TALLINNA TEHNIKAÜLIKOOL
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ROBOTIZATION OF INDUCTOR SOLDERING PROCESS

INDUKTIIVPOOLI TOOTMISLIINI JOOTMISPROTSESSI ROBOTISEERIMINE

MASTER THESIS

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SUMMARY

The current trend in the industrial robots market shows that prices are falling and production quantity is increasing. This creates an opportunity for small and medium-sized manufacturing companies to integrate robots to their production. Robots can handle extreme environmental conditions, they don't ask wage, and are good in repetitive and precise tasks.

Robotization of inductor soldering process is a thesis topic that explains design of robot cell for the inductor production company, to improve the solder quality of inductors. As the paper progresses, the design and equipment choices for the various parts of the assembly will be explained.

The author became familiar with the manufacturing process of inductors in the company, which revealed that the soldering quality of some of the inductors, when soldered in tin bath, does not meet the quality requirements. A lot of time is spent on cleaning the solder, which makes the production inefficient. To solve the problem, production executives wanted to try other type of soldering machine, but this machine poses a major risk to human health because of the high probability of serious burn damage. To overcome this issue, robot should solder the inductors.

Before designing phase, the requirements were determined. Robot cell has to fit in a 2x2 m area. Safety requirements have to be met. Inductors are fed to the robot on a tray in quantity of at least 100. Gripper must be able to grab 4 inductors, must not damage it, and in case of power supply failure it maintains its state.

Robot frame is built from aluminium profile and footprint is approximately 1x1 meters. Robot, soldering machine and part feeding system is placed on a desktop in a layout configuration that provided optimal robot motion. Part feeding system and soldering machine is as far as possible from each other to eliminate heat radiation threat to other devices. Electronics cabinet and robot controller is placed under the desktop. Robot is surrounded by physical guarding from three sides. Robot cell accessibility is provided by placing safety laser curtains in the front and doors with safety magnetic switches to the back of the robot cell. Robot frame ability to handle forces and torques of the robot is simulated in SOLIDWORKS and by real testing.

Part feeding system was designed inspired by Poke-Yoke mistake proofing method. As a result tray is fixed in one possible way and fits 100 inductors that sit in specially designed sockets. Tray is made out of POM.

Electrical parallel gripper with worm gear unit was selected, as it is self-locking and integration to the system is cost effective. Gripper position feedback is given by position sensor with. To withstand heat from the soldering machine and to have surface roughness that does not damage the inductor, the "claws" were made of stainless steel, attaching to the aluminium "fingers". "Claws" were designed to be able to handle 4 different inductors.

Safety equipment were connected to the robot controller in a way that hazardous situation will cause robot to stop. State of the robot cell is visually indicated by signal tower. External PLC and robot controller are interfaced via Profinet. Gripper control program is written in the PLC and robot controller is giving commands to open or close the gripper.

The success of this project can be measured in real outcomes. With the latest feedback from an inductor production company, for whom the robot cell was made, they claimed that these inductors, which quality were poor with tin bath soldering, are meeting the quality requirements with robot soldering solution.

KOKKUVÕTE

Hetke trend tööstusrobotite turul näitab märke hinna langusest ja mahtude suurenemisest. See annab võimaluse väikestele ja keskmistele tootmisettevõtetele integreerida roboteid oma tootmisesse. Robot taluvad ekstreemseid keskkonna tingimusi, nad ei küsi palka ning on head korduvates ja täpsetes liigutustes.

Induktiivpooli tootmisliini jootmisprotsessi robotiseerimine on lõputöö teema, mis kirjeldab robot töökoha disainimist induktorite tootmis ettevõttele, et parendada induktorite joote kvaliteeti. Töö arenedes arutatakse koostu disaini ja seadmete valikuid.

Autor tutvus ettevõtte induktorite toomis protsessiga, kus selgus et osade induktorite jootis kvaliteet ei vasta nõuetele, kui neid joota tina vannis. Kvaliteedi parendamisele kulub palju aega, mis muudab tootmise ebaefektiivseks. Probleemi lahendusena soovitakse võtta kasutusele teist tüüpi jootis masin, millega töötades peaks kvaliteet paranema, kuid see masin kujutab ohtu inimese tervisele, sest on võimalik saada tõsiseid põletus haavu.

Ennem disainimist pannakse paika nõuded. Robot töökoht peab mahtuma 2x2 m pindalale. Peab vastama ohutus nõuetele. Minimaalselt 100 induktorit peab mahtuma kandikule, mis söödetakse robotile. Haarats pea olema suuteline haarama vähemalt nelja induktorit, ei tohi tooteid kahjustada ja toite allika rikke korral ei tohi muuta oma olekut.

Disainitud robot raami pindala on umbes 1x1 meetrit ning ehitati alumiinium profiilist. Robot, jootmismasin ja toote etteande süsteem paigutatakse tööpinnale pinnalaotuses, mis võimaldab optimaalset roboti liikumist. Etteande süsteem ja jootmismasin on üksteisest võimalikult kaugel, et kiirguv soojus ei saaks kujutada ohtu teistele seadmetele. Elektrikapp ja roboti kontroller paigutatakse töölaua alla. Robot on ümbritsetud ohutus piiretega kolmest küljest. Ligipääs tööalale on tagatud ohutus laser kardinatega eesmiselt küljelt ja ohutus magnet lülititega tagumiselt küljelt. Robot raami vastupidavust roboti poolt tekitatud jõududele ja momentidele on simuleeritud CAD tarkvaras SOLIDWOKS ning veendutud reaalsetes katsetustes.

Etteande süsteemi disain on inspireeritud Poke-Yoke meetodist. Tulemusena on võimalik kandik fikseerida ainult ühel võimalikul paigutusviisil, et ei oleks võimalik

eksida. Kandikule mahub 100 induktorit, mis on paigutatud spetsiaalselt valmistatud pessa. Kandik on valmistatud plastikust POM.

Tööriistaks valiti elektriline paralleel haarats tigu-ülekandega, mis on ise-lukustuv ning selle integreerimine süsteemi on kulu efektiivne. Haaratsi positsiooni tagasisidet loetakse positsiooni andurist. Jootmismasinast eralduvale kuumusele ja nõutud pinnakareduse saavutamiseks toodeti „küüned" roostevabast terasest ja kinnitati alumiiniumist „sõrmede" külge. „Küüned" suudavad haarata nelja erinevat induktorit.

Ohutus seadmed ühendati roboti kontrolleriga sellisel viisil, et ohukorral robot peatub. Robot töökoha olekut näitab signaalpost. Väline tööstuskontroller ja roboti kontroller ühendatakse võrku üle Profineti. Haaratsi juhtprogramm on kirjutatud tööstuskontrollerisse ja roboti kontroller saadab talle käske haaratsi avamiseks ja sulgemiseks.

Selle projekti edukust saab mõõta reaalsetes tulemustes. Tehas, kellele robot töökoht konstrueeriti, väitis viimases suhtluses, et need induktorid, mille kvaliteet tina vannis jootmisel jäi kehv, vastavad kvaliteedinõuetele robotiga jootes.