort Engineering is compromised, an overview of Total Quality Management (TQM) background is presented and the theoretical perspective of Human Engineering with respect to ISO certificates are explicated.

- The company current situation in terms of Human Engineering, Process Automation, product/service quality, operational aspects, TQM implementation and Employee integration challenges are clarified, so that the thesis can structure a methodology based upon real life company status.

- In Methodology, the variables are defined, the hypotheses are designed, the survey is developed, the equation is structured, the participant are appointed, and prepared for questionnaire conducting.

- In the Result and Discussion, once the questionnaire result and findings are collected, the output data are evaluated in order to whether accept or reject the hypotheses in order to make fact-based conclusions.

- Lastly, the results are finalized, and constructive solutions are offered to NAZGOL manufacturing company of sunflower oil. In Summary, an abstract of thesis, including the goal of the thesis research (why research was initiated), methods used for research and method for results analysis are briefly summarized.

2. LITERATURE REVIEW AND STUDY BACKGROUND

2.1 Industrial Engineering's role in relation with Human Engineering

According to Narayan Rao, "Industrial Engineering is Human Effort Engineering. It is an engineering discipline that deals with the design of human effort in all occupations: agricultural, manufacturing, and service. The objectives of Industrial Engineering are optimization of work-systems productivity and occupational comfort, health, safety and income of persons involved" [2].

To put it more specific, the Industrial Engineering's responsibility is to coordinate the employees' duty of work, making sure the workflow is efficient, the working environment complies with ISO standards or company methodology of the internal standardization, the employees are well instructed and update material is accessible. Lastly, there is an integrating strategy in place to increase staff collaboration and commitment.

These statements above clarified a remarkable era of Industrial Engineering's role concerning Human Engineering philosophy. In fact, Industrial Engineering (IE) aims to increase productivity by being in charge of optimizing employees' performance in which it is interconnected to the discipline of Human Effort Engineering.

In conclusion, it could be understood that Industrial Engineering should strongly contribute to the improvement of human-factor engineering; ensuring the employees contentment is met and the working place is standardized enough to expect desire job performance, accuracy and commitment. The Industrial Engineering tools namely; Bottleneck Analysis, Continuous Flow, Gemba (The Real Place), Jidoka (Autonomation), Just-In-Time (JIT), Kaizen (Continuous Improvement), Kanban (Pull System), Overall Equipment Effectiveness (OEE), Root Cause Analysis, Standardized Work, Takt Time, Value Stream Mapping can also be performed towards this approach.

2.2 Origins of Total Quality Management (TQM)

To continue, it is necessary to know where TQM came from and how it evolved over the past decades. TQM has evolved from the Quality Assurance methods that first developed around the time of World War I. Large-scale manufacturing efforts were required at the time to meet the demand, while the quality inspectors were first introduced to oversee the quality by measuring defects. After World War I, quality inspection became more commonplace in manufacturing environments and this led to the introduction of Statistical Quality Control (SQC), a theory developed by Dr. W. Edwards Deming [3].

It started from the method of sampling the unit since the large-scale of the product was uncountable. The concept of SQC was formed on the idea that a variation in the production process and end product are interrelated. For instance, once the process variation is removed this would lead to increase quality in the end product.

Post World War II, Japanese industrial manufacturing was unpromising. Therefore, the Japanese Union of Scientists and Engineers invited Dr. Deming to instruct engineers in quality processes.

In the 1950s quality control was a vital part of manufacturing in Japan and adopted within all levels of employees within an organization. In the 1970s the concept of total quality was being discussed. This was seen as company-wide quality control that involved all employees from top management to the workers, in quality control. Later, more companies worldwide started introducing quality management procedures, followed by the Japanese model [3].

2.3 TQM implementation

The new wave of quality control became acknowledged as Total Quality Management (TQM), which was deployed to describe the many quality-focused strategies and techniques that became the center of focus for the quality movement.

In theory, Total Quality Management (TQM) consists of organization-wide efforts to "install and make permanent climate where employees continuously improve their ability to provide on-demand products and services that customers will find of particular value" [4].

The concept statement emphasizes three pillars, including Human Effort Engineering in the center, continuous improvement, and lastly customer satisfaction as the ultimate goal. Industrial engineers are to think deeply about an alternative, doable and affordable way to meet customers' values. In theory, customer's satisfaction is influenced by three elements. This includes higher quality, cheaper price in shorter time of delivery.

The second pillar is to focus on Human-factors Engineering, which described by Guastello as an applied science of coordinating the work system design, Ergonomics, and physical condition of the workplace, synchronized with the employees' capabilities, requirements, and psychological characteristics [5].

Continuous improvement is achievable by placing Industrial Engineering IE tools (The PDCA cycle, Gemba Walks, JIT or Motion & Time Studies) into practice in the purpose of analyzing operations, designing workflows and production processes, reducing inefficiency, and ensuring that final products meet the established quality standards [6].

In theory, TQM is an organizational structure, providing duties, procedures, process and resources which carry out a management function to determine and enforce quality principles. The system defines what people, actions, and documents are going to be taken into account, to carry out the work in a consistent manner, leaving evidence of what has happened [7].

The 8 universal principles of Total Quality Management (TQM) are Focus on the customer, Employee commitment, Process approach, Integrated system, Strategic & systematic approach, Decision-making based on facts, Communication, and Continuous Improvement.

These principles are necessary elements to implement TQM. The principles set out by ISO 9001 in which were invented in the 1990s by a small group of experts, who created them using the philosophical teachings and business knowhow of the previous century [8].

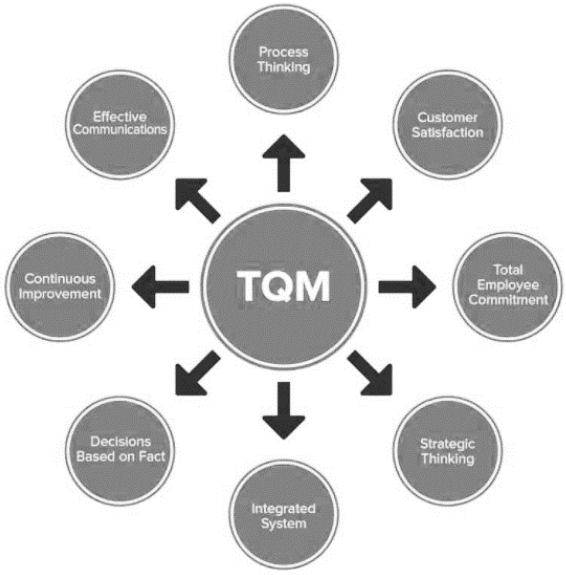


Figure 1 Total Quality Management principles [9]

Employers expect cost reduction, high efficiency, and quality improvement, fast delivery, flexibility, and dependability. The employees, on the other hand, look for higher salary payment, better working environment, Ergonomics, systematic integrating system, constructive training program, and fair treatment [10]. TQM is an approach of nowadays businesses in reaching a compromise, where the employees kept satisfied and the business is booming simultaneously.

2.4 The theoretical concept of Human Effort Engineering

The mismatch between the capabilities of man and the type of work will lead to dramatic consequences. This includes injury, accidents, decreased productivity, caused by the low level of work standard, inspection, protocol, or management. According to William K. Professor of Business, State University of New York at Albany, "Human-factors engineering, also called Ergonomics or Human Engineering, science dealing with the application of information on physical and psychological characteristics to the design of devices and systems for human use" [11]. This thesis introduces the key factors of Human Effort Engineering for better understanding their impacts on company quality management.

2.4.1 Employee training and integrating program

It is arguable that some companies comprehend sophisticated training a pointless expense, and presume newcomers to learn on the job, from supervisors and current employees. However, this way of training is often poor and causes consequences for the business. This includes poor job performance as well as increasing levels of work-related stress. To put it simply, the impact of an in-depth training system is leading to enhance the employee's knowledge of workflow, awareness of potential risk to product quality, waste or physical safety, and etc. By contrast, untrained employees underperform and make mistake cause the company lost time and finance. They have low production value; the quality of their work is lower and of less value. On top of that, insufficient staff training means lost customers.

"Having a trained workforce means your workers are learning new skills that can improve production, cut time spent in creation of your product (or service), reduce production costs, reduce mistakes, build confidence in your workforce, and create a better working environment" [12]

2.4.2 Ergonomics

According to William K, the science of Ergonomics, if carried out in all organizations, will increase productivity, increase production and efficiency, and prevent absenteeism and fatigue at work, and thus increase the income of companies [11].

Consider an employee who works 8 hours a day and, according to his/her profession, sits at a desk all this time and works with a computer. After 2 hours, his accuracy in work becomes less and it causes him fatigue. But if the computer desk and chair following principles ISO 24496:2017(en) Office furniture, it can be said that a person's fatigue is reduced and his efficiency is increased. In addition, what if the person gets up from behind the desk after working for a while; and does some stretching exercises.

In conclusion, optimizing the work environment will eventually save unnecessary energy consumption which helps companies to have better financial matter. Optimal use of ergonomic principles helps a lot in reducing costs during work, including the costs of compensation or disability due to ISO 45001 [14]. According to the International Labor Organization, more than 7600 people die from work-related accidents or diseases every single day [15]. That’s why an ISO committee of occupational health & safety experts set to work to develop an International Standard with the potential to save almost three million lives each year.

2.4.3 Process Automation

Prof. Ralph Barnes clearly stated that “process-operation improvement for productivity increase has to consider doing an element of sub-operation of an operation in the process using various combinations of human effort, machine effort, and automated system effort” [16]. Likewise, Taylor and Gilbreth, emphasize the role of machine and man in engineering work through the discipline of Industrial Engineering in the productivity improvement [17]. The various human-machine combinations’ impacts are to reduce 7 categories of wastes that were identified by Taiichi Ohno [18]. Additionally, the concept contributes the employees to integrate faster into the system, work in safer, less physical, more ergonomic and systemized environment, be well-monitored and well-instructed through various technological measurers, communicate and share knowledge easier and lastly be able to work-from-home once needed.

The top management can expect labor cost reduction by focusing on robotizing, automating, IoT, Large-scale machine-to-machine communication (M2M), outsourcing, and remote-working.

Since we are taking into consideration the influential factors on improving the workplace, Process Automation can be a reasonable and undeniable effort. Industrial Engineering can peruse automation solution that covers a vast range of activities in the workplace. This research strongly includes the concept of Process Automation as a potential approach, not only to improve the working environment, but also a contributing factor to the company's objectives, quality product/service and TQM implementation. The enforcement of Process Automation should comply with ISO/TC 184 - Automation systems and integration (interoperability, integration, and architectures for enterprise systems and automation applications).

