KOKKUVÕTE

Lõputöö teema oli UCU koostamise automatiseerimise analüüs ettevõttele ABB AS. UCU koostamise automatiseerimine on ettevõttele oluline, sest UCU mudelite tootmismahud järgnevatel aastatel suurenevad. Lõputöös lahendatavaks probleemiks oli UCU koostamise liiga pikk aeg ning koostamise vähene automatiseeritus. Lõputöö põhieesmärgid olid UCU koostamise automatiseerimise analüüs ja toote disaini kitsaskohtade väljatoomine, esialgse lahenduse väljapakkumine UCU koostamise automatiseerimiseks ja selle majandusliku kasu leidmine ettevõttele ning UCU koostamise aega vähendava abivahendi projekteerimine.

Esimeses peatükis on toodud UCU toote kirjeldus koos selle olulisusega sagedusmuundurite juhtimisel. UCU-d on võimalik kasutada näiteks sagedusmuunduriga ACS6080, millega saab juhtida erinevat tüüpi vahelduvpinge elektrimootoreid. UCU mudelid jagunevad fiiberoptika ühenduste arvu järgi neljaks mudeliks: UCU-22, UCU-23, UCU-24 ja UCU-26.

Teises peatükis on toodud UCU koostamise automatiseerimise analüüs. Suurima tootmismahu osakaalu põhjal valiti automatiseerimise analüüsiks UCU mudel UCU-22. Peale selle toodi välja UCU erinevate mudelite komponentide arvud ning ülevaade UCU-22 komponentidest. UCU-22 peakoost jagati neljaks alamkoostuks: korpuse pealmine pool, korpuse alumine pool, mälukaardihoidja koost, trükkplaatide koost. Sellele järgnes UCU koostamise ala kirjeldus ning UCU-22 käsitsi koostamise etappide ülevaade, mis koosneb 18 etapist. Koostamise protsessil teostati koostamise aja ja komponentide ühendamisjõudude mõõtmised. Lisaks toodi välja praeguse UCU-22 koostamise puudujäägid. Sellele järgnes UCU-22 disaini analüüs automatiseeritud koostamiseks, kus DFA2 meetodiga analüüsiti UCU-22 disaini nii komponendi- kui ka koostupõhiselt.

Kolmandas peatükis on toodud UCU-22 koostamise robotiseerimine. Selle jaoks valiti DFA2 indeksite, koostamise ajakulu ning majandusliku otstarbekuse põhjal välja robotiseerimiseks sobiv koost, milleks osutus trükkplaatide koost. Järgmisena valiti välja trükkplaatide koostu robotiseerimiseks sobivad koostamisetapid ning nende põhjal loodi robotiseeritud koostamise etapid, kus on kirjeldatud robotiseeritud koostamise tegevused. Sellele järgnes robotiseeritud koostamiseks vajalike komponentide valimine, kus valiti koostamisel sobivaks haaratsiks OnRobot RG6, toodi välja haaratsi sõrmede prototüübi disain ning kirjeldati muudatusi UCU tööala komponentides. Antud peatükis väljatoodud valikukriteeriumite põhjal tehti sobiliku roboti valik, milleks osutus ABB koostöörobot CRB 1300-11/0.9. Roboti tööruumi põhjal pandi paika roboti töökoha ja komponentide paigutus ning tehti muudatused UCU tööala CAD mudelisse. Järgmisena kasutati muudetud tööala mudelit programmis ABB RobotStudio, kus simuleeriti trükkplaatide koostu robotiseeritud koostamist. Simulatsioonist selgus, et robotiseeritud koostamiseks kulus 121 sekundit, mille põhjal on robotiseeritud koostamise ajaline võit võrreldes käsitsi koostamisega 81 sekundit. Sellele järgnesid majanduslikud arvutused, kus selgus, et kui tootmismaht on 25000 toodet / aastas, siis on robotsüsteemi tasuvusaeg ligikaudu 6,9 aastat.

Neljandas peatükis on toodud UCU abivahendi projekteerimine. UCU abivahend projekteeriti UCU fiiberoptika katete eemaldamiseks ja paigalduseks. Abivahend projekteeriti universaalsena, mistõttu on võimalik seda kasutada kõikide UCU mudelite puhul. Projekteerimisel toodi välja abivahendi tööpõhimõte ning tähtsamate detailide projekteerimine ja arvutused. Sellele järgnes prototüübi testimine, kus selgus, et kõige suurem kasu saadakse abivahendi kasutamisega UCU-26-l, mille korral koostamise ajakulu väheneb ligikaudu 124 sekundit.

SUMMARY

The subject of this thesis was UCU assembly automation analysis for ABB AS. The automation of UCU assembly is important for the company because the production volume of UCU will increase in the following years. The problem to be solved in this thesis was that UCU assembly takes too long time and it is not automated enough. The main objectives of this thesis were UCU assembly automation analysis and identification of shortcomings in the product design, proposal of the solution for UCU assembly automation and finding it's economic benefits for the company, and designing a jig that reduces the time of UCU assembly.

In the first chapter, the description of the UCU along with it's importance as a controller for frequency converters is explained. The UCU can be used, for example, with ACS6080 frequency converter, which is used to control different types of AC electric motors. UCU is separated into 4 models based on the number of fiber optic connections: UCU-22, UCU-23, UCU-24 and UCU-26.

In the second chapter, UCU assembly automation analysis was done. Based on the production volume of different UCU models, UCU-22 was chosen for automation analysis because it has the largest production volume. In addition, number of components of different UCU models were presented and a overview of UCU-22 components was listed. UCU-22 main assembly was divided into four subassemblies: upper half of the case, lower half of the case, memory card holder assembly, circuit board assembly. This was followed by a description of the UCU assembly work area and an overview of UCU manual assembly steps, which consists of 18 steps. During the assembly process assembly time and component connection forces were measured. In addition, the shortcomings of the current UCU-22 assembly process were pointed out. This was followed by an analysis of the UCU-22 design for automated assembly, where UCU-22 design was analyzed on part and assembly level.

In the third chapter, robotization of the UCU-22 assembly was presented. Based on DFA2 indexes, assembly time and economic feasibility, an assembly suitable for robotization was selected. The selected assembly was the circuit board assembly. This was followed by selection of assembly steps that are suited for robotic assembly process. Based on that selection, robotic assembly steps were created and described. This was followed by the selection of components required for robotic assembly, where OnRobot RG6 was selected as the suitable gripper for assembly, the design of the gripper finger prototype was presented, and changes in the components of the UCU work area were described. Based on the selection criteria presented in this chapter, a suitable robot was

chosen. The chosen robot was an ABB collaboration robot CRB 1300-11/0.9. Based on the robot workspace, the layout of the robot's work area and components were determined, and changes were made to the CAD model of the UCU work area. This was followed by an ABB RobotStudio robotic assembly simulation, where the modified work area model was used. Based on simulation, robotized assembly of the circuit board assembly took 121 seconds. Compared to manual assembly time, robotized assembly had an assembly time reduction of 81 seconds. This was followed by economic calculations. Based on calculations, if the production volume is 25000 products per year, then the payback time of the robot system would be approximately 6,9 years.

In the fourth chapter, design of the UCU jig was presented. This was designed for the removal and installation of UCU fiiber optic covers. The jig was designed to be universal for all UCU models. The working principle of the jig was presented, which was followed by calculations and design of the most important parts of the jig. Finally, the prototype of the UCU jig was tested and it was found out that biggest benefit was achieved when using the jig with UCU-26. Assembly time of UCU-26 can be reduced by approximately 124 seconds when using this jig.