

HAN Master Major Project

Major Project Plan

Using Fanuc FANUC R-2000iC (6-axis robot) for improved efficiency in FRC parts formation

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Date: 12/09/2019

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Background

Fiber-reinforced composite materials are seeing a widespread use in a large number of applications ranging from aerospace systems over renewable energy production to automotive parts [5] [2]. These composite materials generally provide high specific strength and improved stiffness compared to other materials [3]. Through the combination of different materials, desirable mechanical properties like low weight with high stiffness can be achieved that would be hard or near impossible to recreate with single compound materials [7]. The attributes of an FRC can generally be described as the combination of three components [6]:

- The matrix, made of a polymer. This polymer can either be applied as a resin that hardens irreversible or a thermoplastic is used, that needs to be heated for application.
- The reinforcement component which consists of fibres with high strength and modulus. These days preferred materials are glass, carbon or polyethylene fibres.
- The fine interphase region. It's the interface between the matrix and the reinforcement that transfers the load between these.

FRC's can look back to a long history since the beginning of the 20th century with phenolic sheet Bakelite being the first fibre-reinforced plastic. Bakelite, a thermoset being the matrix was combined with different fibre materials like paper, cotton fabrics, or synthetic fabrics to create parts that can meet diverse mechanical, electrical and thermal requirements. [4]

In this project, a thermoplastic matrix will be used together with carbon or glass fibres. The mixed reinforced thermoplastic being supplied as pellets in various sizes for different properties is dried and then melted in an extruder through a continuous process. The material is then portioned into pieces by a guillotine and combined and stacked into assemblies by a delta robot. These assemblies are then brought to temperature again before being loaded into a hydraulic press with a mould by an industrial robot arm. [1]

Problem Definition

Assemblies of hot, formable Thermoplastic are delivered on a conveyor belt in varying positions after being reheated in an oven. The assemblies then need to be picked up with a FANUC R-2000iC/210F 6-axis Industrial robot arm from the conveyor belt through a small window in a heat shield that keeps the assemblies warm. The Industrial robot then swings over to the press when it is open and the mould is free. The assemblies are then placed inside the mould at desired spots while making sure, the robot arm does not collide with any part of the press. After all parts are placed, and the robot arm has pulled back in a safe position, the press is activated and forms the parts with heat and pressure. When the forming process is finished, the press opens, the product is picked by the robot arm and placed on another conveyor belt for further processing. As the press is free, the cycle can repeat. [1] The overall goal of the Smart Production Cell is to drive down cycle time for these composite parts from ca. three minutes to one minute. Also the robot needs to cooperate with different parts of the process like the oven and the press and it plays a major role in synchronization between the subprocesses.

Project Objectives

A control strategy with efficient movements guided by placement position data from the delta robot, velocity signals from the conveyor belts and flags from the press needs to be implemented in software on the accompanying FANUC R-30iB controller and the affiliated Siemens SIMATIC S7-1500 PLC .

Requirement Analysis

Certain conditions need to be fulfilled to make the project a full success. These can be split up into external and internal factors.

External requirements:

Power Supply In order to supply the whole production line with enough energy, 400A fuses need to be installed in the 400V 3-Phase building connection.

Surrounding Subprocesses All subprocesses (extruder with supply hopper, conveyors, delta robot with gripper, press with mould, robot gripper, oven with heat-shield) need to be in place and running on their own.

Test Material Some kind of test material needs to be supplied to demonstrate all abilities of the robot arm.

Internal requirements:

Fieldbus An Ethernet network needs to be set up to host the communication via Profinet between the subprocesses.

Software For simulation Visual Components and for control ROBOGUIDE with Karol Programming Language as well as TIA Portal need to be made available, installed and configured.

Robot Placement The final placement of the robot is not yet determined and the robot needs to be bolted to the ground in its final position before it can be used.

Activities and Products

With regard to the goals, following activities need to be carried out which produce below mentioned Products.

Activities:

Mounting and Floorplan All parts involved in the process except from the press are not yet bolted to the ground. A floorplan needs to be developed based on simulations in Visual Components. Together with the SPC team and consultants from Quing this

floorplan will be developed. Then the FANUC R-2000iC/210F together with all other components can be moved to their final position and bolted to the ground.