2.4.4 Working Environment in compliance with ISO

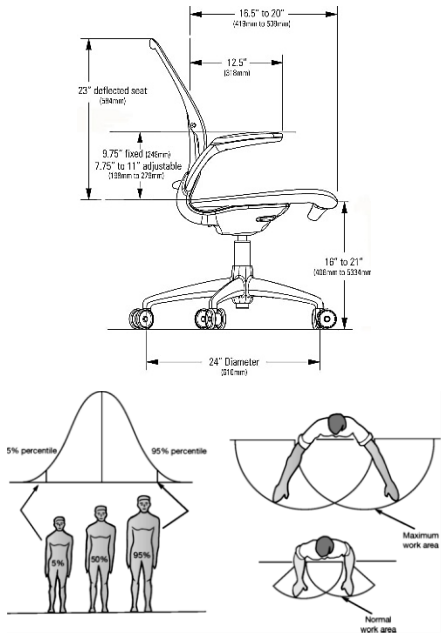
According to ISO 6385:2016 Ergonomics principles [13] in the design of work system, the physical elements that exist in work environments can be Facility management, Light and lighting, Office furniture, Ergonomics of human-computer interaction, Noise, Temperature, Machinery directive, Occupational Health & Safety Management, which discussed below some of these key factors associated with correspondent ISO standards. The aim is that the employees can perform with the desired level of standard and contentment.

ISO was founded with the idea of answering a fundamental question: "what is the best way of doing this" [13]. Customer can have confidence that their product is safe, reliable and of good quality. The standard helps businesses increase productivity while minimizing errors in waste. The standard also able to safeguard consumers and the end users of products and service ensuring that t certified product conform to the minimum standards set internationally. ISO standards provide specifications to ensure product and service work the way you expect them to. In some industries ISO certification may be required by law or contractually. Benefits conforming to ISO standards are as below.

- Saving time and money by identifying and solving recurring problems
- Improving system and process efficiency.
- Increasing customer satisfaction
- Being more competitive when tending for contracts
- Getting more value out of all resources
- Boosting your credibility in the eyes of your customers
- Improving environmental health
- Improving employee health and satisfaction

Table 1 Working environment associated with ISO certificates [13]

ISO types	**Description**	**Relations with Human Engineering**
ISO 41001	Facility management	The guideline of ISO 41001 is proportionality. This includes light, size and color, and other visual elements affect employee morale in the environment. A very fine-looking and even expensive design can have a negative or devastating effect on work performance. For example, in a work environment based on intellectual activities that require calm, focus, and concentration, the presence of warm colors, especially red, will not have good results.
ISO/TC 274	Light and lighting	The characteristics of a satisfactory lighting system include the following according to ISO/TC 274 - Light and lighting. • Light is optimal in terms of frequency distribution • The brightness of the work surface should be such that it does not cause blinking • The amount of light is sufficient • No annoying shadows The reflection of light from the lamps of shiny objects or windows causes glare, so you should try to focus the light on the desk. The radiation angle of the light sources must

		be fully adjustable. Also, light sources should have a filter so that we can have scattered or direct light if needed.
ISO 24496:2017	Office furniture	The table surface should allow you to place the tools you need for your work in front of you, and in work environments where computers are used, the table surface should be such that the monitor is placed directly in front of you so that the distance between you and the monitor should not be less than 20 inches or 50 cm. Parts such as the case should not be placed on the desk. The limited space of the desk may cause the use of computer components to be in poor condition. The edges of the desk should be covered with soft material and also be round. A wrist rest on the desk should be settled. The characteristics of a good and comfortable chair are as the figure below.  *Figure 2 Ergonomic chair and desk, ISO 24496:2017(en)*
ISO 9241:	Ergonomics of human-computer interaction	ISO carries out its work through a series of technical committees, one of which is ISO 9241–220:2019 Ergonomics of Human System Interaction, which is responsible for Ergonomics standards for situations

		where human beings and technological systems interact. Adherence to ergonomic standard principles reduces eye damage, headaches and back pain for operators and computer users. The use of computers has gone to the highest demand since the pandemic, so it is important to know the factors affecting the work environment with computers. Inadequate working conditions and lack of attention to safety when working with a computer may lead to diseases and abnormalities in the long run. The minimum features of a work environment suitable for computer users based on ISO ISO 9241–220:2019 Ergonomics of Human System Interaction Committee are as follows: 1- Existence of air conditioning system 2- Adequate and suitable light 3- Using a special table that has standard dimensions 4- Using a computer chair with adjustable height to prevent discomfort to the user's spine 5 - Use the foot to prevent numbness of the legs 6- Wooden or plastic flooring to prevent static electricity Despite the above points, there is still the possibility of specific diseases for the operator. Sedentary lifestyle while working with a computer, staring at the monitor screen for a long time, and uniform wrist movements may cause a variety of abnormalities.
ISO 11204:2010,	Noise	Workplace noise is considered a very insidious and dangerous attacker. Because it destroys a large number of auditory cells every day, loud noises affect people's health, but not all loud noises are the same. Whenever a worker or employee feels that they have lost their hearing, it is too late because the tragic deafness caused by the noise are irreversible. Noise damage is not limited to the ear but covers the entire body. Noise pollution in the workplace can seriously endanger the safety of employees and workers. The impact of noise in the

		workplace is related to the nature of work and in general the impact can be far more dramatic once there are complex, cognitive tasks involved.
ISO 1:1975,	Temperature	By acknowledging ISO 1:1975, various element impacting the employees' performance are exposed. In theory, the heat that a person feels in the environment is called effective heat, which is different from the temperature of the air. Effective heat depends on various factors such as air temperature, humidity, air flow, natural position, season, time of the day, thermal radiation of surrounding objects, the color of the environment and individual differences. While air temperature only expresses the temperature of the air in the open space and outside the influence of the mentioned factors. Humans are warm blood creatures and have a constant body temperature. Therefore, deviating from the optimum level of 27 ° C causes a feeling of cold or heat. One of the ways to establish thermal equilibrium is the body's self-regulating property, but if the deviation from the optimal level exceeds a certain limit, the body's thermal equilibrium must be provided by regulating thermal behavior. In general, heat degrades a person's cognitive abilities. Research shows that cold also affects our work and activity and reduces our efficiency. Humidity reduces a person's efficiency for two reasons. • In terms of reducing free oxygen in the air through alternatives • Due to the saturation of the air with water vapor.

ISO 13849-1:2006,	Machinery directive & ISO 45001:2018 Occupational Health & Safety Management	All machines supplied in the EEA European Economic Area, must comply with Machinery Directive and be safe. Machinery Directive concerning machinery and certain parts of machinery. Its main intent is to ensure a common safety level in machinery placed on the market. The high level of integrity in the field of health and safety is ensured by European standards which – on the basis of the requirements laid down in the Machinery Directive – deal with the more specific issues of the respective machinery. For technical harmonization and standardization, a new approach was established which is based on the following principles. • Directives specify essential safety requirements. • Harmonized standards stipulate technical requirements. Machinery constructed in accordance with these standards must be presumed to comply with the relevant essential safety requirements.

3. THE COMPANY CURRENT SITUATION AND OBJECTIVES

3.1 Introduction

In NAZGOL sunflower oil company, the manufacturing goes through various phases including a cold-pressing mechanism (below 40 °C) of dark seeds and refining via a filtration system. The company also produces drinking/flavored water, mayonnaise, sugar, vinegar, and juices which are exclusively for domestic market. In this company, the production is mainly concentrated on the processing of sunflower seeds into natural, no preservative sunflower oil in bottles. The bottle capping is processed via a semi-automatic machine in collaboration with one factory worker. To maintain the product quality, internal standardization is taken place along with various methodologies for process control in the production lines. The company has process map; quality control and other procedures to develop. This includes Product inspection, Process inspection, and Inspection analysis, along with Statistical Quality Control (Analysis of Samples, Use of Control Charts, and Corrective Measures).

The company is facing various challenges since the Chinese products and other competitors offering cheaper products thus rapidly dominating the oil market. On the other hand, the company had to raise its product price to deal with escalating costs, even though customers are never happy about price increases. The costs are composed of three major forces; machine maintenance, direct labor, and overhead. The employees, on the other hand, can be motivated by a pay rise and/or a better working environment. Aside from the current situation, the company decided to take the business to the next level, finding a new market outside the country. In that sense, the company is seeking to obtain CE Marking, ISO certifications as well as implement TQM.

One strategic approach comes from Effective Human Effort Engineering (including Ergonomics, workstation design, working environment, new employee integration, and training program) and Process Automation. Ergonomics or human-factor engineering is combined science that tries to standardize tools, machines, work environment, harmonized with the physical-intellectual abilities of the employees [5].

3.2 Process Automation

Process Automation, on the other hand, is a philosophy, intending to increase productivity, quality, and speed, simplifying the workflow via a human-machine collaboration, robotizing, digitalizing, and automating [19]. In NAZGOL manufacturing company, several machines produce and refine oil via cold pressing or filtering. However, there are many areas that Process Automation can be taken into considerations, including inventory, storing, quality inspecting, material handling, processing, and packaging. The current process of sunflower oil manufacturing is also as below. It can be seen that several processes are performed manually.

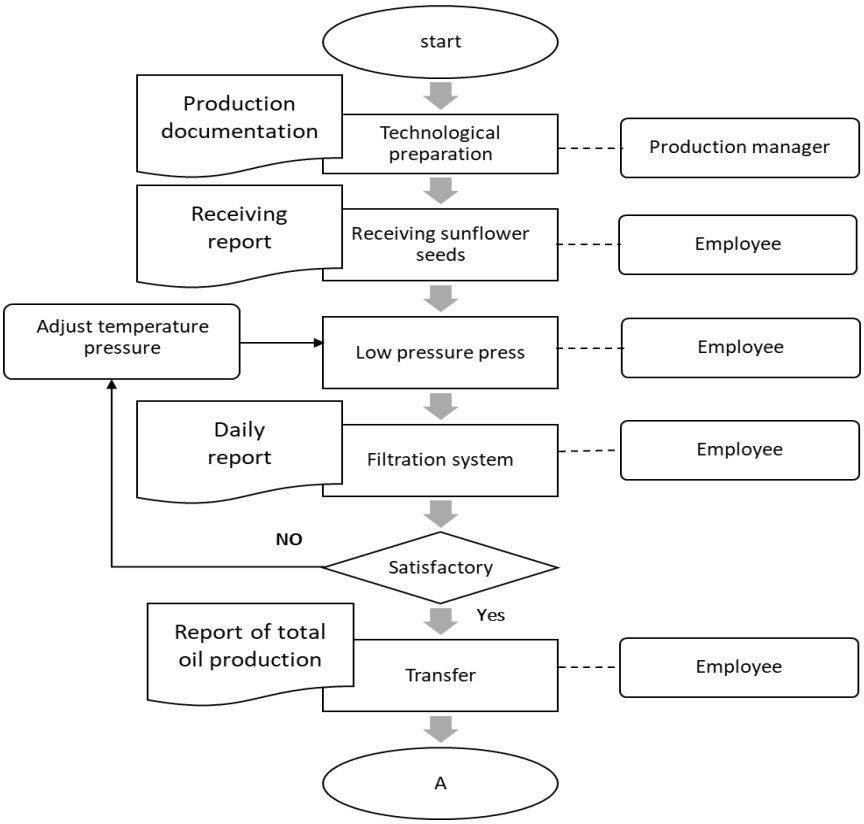


Figure 3 Diagram of oil flower manufacturing process in NAZGOL company I

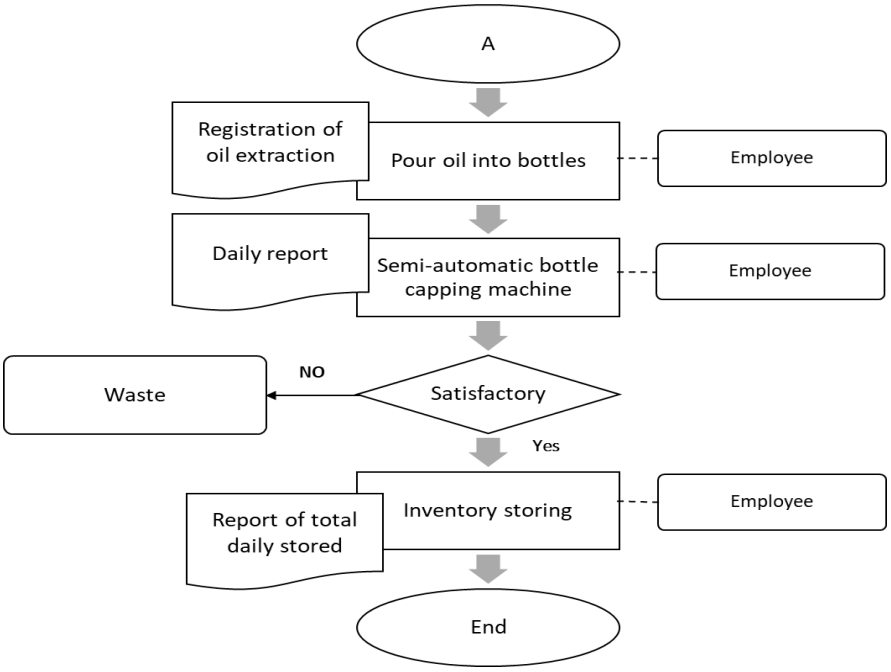


Figure 4 Diagram of oil flower manufacturing process in NAZGOL company II

The company specifically analyzed the activities in several departments, including Production, Finance, Security, Administration, Logistics, Inventory, and IT. Almost 100 employees are factory labors (production lines) and 170 employees work with computers, and no one works from home. The organizational hierarchical structure of the company for processing sunflower oil is as below.

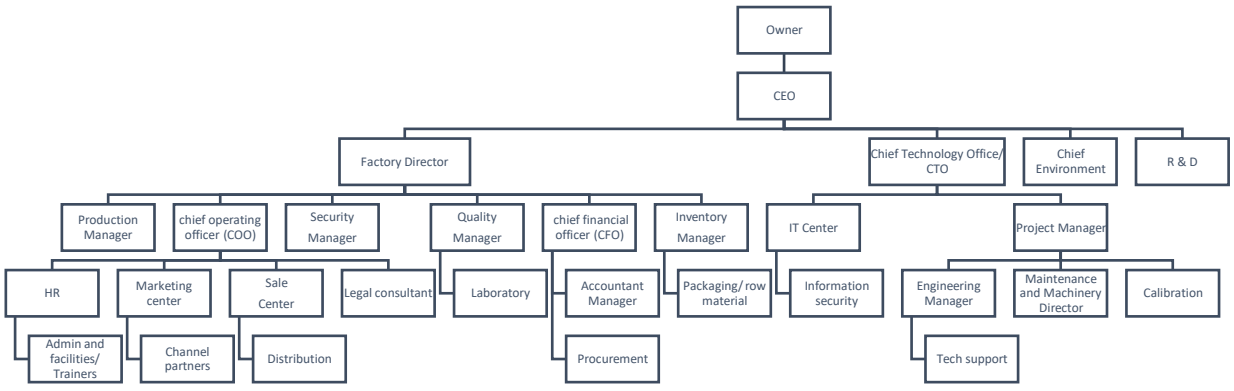


Figure 5 The organizational hierarchical structure of NAZOL Manufacturing company

3.3 Customer satisfaction

With regard to Enrique Diaz "quality is the degree to which a set of inherent characteristics fulfils requirements" [20]. Arguably, quality is not the only parameter that matters to the customer. By focusing on the operational level (the figure below) of the company organizational structure, this is visible that there are other objectives come along. With accordance to Nigel Slack, the operational level (bottom line) consists of quality, speed, cost, flexibility, and dependability in which these five performance objectives are most likely any company's common ultimate goal to meet the customer's requirements [21].

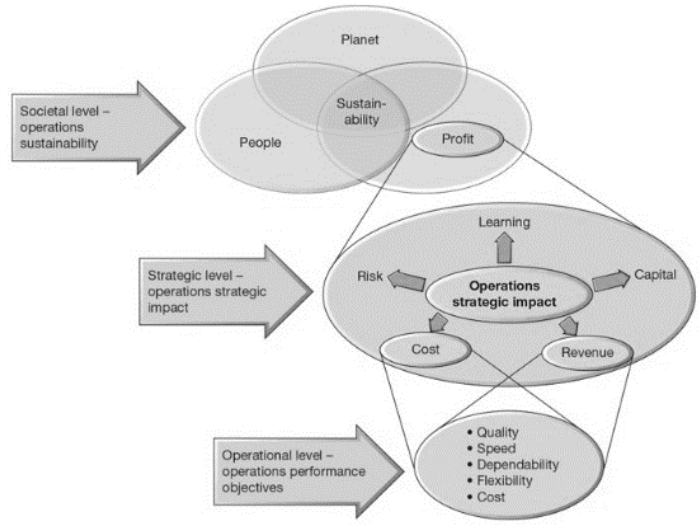


Figure 6 levels of company structure [21].

3.3.1 Product quality/service

The company is expecting an increase in quality. Theoretically, quality has no meaning other than what the customer wants [22]. Quality should be defined as the product adapting to customer needs. In another word, "the totality of features and characteristics of a product or service that bears on its ability to meet a stated or implied need", expressed by the ISO definition [13]. In a simple word, quality is defined by the customer, not the manufacturer or service provider.

The NAZGOL manufacturing company of sunflower oil is known for natural, no preservative product through the harvest of organic and sustainable sunflower farms in Kermanshah, Iran. The brand is known for over four decades among the customers. However, since the Chinese products are dominating the market by offering cheaper price and bulk quantity, the company is facing various challenges to compete. One that matters the most for maintaining the good quality, is the machineries and equipment advancement to convert the dark seeds into pure oil. The cold pressing machine for instance, should not be heated up during the process, since the high temperature (over 40 °C) spoil the oil quality instantly. The second parameter is the fineness of the filtration system where the oil is refined. Lastly, is the quality of the bottle itself and the process of bottle capping. The oil inside the bottle should be kept away from air exposure and light, so that the oil lasts for at least 18 months.

Apart from the product quality, service quality involves intangible element of quality namely accessibility, availability, and usability personalization. Service quality is the value of a service to customers. This is inherently subjective as it is driven by the needs, expectations and perceptions of customers [23]. This can be argued that the ergonomic, comfortable and efficient working environment can have an impact on the quality of service given to the customers. Potentially, satisfied employees physiologically are up to deliver better performance and make more commitment to the company's goal.

3.3.2 Manufacturing cost

Among the operational objective, cost reduction is the primary process of reducing the amount of money that the company spends on unnecessary expenses such as frequency of maintenance, inefficiency of production, waste of energy, human error, defect, rework and avoidable motion of resources due to an inefficient workplace design. To the principle, the company has to compete with the price offered along with other parameters. The product price consists of the manufacturing cost plus the profit. The manufacturing cost is computed by dividing the total manufacturing costs for some period (quarter of a year) by the numbers of units of the products manufactured during that period [24].

Another way to divide manufacturing costs is between fixed costs and variable costs. Fixed costs are those that incur regardless of how many products are manufactured. Variable costs are those that incur in direct proportion to the number of units manufactured.

One possible approach is to automate some of the processes that leads to reduce labor cost. These changes in manufacturing process, not only can reduce the cost of labor, but also defect, motion, rework and energy.

The company also may comply with ISO 45001 — Occupational health and safety to reduce the cost of labor injury [14]. Ergonomic and comfort working environment can increase the labor work accuracy, employees' satisfaction level thus reducing the cost of human error or defect. Lastly, dynamic training and regular update can increase the employee's accuracy in job thus reducing the cost of rework and waste of material.

3.3.3 Lead time

The third company operational objective it to eliminate non-value-added steps. Lead time is the amount of time needed to convert a product from the raw material to finish product, in our case sunflower oil. The company should track and measure the time, employees spend on various tasks to produce this product. Work-In-Process (WIP) causes the most non-value-added time during a production process [25].

3.4 Employee Integration program

New employees go through various stages to integrate with the company system, this includes training sessions, tests, internship and probationary period, and supervising. However, In NAZGOL company, there are other factors within the organizational structure in which, not only the newcomers, but also current employees, struggle with integrating into the system. Some of the company current situation and general thoughts, concerning employee integration difficulties are discussed below.

3.4.1 Lack of accessibility and simplicity in Quality Management System

The major problem comes from the complexity causing the biggest challenges for the employees. Lack of direction and navigation always brings confusion to access the right information in considerably less time. For example, every employee in the organization structure take different steps to plan, do, check, and action within the different department; and in the smaller scale of company activities. To be more specific, what if the quality content does not fit with the latest technology, cognitive computing, data visualization, IOT, automated or autonomous robotic, digitalization, DevOps and the company future pattern for continues development. The majority of employees still face some challenges tracking updated process information and benchmarks in QMS. In this intensely competitive world, it's inevitable that some companies will go out of business if they miss the adaption to what the market wants.

3.4.2 The over-the-wall cooperation

An integrated system means that the departments from marketing, engineering, manufacturing, and quality management work towards the company's ultimate goal. The decisions are not made, in favor of one department. Unfortunately, in NAZGOL manufacturing company, the production process turns into an "over-the-wall" cooperation thus strictly sequential. For instance, the company director hands the order sheet over to the project manager, likewise it goes to manufacturing manager. Lastly, the quality takes care of the rest without actively participating in the previous processes. This cause employee integration to fail [26].

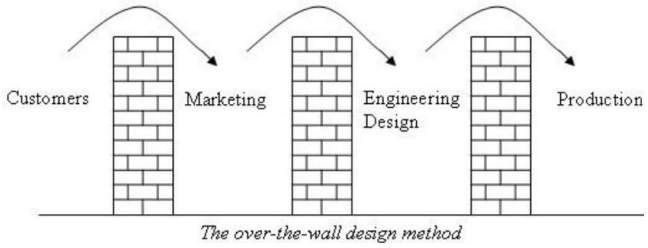


Figure 7 the over-the-wall design [26]

3.4.3 Inaccurate positioning of employees in an organizational structure

Organizational structure is designed based upon the company core activity, characterization or objective. The company incorporation with the employees, also depends on the organization strategy in a sense, in what direction or go around what core of activity the main expectations are more focused [21].