- Wiring** The FANUC R-2000iC/210F is not connected to power and to its accompanying R-30iB controller. Cables need to be connected to the robot and the controller.
- Commissioning** The FANUC R-2000iC/210F although being a second hand robot has never been put into operation at the SPC. The robot and its R-30iB controller need to be placed into operation step by step with several function tests.
- Fieldbus - Hardware** A Profinet fieldbus network needs to be designed and installed to connect all components with each other for exchange of data and commands. For this, an Industrial Ethernet network needs to be set up with a Profinet Stack. Twisted-Pair-Cables need to be cut in the right length and equipped with RJ45 connectors. Also additional network components like an industry grade switch for routing and Ethernet hubs as well as USB network adapters for package sniffing need to be selected and procured.
- Fieldbus - Software** To use Profinet, all involved network interfaces, input and output of data as well as global commands and flags need to be configured to make all devices communicate with each other.
- Modelling** To develop and test a controller for the FANUC R-2000iC/210F, a simulation in software will be made with the help of Visual Components. To get a deeper understanding of the robot arm, a kinematic modelling will be done.
- Sensors** All virtual and physical sensors necessary to guide the FANUC R-2000iC/210F will be identified, and connected to a Profinet member.
- Control Scheme** A control scheme for the FANUC R-2000iC/210F will be developed with the help of an iPendant connected to a R-30iB Plus controller and Karel Programming language in the software ROBOGUIDE to fulfill the desired tasks.
- Programming** Parts of the program for integration of the FANUC R-2000iC/210F robotic arm into the overall production line will run on a Siemens Simatic S7-1500 Programmable Logic Controller (PLC). This PLC is the brain of the plant where all information from different subprocesses comes together and is processed.
- Testing** After developing a program to control the robot, extensive testing is needed to verify safety and assure 24/7 operation.
- Report** A report will be made, and drafts will be sent to the supervisor for feedback.
- Fine Tuning** When all subprocesses work properly together, fine tuning can be applied based on observations to drive down the cycle time or reduce energy consumption.

Products:

- Floorplan** Floorplan including all major relevant components
- Model and Simulation** Model and simulation of the robot arm in the software Visual Components
- Control Scheme** Control scheme implemented in software
- Presentation and Report** Major project report and a real-life presentation of the movements of the Fanuc R-2000iC/210F

Organization

HAN Automotive has founded a Smart Production Center(SPC) in order to research the possibilities for improvement in mass production of lightweight automotive parts using Fibre Reinforced Thermoplastics (FRT). The SPC is located in the Mobility Innovation Center (MIC) in Industriepark Kleefse Waard (IPKW) in Arnhem.

The SPC provides a room for companies to collaborate with the HAN. Some of these companies interested in the project and inclined to help are located in the direct surroundings of the MIC building such as Quing who are involved with the simulations.

Peter Verschut, the Program Manager of Automated Composites and Didier Polling, researcher in lightweight structures keep an overview over the activities of all students involved. Suzanne Ezendam is Project coordinator and head of the building and labs.

Master Level

This Thesis project demands creating a model of the robotic arm. The modelling of the 6 axis FANUC R-2000iC/210F will require knowledge from Systems Modelling. Based on this model, a controller can be developed and a range of paths can be found through inverse kinematics. This controller is an extension of the subjects taught in the module Advanced Controller Design. The number of resulting paths can then be narrowed down further for example based on safety restrictions or the desired working area of the robot. This will be a further development of the knowledge conveyed in Applied Control Strategy from the module Applied Control. This results in a control scheme that can be implemented in the Karel programming language on the R-30iB controller. The basics of implementation were shown in Controller Implementation from the module Applied Control, although different programming languages will be used here. The control logic blending the robot into the overall process will be implemented on the Simatic S7-1500 PLC using the TIA portal software. This combination of multiple controllers working together was taught in the module Distributed Systems.

Besides this systematic approach for control, other tasks will be carried out. This includes the whole process from setting up the robot for first operation down to fine tuning for maximum efficiency. Additional requirements like safety need to be taken into account besides the goals of control. On top of that, feedback control with corrective signals from other subprocesses needs to be developed for optimal efficiency.

This project requires all abilities of a Control Systems Engineer, as not only knowledge taught in class is applied, but needs to be extrapolated in order to work with the given system. Multi-domain insight brought together in one control strategy will result in a smooth and reliable production process. Finally, as this project is a team effort where all knowledge is shared and implemented where required, efforts in team lead and management need to be made.

With this wholistic approach I will demonstrate my master level.

Restrictions

- To fully demonstrate all abilities of the FANUC R-2000iC/210F, all sub-processes need to be complete. Also test material will be needed that can be picked up and placed.
- The robot arm currently does not have a gripper. To demonstrate the picking abilities in real life with test material, this gripper will need to be designed in time.

References

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Timeplan