For example, In NAZGOL company, the favorite version of placing IE is under production department where the technical aspects are taken placed. It is arguable whether this positioning distances IE from Quality Management System. Logically, the company finds this positioning, strategic and advantageous, since the primary objective of the department is exclusively to improve processes in production or to solve particularly technical matters within the given product group. In this situation, the nature of IE's job content is ignored and restricted across the company. What about process optimization, system integration, and non-production improvement? Due to such incorporation arrangement, the QMS techniques and tools will become partially remote, and out of IE's department reach.

In summary, the company current situation showed various elements of neglecting human-factor values, inefficient integrating structure and absence of Process Automation. It is arguable, if by resolving these factors, the company ultimate objectives can be met.

4. METHODOLOGY

4.1 Introduction

In this chapter, the definition of variables and hypothesis, statistical population and research sample, validity and reliability of the research tool, and the method of survey (in the format of a comprehensive road map), are presented. The research aims to analyze the Human Effort Engineering (including Ergonomics and workstation design, new employee's integration, and training) impact on implementing TQM, delivering operational benefits and high quality products/service offered. Our findings will contribute much to a sense of the relationship between the company Human Effort Engineering and customer level of satisfaction. Indeed, we ultimately focus on enhancing the customer satisfaction fundamentally through focusing on Human Effort Engineering philosophy in combined with Industrial Engineering's tools.

As Industrial engineers, we assess any possible action to reduce waste, optimize productivity and maximize quality. We made an investigation into our chosen company (NAZGOL Co) to measure various matters. For example, how well the workstation design is ergonomic, comfortable, and safe for the employees. Dose any slight change in elements, such as height-adjustable workbenches, optimal bench dimensions, lighting, and individual tool positioning put a direct or indirect impact on the commitment and performance of the employees. How it reflects on operational objective (such as reduced manpower, enhanced work accuracy, effective communication among business partners and reduced operational costs) [1]. Lastly, is there an interconnection between the workers' contentedness with their job and ultimately customer satisfaction enhancement?

4.2 Definition of variables

We tend to make a multi-level analysis using equations by collecting data from several indicators which related to four main latent variables (Human Effort Engineering, Process Automation, Operational benefits and TQM implementation). The data is collected in three various of departments (including Manufacturing, Technology and Quality) using four different types of questionnaires. The Multi-level analysis helps the company to better understand the interconnection between the concept of Human Engineering and TQM implementation, operational benefits and high quality product/service. The range used in this research is a Likert scale consisting of answer options on this scale of 1 to 10. This indicate the degree to which the respondent agrees or disagrees with a particular topic or concept, whether confident (10) or unconfident (1).

4.3 Definition of hypothesis

4.3.1 Hypothesis 1 (H1):

Effective Human Effort (including Ergonomics and workstation design, new employee's integration, training etc.) Engineering discipline has a positive effect on the operational benefits and/or on a high quality of products produced/services offered

In this Hypothesis, we present a scenario to measure the impact of Effective Human Effort Engineering discipline on company's objectives, without including Total Quality Management (TQM) as a core management method. The reason behind is to picture a scenario whether the top management can expect acceptable improvements (eliminate waste, reduce labor cost, increase productivity, quality and profitability) within the company by only focusing on the discipline of Human Effort Engineering. This includes improvement in various elements within the workplace, staff instructing and integrating program as well as Ergonomics. To put it simply, can Human Engineering alone, guarantees higher quality product/service as well as operational objectives in a way to meet stakeholder needs and expectations? Is TQM really needed in that sense?

4.3.2 Hypothesis 2 (H2):

Effective Human Effort Engineering effective application in industry leads to effective TQM implementation

Total Quality Management (TQM) within an enterprise should be conducted in eight principles of Customer focus, Total employee commitment, Process approach, Integrated system, Strategic and systematic approach, Fact-based decision-making, Continual improvement, and Communication [8]. In this hypothesis, we investigate the impact of Effective Human Effort Engineering (Ergonomics, standardizing working environment, staff training program and etc.) on TQM implementation. McQuater et al classified five possible factors independently or combined, resulting the failure or success of executing TQM essentials. These are management, education, training, resources and experience [27]. In theory, these factors concern the employers to prioritize the employee's skills, engagement, performance and interaction with other resources such as machineries. By contrast, shortcoming of Human Effort Engineering privileges in the company, result a hinder to TQM implementation. In practice, this hypothesis tends to develop a deep understanding of the real impacts of Human Effort engineering, its relation with TQM principles, company's objectives, product/service quality and customer satisfaction.

4.3.3 Hypothesis 3 (H3):

Processes Automation supports Human Effort Engineering, leads to good working environment and thus to effective TQM implementation

Technological advances such as smart machines, robots, IT, IOT and further automation in production of Industry 4.0 or 3.0 have had a significant impact on ensuring the production of goods that meet design specifications and enhance customer satisfaction. Undoubtedly, the advancement of technology, in addition to improving the standard of working environment, has played a prominent role in drastically improving comfort, fast-processing and better-monitoring. Additionally, we can optimize performance, achieve greater productivity and ensure employees' health by implementing the standard principles in the machine design, supply and use of technology in compliance with ISO 11161:2007 safety of machinery [13].

This hypothesis mainly focusses on replacing various slow-manual processes with advanced Process Automation. For example, deploy machine-learning algorithm instead of sorting the dark seeds by hands, deploying full-automatic capping instead of semi-bottle capping, robot palletizing or automated inventory system instead of moving the packages with forklift or hands, and lastly using automated conveyer instead of manual material handling throuout the factory.

The term Process Automation Support is the study of factors that describe the comfort, satisfaction, and efficiency of people working with production systems and equipment [28]. This hypothesis looks for a relationship between the automating the process, using advanced technology and its impact on the working environment. Unlike previous hypothesis (H1, H2), here we include the reflection of process automating into employees' working environment thus to effective TQM implementation.

4.3.4 Hypothesis 4 (H4):

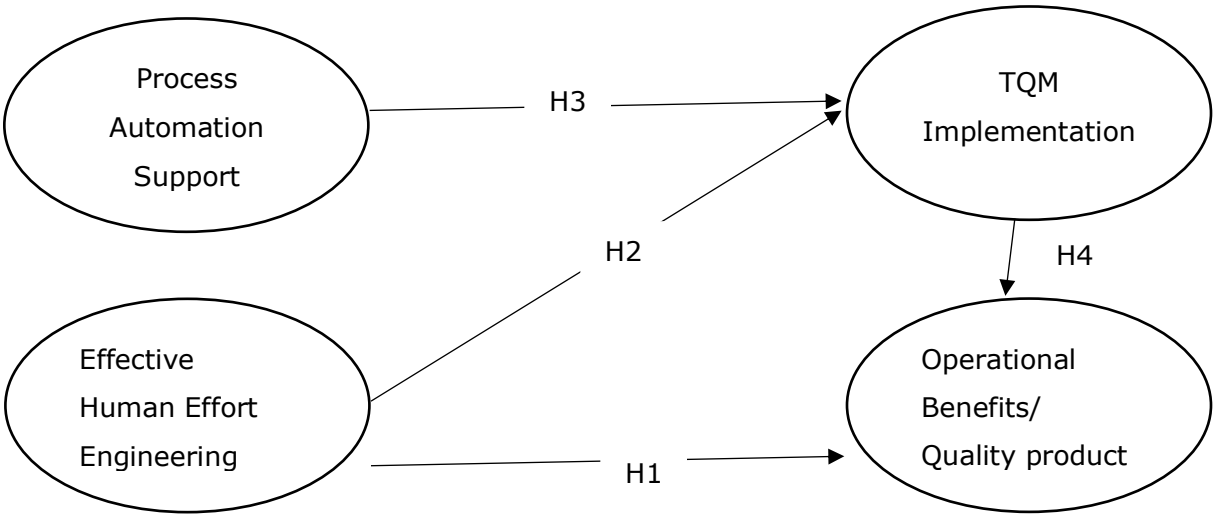
Managers and TQM implementation influence working environment and thus high quality products and operational benefits

According to Dr. Isaiah O. Ugboro, "Top management facilitates employee empowerment and improved levels of job satisfaction through its leadership and commitment to the Total Quality Management (TQM) goal of customer satisfaction by creating an organizational climate that emphasizes total quality and customer satisfaction" [29].

This hypothesis argues whether the top management commitment is reflecting the success of TQM implementation by focusing on the Human Effort Engineering discipline. In this survey, the company top management of quality, project, and production participated in the questionnaire to arguably discuss their roles in providing an ergonomically designed working environment, staff instructions, and integration program. Furthermore, how much their efforts lead to operational benefits. The company's aim is to reduce labor cost, implies effective communication internally and externally, diminish waste and increase quality, productivity, and profitability. By accepting this hypothesis, it can be concluded, The stronger their commitments, the greater the potential for program success [30]. By contrast, if they less make commitment towards the company mission, the TQM implementation is most likely to fail.

In summary, the figure below illustrates graphically four hypotheses and relationships between variables.

Figure 8 The Hypotheses map



4.4 Survey development and questionnaire design

In this survey, we conduct an online interviewing (including 10 questions associated with each hypothesis) with 3 persons/experts. Our sample consists of the Quality Manager, Production Manager, and Project Manager, connected with the TQM system. We perform statistical analyses of biological, mechanical, technical, psychological, and perceptual perspectives of the relationship between the latent variables. The final questionnaire is structured into three stages: initial input data analysis, critical success factors of the hypotheses, and possible solutions. They are answered on a Likert scale with values between one to ten, where one indicates that this activity has a little impact or the participant disagree with the statement, and ten indicates that the activity has a remarkable impact and the participant fully agree with the statement. The table shows a brief explanations of the questionnaire final design. In overall, four lists of questions, representing the four hypotheses are developed.

Table 2 Questionnaire structure and conceptual factor

Number of questions	**Indicators**	**Possible Outcome**	**Hypothesis**
1	ISO implementation	operational benefits ,quality product and service	**Hypophesis1**
2	Facility layout improvement		
3	Staff training		
4	Inspectors on site		
5	Motivating program		
6-10	Ergonomics		
11-20	Standardized workplace environment	TQM implementation principles	**Hypophesis2**
21-30	Process Automation and Advanced Technology supporting Human Effort Engineering	TQM implementation principles	**Hypophesis3**
30	Managers and TQM on working environment	high quality products and operational benefits	**Hypophesis4**

4.5 Sampling method and selection of respondents

Since we should evaluate our hypotheses in various departments, we rather Stratified Sampling to cluster the population into groups based on characteristics. In our case, we sample 3 participants of each Management level in Quality, Production, and Project with five years of experience and good knowledge of TQM implementation. We may reduce sampling errors when every member of a population belongs to our desire characteristics. Department Managers oversee the functioning and productivity of a company division. They have access to the data of evaluating staff performance, working environment and TQM Implementation. Their contributions will lead us to precise analysis and conclusion.

4.6 Data collection method

In the present study, both library and field methods have been used to collect data
In this research, two methods are used to collect data:
1- Library method: The researcher has used the library method to study the research literature (theoretical foundations and research background).
2- Field method: The field method has been used to examine and test the research using various questionnaires.

4.7 Structural Equation Model

Often a hypothesis concerns some population parameter θ. Because the parameter is numerical, there are different types of basic hypotheses: two one-tailed tests and one two-tailed test. In our case, the one-tailed hypothesis pairs is used.

H0: $\theta =< \theta_0$ vs. H1: $\theta > \theta_0$.

It is tested at the level of significance "α" by calculating from the realized sample the upper 100(1− α) % confidence limit which in our case is 90% of confidence level. The hypotheses are accepted if that the correct value of the parameter θ is not equal or less than reference the value θ_0.

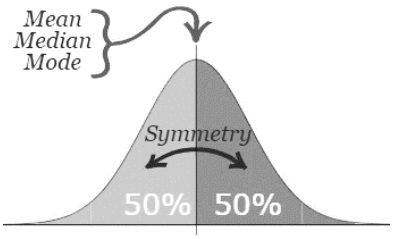
Stage 1: We assume our reference value $\theta_0=7$
7 was selected as the mean value that, since it is considered as majority in most statistical analysis.

Stage 2: Then we calculate the standard deviation following the formula below.

Equation 1 Standard deviation

$$\sigma = \sqrt{\frac{\sum(x_i - \mu)^2}{N}}$$

Stage 3: We calculate the μ (The mean/median/mode) following the formula below.



Equation 2 Analysis of experimental data via calculating the mean

$$\hat{\mu}_{\mathrm{L}} = \overline{x} - z_{\alpha}\frac{\sigma}{\sqrt{n}}$$

Z is the "z-score" (Standard Score)

confidence	**80%**	**85%**	**90%**	**95%**	**99%**	**99.5%**	**99.9%**
Z	1.282	1.440	1.645	1.960	2.576	2.807	3.291

x is the value to be standardized

μ ('mu") is the mean

σ ("sigma") is the standard deviation

Stage 4: We analyze the result by rejecting or accepting the hypotheses and present additional data analysis. The result of hypothesis testing is either of the following:

• Strong enough evidence has been found to reject the null hypothesis H0. We'll continue by assuming that the alternate hypothesis H1 is true.

H1: $\theta > \theta_0$

• The sample and the test method used haven't given strong enough evidence to reject H0. This may result because H0 is true or because the test method wasn't strong enough. We'll continue by assuming that H0 is true.

H0: $\theta =< \theta_0$

Indeed, we conduct the Structural Equation Modeling (SEM) technique, integrated in Excel software.

5. RESULTS AND DISCUSSION

5.1 Introduction

After conducting the questionnaire during March 2021, from NAZGOL Oil Manufacturing in Iran, 3 questionnaire including 120 answers have been collected for further analysis. The table below illustrate the identity of each participants including age, gender, experience (with the company) and the level of education.

Table 3 Participants identity

Positions	**Age**	**Gender**	**Experience**	**Education**
Quality Manager	40	Female	21 Years	Master's
Production Manager	52	Male	12 Years	Master's
Project Manager	49	Male	11 Years	Master's

5.2 Descriptive Analysis of the Data

The table down below illustrates a descriptive analysis of the latent variables in which the median range are exposed, arrange in descending order occurring to the maiden value for every latent variable. In this table, the three factors that have the highest impact are only shown. The entire questionnaire data can be found in the Appendix.

Table 4 The questionnaire output data

Latent Variable/ Observed		**Median**	**IQR**
Hypothesis 1: Human Engineering impact on operational benefits, product/service			
1	ISO 6385:2016 - Ergonomics principles	9.67	1.00
2	Employee's job rotation, shift regulating, rewarding program	9.33	1.00
3	Facility layout	9.00	2.00
Hypothesis 2: Effective Human Engineering impact on TQM implementation			
1	Total employee commitment	9.67	1.00
2	Customer satisfaction level	9.33	1.00
3	Integrated system	9.33	1.00
Hypothesis 3: Process Automation impact on TQM implementation			

1	Data collection and analysis	9.67	1.00
2	Communication channels	9.67	1.00
3	Continual process improvement	9.33	1.00
Hypothesis 4: Manager/ TQM impact on operational benefits, quality of product/service			
1	Flexibility to keep up with market	9.67	1.00
2	Effective communication among business partners	9.33	1.00
3	Customer focus and satisfaction	9.33	1.00

Lastly, In the table above, we calculate the First **Quartile**(Q1) =((n+1)/4) th and Third **Quartile**(Q3) =(3(n+1)/4) th using Excel formulation. The result (IQR=Q1-Q3) provides us information about both the center and the spread of the data. It can be concluded by looking at the spread data, that all participants gave quiet similar responses.

- With regard to the first hypothesis (H1), the participants highly emphasized the importance of performing ISO 6385:2016 - Ergonomics principles [13]. They also believed that employees' rewarding/motivating programs, frequent day-offs and job rotation relieve fatigue and tiredness thus improving product/service quality. In addition, in-depth and comprehensive facility layout can help improve workflow efficiency and reduce waste mainly motion, inventory and waiting.

- Hypothesis (2) proved that Training staffs, Standardizing workplace and Ergonomics have the most impacts on improving employee commitment, enhancing customer satisfaction and building an integrated system of various disciplines.

- On the other hand, Advanced Technology and Process Automation (H3) could improve data analyzing/analyzing, build better commination channels, and deliver continual process improvement using IE methods.

- The last hypothesis showed The commitment of top management and TQM help the company to keep up with market change, effective communication with the stakeholders, and increases customer satisfaction level.

5.3 Hypotheses test

At first, the mean (the average of the responses) are calculated for each hypothesis.

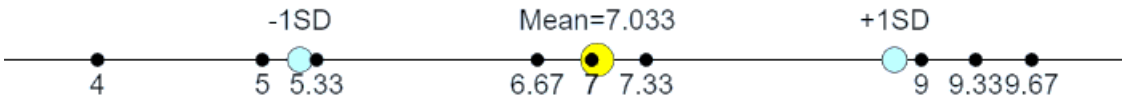
Hypothesis	H1	H2	H3	H4
Mean (X)	7.033	8.033	8.135	8.067

5.3.1 Hypothesis (1)

With regard to the hypothesis (H1), the experimental data below is gathered for the formulation. The "Z" value for the Confidence level of 90% is 1.645.

Mean (x)	Standard Deviation (σ)	Count (n)	Variance	μ	Z (90%)
7.033	1.804	10	3.25	7	1.645

	Hypothesis (1)	Test
H0	Effective Human Effort Engineering considering during TQM implementation has **NO** positive effect on the operational benefits and/or on a high quality of products produced/services offered	$\mu = 7$ $\mu < 7$
H1	Effective Human Effort Engineering considering during TQM implementation have a positive effect on the operational benefits and/or on a high quality of products produced/services offered	$\mu > 7$



$\mu_L = x - z * \sigma / \sqrt{n}$ $\mu_L = 7.033 - 1.645 * 1.804 / \sqrt{10} = 6.09$ $6.09 < 7$

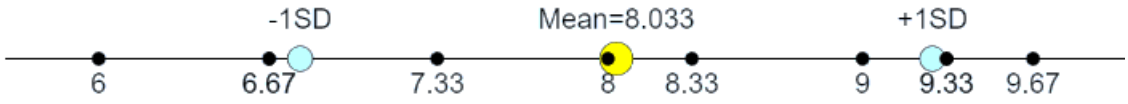
We can come to a conclusion that the Hypothesis H1 is rejected thus Effective Human Effort Engineering has **NO** (or not significant) effect on the operational benefits and/or on a high quality of products produced/services offered.

5.3.2 Hypothesis (2)

With regard to the hypothesis (H2), the experimental data below is gathered for the formulation. The "Z" value for the Confidence level of 90% is 1.645.

Mean (x)	Standard Deviation (σ)	Count (n)	Variance	μ	Z (90%)
8.033	1.241	10	1.54	7	1.645

	Hypothesis (1)	Test
H0	Effective Human Effort Engineering effective application in industry does not (or considerable less) to effective TQM implementation	μ = 7 μ < 7
H2	Effective Human Effort Engineering effective application in industry leads to effective TQM implementation	μ > 7



$\mu_L = x - z * \sigma / \sqrt{n}$ $\mu_L = 8.033 - 1.645 * 1.241 / \sqrt{10} = 7.38$ $7.38 > 7$

We can come to a conclusion that the Hypothesis H2 is accepted thus Effective Human Effort Engineering effective application in industry leads to effective TQM implementation.

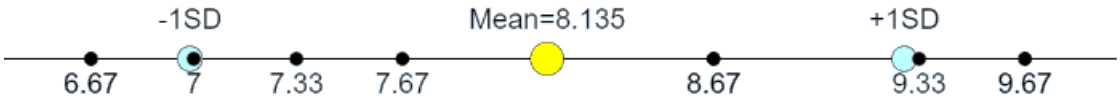
5.3.3 Hypothesis (3)

With regard to the hypothesis (H3), the experimental data below is gathered for the formulation. The "Z" value for the Confidence level of 90% is 1.645.

Mean (x)	Standard Deviation (σ)	Count (n)	Variance	μ	Z (90%)
8.135	1.147	10	1.31	7	1.645

	Hypothesis (1)	Test
H0	Processes Automation supports Human Effort Engineering, **does not** leads to good working environment and thus to effective TQM implementation	μ = 7 μ < 7

H3	Processes Automation supports Human Effort Engineering, leads to good working environment and thus to effective TQM implementation	μ > 7



$\mu_L = x - z * \sigma / \sqrt{n}$ $\mu_L = 8.135 - 1.645*1.147/\sqrt{10} = 7.53$ 7.53>7

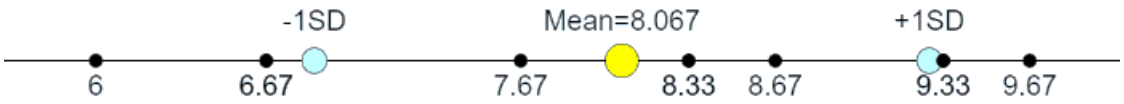
We can come to a conclusion that the Hypothesis H3 is accepted thus Processes Automation supports Human Effort Engineering, leads to good working environment and thus to effective TQM implementation

5.3.4 Hypothesis (4)

With regard to the hypothesis (H4), the experimental data below is gathered for the formulation. The "Z" value for the Confidence level of 90% is 1.645.

Mean (x)	Standard Deviation (σ)	Count (n)	Variance	μ	Z (90%)
8.067	1.208	10	1.45	7	1.645

	Hypothesis (1)	Test
H0	Managers and TQM implementation **has no** influence working environment and thus high quality products and operational benefits	μ = 7 μ < 7
H3	Managers and TQM implementation influence working environment and thus high quality products and operational benefits	μ > 7



$\mu_L = x - z * \sigma / \sqrt{n}$ $\mu_L = 8.067 - 1.645*1.208 / \sqrt{10} = 7.43$ 7.43>7

We can come to a conclusion that the Hypothesis H4 is accepted thus Managers and TQM implementation influence working environment and thus high quality products and operational benefits.

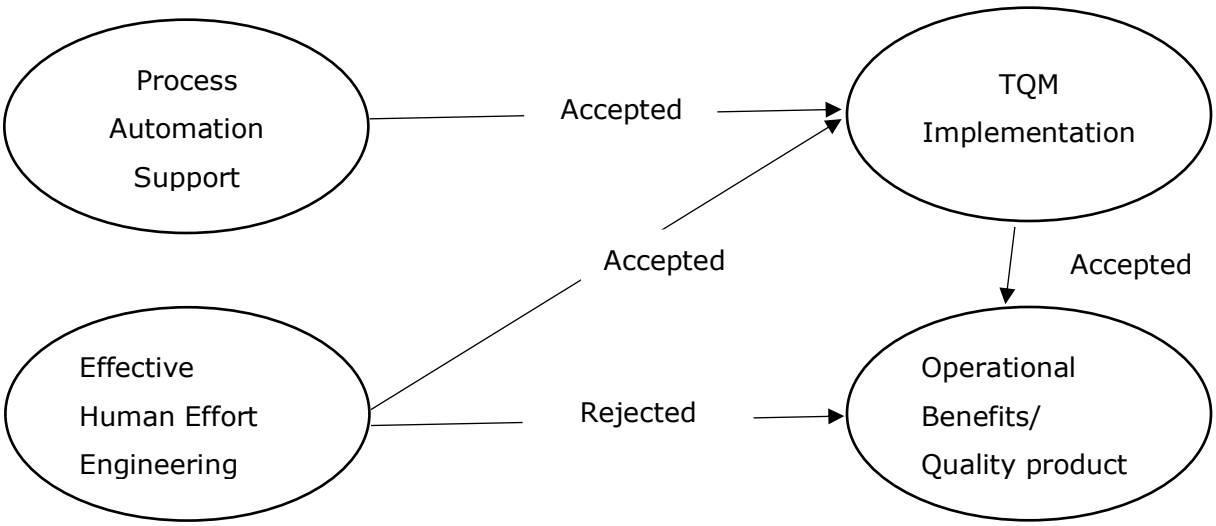
5.4 Direct effects

Table below describes a summary of the hypotheses conclusions.

Table 5 Conclusions of the hypotheses (L.V. = Latent Variable)

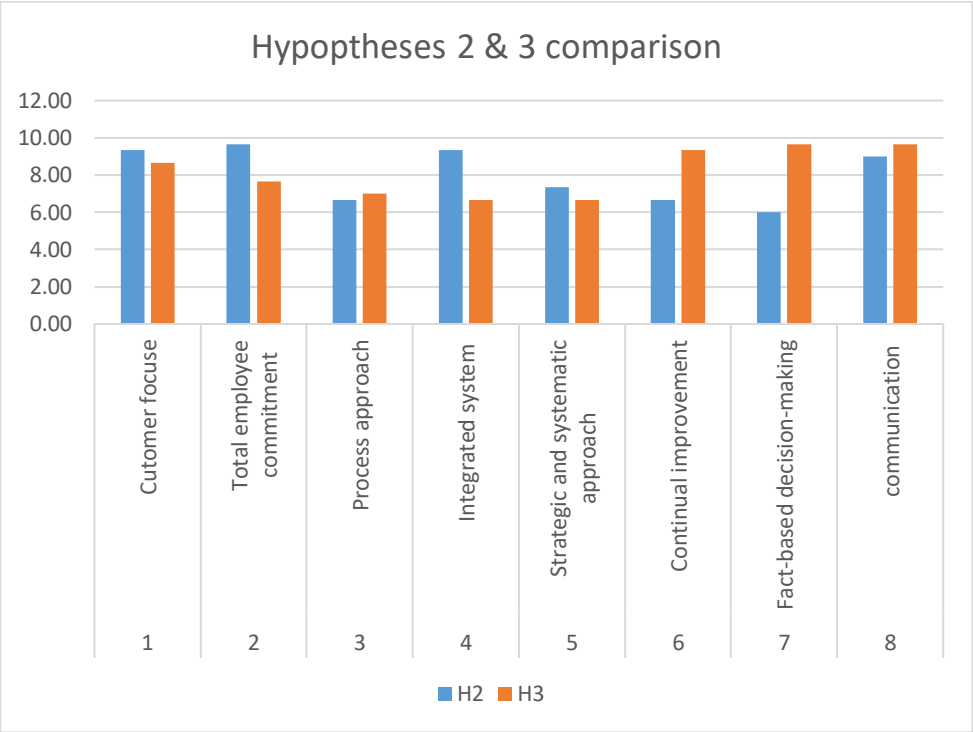
Hi	Independent L.V.	Dependent L.V.	μ_L	μ	Conclusion
H1	Human Effort Engineering	Operational Benefits	6.09	7>	Rejected
H2	Human Effort Engineering	TQM Implementation	7.38	7>	Accepted
H3	Process Automation	TQM Implementation	7.53	7>	Accepted
H4	Top Management/ TQM	Operational Benefits	7.43	7>	Accepted

Figure 9 The Hypotheses result on model



The chart below demonstrates how much Human Effort Engineering (H2) and Process Automation (H3) have an impact on TQM implementation.

Table 6 Hypotheses (H2) & (H3) comparison



5.5 Result

This survey discovered number of findings throughout the questionnaire and further analysis of experimental data using one-tailed hypothesis pairs.

With regard to the first hypothesis, we are not given enough evidence to conclude that there is a relationship between the two variables. In another word, Effective Human Effort Engineering may or may not have a positive effect on the operational benefits, high quality product/service offered. The company tends to eliminate waste, reduce labor cost, increase productivity, quality and profitability by considering Human Effort Engineering (without including TQM). Nonetheless, there is no guarantee of higher quality product/service or operational objectives, only by improving few features in the workplace or Ergonomics. It can be concluded that the company is required a fundamental and comprehensive philosophical method— such as TQM—to form continual improvement (Six Sigma), reduce error and integrates employees in the aim of increasing the overall quality of the final product or service.

In continue, (H2) and (H3)—by focusing on key principles of TQM—showed that working environment, Ergonomics and Staff training as well as Process Automation had a desired effect on company operational objectives. According to the figure above, Human Effort Engineering highest impacts are on the employee commitment and establishing an integration system. On the other hand, Process Automation provides communication effectiveness, creates fact-base decision making by systematic data collecting/analyzing.

Last but not least, hypothesis (H4), exposed the importance of top management long-term commitment to execute TQM in order to obtain company ultimate's goals. This includes better customer focus, higher flexibility in production volume and effective communication with partners.

6. CONCLUSION AND FURTHER RESEARCH

The Hypotheses (H2), (H3) and (H4) proved the collaboration amongst the disciplines of Human Effort Engineering, Industrial Engineering, Process Automation perspective and the commitment of top management will lead to perform TQM principles thus succeeding company objectives. On the other hand, the data analysis showed that Human Engineering impact could be partially wasted if it is not empowered by a management framework with continues improvement approach as well as the effective commitment of the company's members. Amongst the discussion, this thesis finalizing this research by proposing constructive recommendations and potential prospects that NAZGOL manufacturing company can comprehend. Various factors come together to finalize these solutions including the theoretical concept of Human-factor engineering, Industrial Engineering's tools, this thesis output data, TQM principles and etc.

6.1 Solutions

6.1.1 Customer focus

The finding highly suggested ISO 9001:2015 to ensures that products and services are up to the correct quality standards for customers as well as other ISO certificates related to the working environment, Ergonomics and safety such as ISO 6385:2016 [13] and ISO 45001:2018 [14]. The company can increase higher quality of product by providing automated manufacturing process. The company can shorten the lead time by systemizing the orders and process. Standardized workplace can cut manufacturing cost by reducing human errors, injury, motion, rework and energy. Human Engineering has a strong contribution to business in any continuous improvement effort which ultimately leads to increase customer satisfaction level.

Some of the ISO standards related to Human Effort Engineering and the workplace are as below.

ISO 45001: Occupational health and safety [14]
ISO 6385:2016 Ergonomics principles in the design of work systems [13]
ISO 9001 Clause 6.4 Work Environment [8]

ISO 24496:2017(en), Office furniture
ISO 1:1975 - Standard reference temperature
ISO 13849 Machinery directive
ISO 13849-1:2006, Machinery directive
ISO 45001:2018 Occupational Health & Safety Management

6.1.2 Total Employee commitment

The company can increase total employee engagement by addressing the employees' Ergonomics aspects (physical, cognitive, and organizational), work safety, constructive training, proving consistent feedback and clear communication among teams of all profiles. In addition, the managers should maintain the motivation techniques to encourage the staff to self-evaluate performance, against personal goals. The company can survey employees for their satisfaction, offer regular day-offs and breaks, validate good work, job promotion and pay rise.

Bedsides, Top management roles are to counsel their staff, make sure they may not remain ignorant for their complications; instruct them in behaviorism that top-level may act upon [31]. Additionally, Least Squares Regression method can tell us how often the staff is needed a break during the work time, by analyzing the impact of various independent variables such as staff productivity, work time and fatigue.

6.1.3 Process Approach

Process Automation (H3) offers continual process improvement with the help of number of Industrial Engineering tools, namely Takt time equation, SMED, Kanban, Just in Time (JIT), TQM, SIPOC, Six Sigma, and One-Piece Flow. Process Automation can reduce operational cost, increase productivity and reliability, ensure high quality and optimizing performance. For example, the company can deploy machine-learning algorithm instead of sorting the dark seeds by hands, executing full-automatic capping instead of semi-bottle capping, robot palletizing or automated inventory system instead of moving the packages with forklift or hands, and lastly using automated conveyer instead of manual material handling throuout the factory.

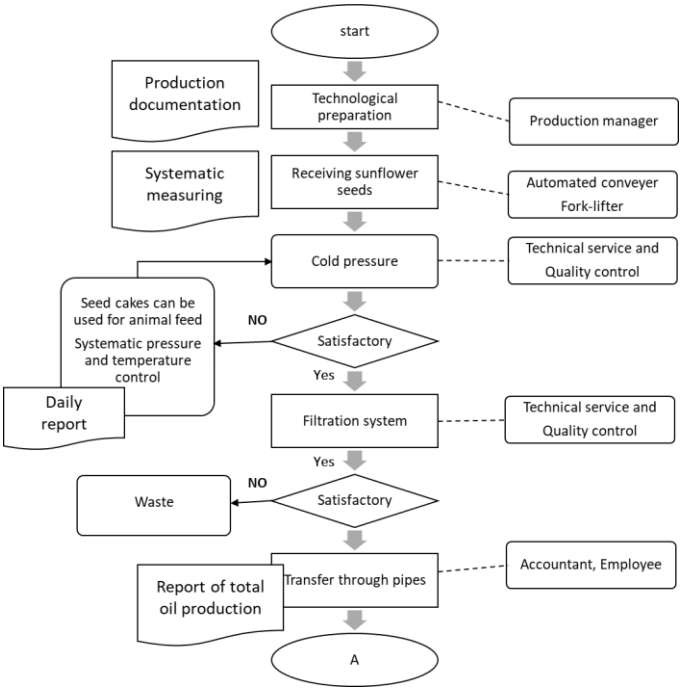


Figure 10 Diagram of oil manufacturing process I (redesigned)

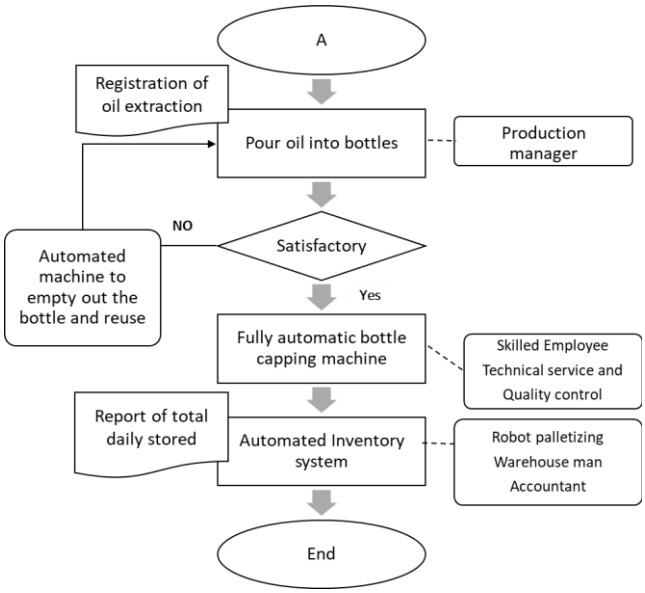


Figure 11 Diagram of oil manufacturing process II (redesigned)

As it can be seen from the chart above, most stages are automated, there are more quality inspection and control within the stages, there are less waste, and more personal integration and top management commitments.

6.1.4 Integrated system

The company can also expect better integration of departments by standardizing policies, objectives, culture, process, and working environment. Human Effort Engineering can provide methods such as As-is process analysis, staff training, newcomers' integrating program, Andon, and VSM. In order to take advantage of the capabilities, delivered by both IE and QM through their tools and techniques, both QM and IE need to be part of the top management, so that they influence maximum efficiency across the entire organizational structure.

The majority of employees in the company, still face some challenges tracking updated process information and benchmarks in QMS. In addition, a flexible Quality Management System—with the ability of customizable features—helps the company to change considerably throughout time [32].

6.1.5 The strategic and systematic approach

Both Human Effort Engineering and Process Automation contribute much to a sense of strategic management, includes the formulation of a strategic plan that integrates quality as a core component. The best strategy for the company is to upgrade technology and equipment, automate the process, standardize the workplace, improve Ergonomics and safety according to ISO standards, involve all personnel working together towards a common vision, goals, and outcomes.

One of the key company operational objective it to eliminate non-value-added steps increasing Lead time—the latency between the initiation and completion of a process [25]. The company should track and measure the time, employees spend on various tasks to produce this product. One possible way is to data collecting the current situation to establish a baseline that present the true condition of the production cycle. After analyzing and detecting the non-value-added steps, the company can facilitate the workplace thus shorter lead times, material flow, and reduced WIP inventory and waiting. Employees should also take part and propose solutions of where, why, and how lead time can be diminished.

6.1.6 Continues improvement

The company should carry out the Plan-Do-Check-Act cycle, as an improvement model. Other methods are Six Sigma, Lean, and TQM [33]. In terms of Human Engineering, the company should value employees' ideas—as they are the closest to the problem. The employees tend to focus on small changes that can be accomplished without a serious expense. Once the modification is conducted, the impact on the criteria, such as KPIs, quality of product, capacity utilization, throughput, waste, manufacturing cycle time, OEE, Yield, or customer rate can be quantitatively measured. Once the measurable data is collected and studied, the company can take action accordingly to improve the weak spots in spiral improvement pattern.

6.1.7 Fact-based decision-making

In order to build and execute TQM in accordance with ISO9001 standard principles [8], the company should make decisions in an evidence-based way. For example, how much automating, robotizing, or systemizing the process can have impacts on the business. Or how much Ergonomics can improve the employees' performance, productivity, and accuracy? KPIs demonstrate sufficiently accurate, reliable, and numerical data. Additionally, the company can use Break-even Analysis to tell how many units of a product must be sold to cover the fixed (new machineries and equipment) and variable costs of production. Another based fact decision- making is to review the financial position, conduct a customer and market analysis and workplace investigation. The decisions should be analytical, rather than conceptual or behavioral. The Gemba tool is also suggested for a better understanding of real-world manufacturing issues via IE personal observation [33].

6.1.8 Communications

Process Automation offers various channels of sharing plans, strategies, and methods. The company should create an official line of communication to keep the staff informed with updates and policy change, exchange, and integrate knowledge to achieve the customer's demands. Another Lean Tool can be a Value Stream Mapping (VSM) to map out the flow of material from the suppliers for better communicating with the stakeholders.

7. SUMMARY

The subject of this thesis is highlighting the impacts of Human Effort Engineering philosophy on NAZGOL company of sunflower oil production, perusing better conditions for WORKFORCE, better TQM implementation, continuous improvement in the company, and thus higher quality of product and satisfaction of costumers.

The study background and theoretical perspectives of Human-factor engineering, Industrial Engineering's tools, TQM principles, Ergonomics, ISO standards, and Process Automation, exposed various disciplinary relationships and potential impacts on the company objectives. It showed how these disciplines can be interconnected to contribute company objectives and how Industrial Engineering's tools can be helpful when it comes to Human Effort Engineering approach.

The company current situation showed the company lack of prioritizing the employees' contentment, staff training gap, integrating challenges, outdated process mechanism of oil manufacturing, shortage of a structural improvement quality such as TQM, and incompliancy with ISO standards in various areas of manufacturing, Ergonomic and safety could be problematic.

Based upon the obtained information, four main latent variables (Human Effort Engineering, Process Automation, Operational benefits and TQM implementation) are defined, along with the hypotheses. Three participants (Management level in Quality, Production, and Project with five years of experience and good knowledge of TQM implementation) are appointed. The questionnaire survey is conducted in a form of four lists of questions, representing the four hypotheses. Once the questionnaire results and findings are collected, the output data are evaluated in order to whether accept or reject the four hypotheses with accordance to the analysis of experimental data equations.

The first hypothesis (H1) is rejected, meaning that Human Effort Engineering without TQM and IE techniques implementation, will not lead to improvement of quality of all processes and products in NAZGOL manufacturing company of sunflower oil. It can be settled that the company is required a fundamental and comprehensive philosophical method—such as TQM—to form continual improvement (Six Sigma), reduce error and integrates employees in the aim of increasing the overall quality of the final product or service.

The statistical analysis of input data proved that a combination of Process Automation (H3) and Human Effort Engineering (H2) can ease the path for implementing TQM for the company, leading to a positive effect on the operational benefits and/or on a high quality of products produced/services offered. The highest impact of Human Engineering is on the employees to make effective commitment and integrate faster onto the system. Likewise, Process Automation has positive influence on establishing a continual improvement method and offer better communication platform. Additionally, top management plays an important role in succeeding TQM; the stronger the top management commitments, the greater the potential for program success within the company.

The position of Industrial Engineers in the company organizational structure should not be limited to the manufacturing of product or product design. A constructive collaboration is required with the entire members to oversee the employees, making sure the workplace is ergonomic, safe, comfort and harmonized with the employees' physiological/physical abilities; in compliance with ISO standards.

This thesis theatrically and statistically opened a new era of understanding the role of employee's involvement in performing TQM thus delivering higher level of product/service quality that will keep customers satisfied. In conclusion, various Industrial Engineering's lean tools are proposed, ISO standards concerning Ergonomics, working environment, safety, Quality Management are outlined, the impact of Human Effort Engineering is highlighted, and many stages of manufacturing processes suggested to be automated.

The employees' contentment and customers' satisfactions are interrelated. Therefore, "Happy employees ensure happy customers, and happy customers ensure happy shareholders—in that order" by Simon Sinek.

KOKKUVÕTE

Selle töö eesmärk oli uurida tööjõu pingutuste haldamise tehnika rakendamise mõju päevalilleõli tootmisega tegeleva ettevõtte NAZGOL tootmisprotsessidele ja toodete kvaliteedile. Nimetatud tehnika kasutamine tagab paremad töötingimused, effektiivsema tervikliku kvaliteedijuhtimise (TQM-i) rakendamise, ettevõtte pideva parendamise ning seeläbi toote kõrgema kvaliteedi ja klientide rahulolu.

Töö alguses oli läbiviidud teoreetilise tausta uuring tööstuses kasutatavate tööjõu pingutuste haldamise tehnika, tööstustehnika võtete, tervikliku kvaliteedijuhtimise põhimõtete, ergonoomika, ISO-standardite ja protsesside automatiseerimise osas, mis paljastas, et kõik need tööstusettevõtetes kasutatavad võtted on omavahel tihedalt seotud. Uuriti ka nende võtete kooskasutamise võimalikke mõjusid ettevõtte eesmärkidele. Nende uuringute tulemusena selgus, et tööstusettevõtetes rakendatavaid võtteid on võimalik ettevõtte eesmärkide saavutamiseks omavahel ühendada ning samuti saadi info, et tööstustehnika võtete kasutamine soodustab tööjõu pingutuste haldamise tehnika edukat rakendamist ning toetab tööjõu rahulolule suunatud lähenemisviisi kasutamist ettevõttes.

Ettevõtte hetkeseisu uurimise tulemusena selgus, et ettevõttel esineb probleeme töötajate väärtustamise, töötajate koolituste, väljakutsete integreerimise osas. Õli tootmise protsessi mehhanism on aegunud. Lisaks esineb raskusi tervikliku kvaliteedijuhtimise põhimõtete rakendamisel ning erinevates tootmisvaldkondades esineb ISO standarditele mittevastavust. Puudulik on ka ergonoomika ja ohutuse aspektide käsitlus.

Lähtudes eelpool toodud informatsioonil, olid valitud neli muutujat (Tööjõu pingutuste haldamise tehnika, Protsesside automatiseerimine, Protsesside eelised ja Tervikliku kvaliteedijuhtimise põhimõtete rakendamine). Vestluse ja uurimise läbiviimiseks olid valitud kolm ettevõtte poolt spetsiaalselt määratud kogemusega osalejat kvaliteedi, tootmis- ja projektijuhtide seast. Küsitluse tulemused olid analüüsitud, kasutades statistilise andmetöötluse viisi, mis põhineb hüpoteeside koostamisel ja nende kontrollimisel. Vestluse küsimused olid jaotatud nelja ossa, mis on seotud nelja hüpoteesiga.

Esimene hüpotees (H1) oli kummutatud, järeldades, et Tööjõu pingutuste haldamise tehnika ilma tervikliku kvaliteedijuhtimise põhimõtete korrektset rakendamist ei põhjusta ettevõtte protsesside ja toodete kvaliteedi parendamist. Viimasest faktist järeldub, et ettevõttel tuleb pideva parendamise ja toote kvaliteedi tõstmise eesmärgi täitmiseks võtta kasutusele kuus sigma (six sigma) võtet. Selle eesmärgi saavutamiseks tuleb tagada kõikide töötajate koostöö ja integreerimise.

Statistilise analüüsi tulemusena selgus, et kolmandas hüpoteesis (H3) figureerinud Protsessi automatiseerimine ja teises hüpoteesis (H2) mainitud Tööjõu pingutuste haldamise tehnika kombinatsioon lihtsustab tervikliku kvaliteedijuhtimise põhimõtete rakendamist ettevõttes tagades protsesside paremad tulemused ja toodete kõrgema kvaliteedi. Kõige suurem mõju Tööjõu pingutuste haldamise tehnika rakendamise poolt avaldatakse tööjõu töösse panustamise efektiivsuse tõstmisele ja ettevõttes kasutatavate protsessidega kiirele integreerimisele. Protsesside automatiseerimine omab positiivset efekti pideva parendamise protsessile ja pakub paremat ettevõtte meeskonna kommunikatsiooniplatvormi. Lisaks juhtkonna panustamine ettevõtte protsesside arendamisse mängib tähtsat rolli tervikliku kvaliteedijuhtimise põhimõtete rakendamisel.

Tööstusinseneride positsioon ettevõtte organisatsioonilises struktuuris peaks optimeeritud ja kohustused ei tohi piirduda ainult toote ja tootmisprotsesside arendamisega. Tööjõu pingutuste haldamiseks on vajalik konstruktiivne koostöö kõigi ettevõtte osakondadega, tagades, et töökoht oleks ergonoomiline, turvaline, mugav ja kooskõlas töötajate füsioloogiliste / füüsiliste võimetega; vastaks ISO standarditele.

Selle töö tulemusena sai määratud tööjõu panuse haldamise tehnika roll tervikliku kvaliteedijuhtimise põhimõtete edukal rakendamisel, mis tagab toote/teenuse kvaliteedi kõrgema taseme ja klientide rahulolu. Töös pakutakse välja mitmesugused tööstustehnika võtted, ergonoomika aspekte, töökeskkonda, ohutust, kvaliteedijuhtimist käsitlevad ISO-standardid, rõhutatakse inimfaktori mõju olulisust ja antakse soovitusi tootmisprotesesside automatiseerimise osas.

Lõpetuseks sooviks esitada Simon Sineki väljenduse töötajate rahulolu ja klientide rahulolu omavahelise seotuse kohta: „Õnnelikud töötajad, õnnelikud kliendid ja õnnelikud ettevõtte omanikud, aktsionärid - selles järjekorras”.

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APPENDICES

List of questionnaire survey

Please fill up your identity
*Name:
*Surname:
*Age:
*Gender (M/F):
*Occupations:
*Experience with the company (year):
*Education level (Bachelor's, Master's, PHD, None):
(Your identity is kept confidential; your response is published)
Hypophesis1 (H1): Please evaluate the impact of Effective Human Engineering factors on your company operational benefits, quality product and service. (one indicates the lowest impact, ten indicates the highest impact)
1. Conduct International Organization for Standardizations (ISO) such as (ISO 6385:2016 - Ergonomics principles in the design workplace) or Total Quality Management program implementation.
2. Facility layout improvement design using the ergonomic approach, ensuring smooth flow of operation.
3. Staff training and integration program for newcomers.
4. Consistent evaluating and monitoring the working environment standard and informing the managers of unsafe or concerning conditions.
5. Offer employees job rotation, regular day-offs, and shift work to relieve fatigue and reduce frequent mistakes. Conduct motivating and rewarding programs.
6. Standardizing the desk surface and chair (in terms of height, space for legs, space for objects and equipment, seat cover, etc.)

7. Increase workstations safety (desks, chairs, tools, computer screen protection, etc.) such as sharp edges or a slippery and unstable surface.
8. Create an ergonomic working environment in terms of noise pollution, temperature, humidity, and presence of ventilation system, temperature, and windows in the office building.
9. Create an ergonomic working environment in terms of light and brightness.
10. Harmonize the body mechanics to its anatomical position (defined as maintaining proper muscular and skeletal positioning during movement such as lifting, handling, etc.).

Please fill up your identity
*Name:
*Surname:
*Age:
*Gender (M/F):
*Occupations:
*Experience with the company (year):
*Education level (Bachelor's, Master's, PhD, None):
(Your identity is kept confidential; your response is published)
Hypophesis2 (H1): Please evaluate the impact of the following factors on the implementing Total Quality Management in your company. Please inform how much you agree with these statements. (Total Quality Management is a lean manufacturing tool that focuses on ensuring the production of goods that meet design specifications and give customer satisfaction)

11. Focuses on manpower (including training staffs, standardizing workplace and Ergonomics) will ultimately have a positive impact on customer satisfaction level.
12. Provide the standardized workplace environment increases total employee commitment and fast integration of new comers.
13. Employees' workstation, training and integration program will reflect on the whole company's process. (A process is a series of steps that take inputs from suppliers—internal or external—and transforms them into outputs).
14. Human Effort Engineering discipline is considerable in constructing an integrated system of different functional specialties.
15. Human Effort Engineering discipline is considerable in formulating a strategic plan and systematic approach to achieving an organization's vision, mission, and goals.
16. Standardizing the workplace, training, Ergonomics reflects on continual process improvement and conduct various improvement methods (including Six Sigma, Lean Management, Re-engineering, Total Quality Management, Just-In-Time and etc.)
17. The company can evaluate how well the organization is performing by evaluating employees' performance data from the database.
18. Effective communications play a large part in maintaining morale and in motivating employees at all levels.
19. Human Effort Engineering discipline is considerable in implementing ISO 9001:2015 - Quality management systems.
20. Standardizing the workplace environment is considerable in implementing ISO 45001 occupational health and safety management [14]

Please fill up your identity
*Name:
*Surname:
*Age:
*Gender (M/F):
*Occupations:
*Experience with the company (year):
*Education level (Bachelor's, Master's, PhD, None):
(Your identity is kept confidential; your response is published)
Hypophesis3 (H3): Please evaluate the impact of Process Automation and advanced technology supporting Human Effort Engineering, leads to good working environment on implementing of Total Quality Management in your company. How much do you agree with the statements below?
21. Automating the number of manual tasks ultimately improve product/service quality to meet customers' demands and enhance satisfaction level.
22. Process Automation and technology improve workplace system, so that the staffs can make effective commitment.
23. A fundamental part of TQM is a focus on process thinking. A combination of Process Automation and human power result better process improvement.
24. Process Automation builds a workplace system where human and machine are interacted (integrated system of different resources)
25. A critical part of the management of quality is the strategic and systematic approach to achieving an organization's goals. Process Automation, supporting Human Effort Engineering, helps the company to formulate a better strategic plan.
26. A large aspect of TQM implementation is continual process improvement. Process Automation create a standardized working environment where continual improvement can be conducted.

27. TQM requires that an organization continually collect and analyze data in order to improve decision-making accuracy. Ergonomic and efficiently designed workplace is offered by Process Automation thus data collection is simplified.
28. Process Automation and Digitalization simplify the communications by building various communication channels between the employees, company and partners.
29. Process Automation constructs a comfortable, delightful and systematic environment thus keeping employees satisfied.
30. Process Automation creates a safe environment and reduces injury thus to better implementing TQM or ISO certificates.

Please fill up your identity
*Name:
*Surname:
*Age:
*Gender (M/F):
*Occupations:
*Experience with the company (year):
*Education level (Bachelor's, Master's, PHD, None):
(Your identity is kept confidential; your response is published)
Hypophesis4 (H4): Please evaluate the impact of managers and TQM on working environment thus high quality products and operational benefits.
31. Improved customer focus and satisfaction
32. Costs reduction and thus better cost management
33. Higher profitability
34. Elimination of defects and waste
35. Strengthened competitive position in market
36. Higher product and service quality

37. Reduced manpower thus less human error and labor cost
38. Flexibility in improving the product, capability of production volume and keep up with market change
39. Effective communication among business partners and stakeholders
40. Reduced operational complexity

The questionnaire responses

Participants Identity	Age	40	52	49
	Gender	Female	Male	Male
	Occupations	Quality	Production	Project
	Experience	21	12	11
	Education level	Master's	Master's	Master's
values between one to ten, where one indicates that this activity has a little impact or the participant disagree with the statement, and ten indicates that the activity has a remarkable impact and the participant fully agree with the statement				
Hypothesis (H1)	**Nº**			
Conduct International Organization for Standardizations	1	10	9	10
Facility layout improvement design	2	8	10	9
Staff training	3	6	7	7
Monitoring the working environment	4	7	8	6
Job rotation	5	10	9	9
Office furniture standardization	6	4	5	3
Work station safety	7	5	7	4
Ergonomics of noise, temperature, humidity and temperature	8	7	8	6
Ergonomics of light and brightness	9	8	9	5
Body anatomical	10	5	5	5
Hypothesis (H2)	**Nº**			
Focus on manpower	11	10	9	9
Employee commitment	12	10	10	9
Integrating program and process thinking	13	7	6	7
Integrating system	14	10	9	9
Strategic plan formulation	15	10	7	5
Continual improvement by standardizing the workplace	16	7	7	6

Organization performance by evaluating the employees	17	7	6	5
Effective communications	18	10	8	9
ISO 9001:2015 - Quality management systems.	19	8	9	8
ISO 45001 occupational health and safety management	20	8	9	7
Hypothesis (H3)	**Nº**			
Automating manual tasks	21	8	10	8
Technology improve workplace system	22	8	9	6
Fundamental part of TQM is a focus on process thinking	23	7	8	6
Human and machine interconnection	24	6	9	5
Strategic and systematic approach to achieving an organization's goals	25	7	8	5
Continual process improvement	26	9	10	9
TQM requires to collect/analyze data to improve decision-making accuracy	27	10	10	9
Simplify the communications by building various communication	28	10	10	9
Process Automation constructs a systematic environment	29	7	8	7
ISO certificates	30	8	10	8
Hypothesis (H4)	**Nº**			
Improved customer focus and satisfaction	31	10	9	9
Costs reduction and thus better cost management	32	7	6	5
Higher profitability	33	8	9	9
Elimination of defects and waste	34	7	6	7

Strengthened competitive position in market	35	9	8	8
Higher product and service quality	36	9	8	8
Reduced manpower thus less human error and labor cost	37	7	6	7
Flexibility in improving the product, capability of production volume and keep up with market change	38	10	9	10
Effective communication among business partners and stakeholders	39	9	9	10
Reduced operational complexity	40	8	7	8