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ROBOTIZED UNDERBODY PRODUCTION LINE FOR AUTOMATIVE INDUSTRY

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Abstract: *In the automotive industry, robots are a widely used and well accepted technology especially for car body assembly, painting and press workshops. Robots work best when the product development and manufacturing processing are designed for robotic application. Product modularity and standardization during the design phase allow for easy and fast system integration by combining standard components.*
Key words: *application, automotive, integration, robotics, safety*

1. INTRODUCTION

Altınay Robotic Technology Inc. is a Turkish company specialized in mechatronic projects and system engineering (Kurtuldu et al., 1999; Tukel at al 1999, Tukel et al., 2006). In 2009, a welding production line consisting of 34 robots including arc welding, projection welding, handling, stud welding and spot welding for the dashboard and underbody production processes of a car was designed and implemented. The line uses standard programmable logic controllers, based on a concept of integrated functions. There are twenty work cells, which work independently, with 34 robots. The underbody production line produces 729 vehicles a day for two shifts. This corresponds to 79 seconds cycle time.

A body assembly system for welding multiple component parts of vehicle bodies into connected assembly requires finish welding stations including accurately locating preliminary preassembled component parts in required accurate geometric relation. This process in itself is very complicated; great care has to be taken to ensure the quality of the product. For that reason fixtures and the welding quality are the key points for the success of this project. The Nut Welding process uses Emhart's drawn arc stud welding technology in manufacturing weld nuts. This process automatically feeds and welds nuts by using a robot. System components include a welder control, two weld heads, and a feeding system. In the automatic mode, the feeder continuously feeds stud bolts. There are two guns controlled by each robot via PLC. As the size of the bolts increases the welding parameters increase as well. First head always welds the smaller bolts, so lower current value. In the process of welding stud bolt to a base metal, the base metal and the forward end of the stud bolt are placed in contact with each other through an electrode element. An electric current is applied between the stud bolt and the base metal to produce an arc discharge for a predetermined period of time.

There are two safety programmable logic controllers, a special class of PLC designed for use in safety critical applications. In industry, the current approach to safety includes fenced equipment work cells with gated entry systems monitoring the use of control panel-mounted safety relays. By replacing the safety relays with a safety network and safety PLC, the hardware, cabling and engineering costs are reduced. The hardware design for the panels is minimized significantly. Also troubleshooting is easier.

The ability to produce a variety of products through the combination of modular components is a meaningful benefit of product modularity (He & Kusiak, 1997). To achieve high performance and correct schedule for such a complicated production lines, product modularity and standardization are essentials of system integration. .

In this application paper, our automation design concepts for the dash production line part of the underbody production line (Fig. 1) will be presented.

2. PROJECT PLANNING

A project has successive steps or phases up to the approval.

Contract: The list of materials allowed to be used, plant master plan (layout), process analysis, cycle time requirements are given.

Design: Main assembly tree for product/process, design of assembly jigs, robot hands, fences and facilities, feasibility of analysis using a software tool like ROBCAD, checking the performance objectives, detailed schedule including modifications.

Technical Approval of Design: Product-Process feasibility, process validations, the level of visually perceived quality that can be achieved are controlled. . Overall studies and detailed studies of assembly jigs and facilities are examined.

Start of Manufacturing, assembly: The prototype is built in the workshop: if alterations are necessary they are developed and any action required for achieving contractual performance is applied.

Test & Modifications: To achieve desired performance and cycle time, necessary modifications are done. All systems are tested with both with and without work piece and under all possible safety conditions.

Technical Approval for Delivery to Customer Plant: For approval, first the system should pass from safety test, without work piece 500 cycles in the automatic mode are implemented. If the system fulfills the requirements, the approval for delivery will be given.

Geometric Reception: In the customer plant, the pieces are produced until the geometric and welding quality, strength and penetration approval is achieved.

Technical Approval for Production: For production

Fig. 1.Dashboard Workcell

approval, system should produce 3000 work pieces without failure in automatic mode. If the system fulfills these requirements it will be ready for production.

3. CONTROL STRUCTURE

In the automotive industry, every car producer company uses a different hardware and software, so control systems could not be easily standardized for a system integrator company. In this project, the customer, Japanese automotive producer preferred Toyopuc programmable controllers and Kawasaki industrial robots. Each workcell has its own plc, operator panel, robot control units and drivers There is a production planning system for the operators showing the product in process and production a list for the process. Production data are stored and analyzed in order to define breakdowns and faults for the operator and the maintenance staff. A user-friendly man-machine interface is developed on a standard operator panel.

Safety (Urdenta et al., 2007) is a very important concern and primary motivation during the development and design of the system. The proper selection of an effective robotics safety system must be based on hazard analysis of the operation involving a particular robot. Among the factors to be considered in such an analysis are the task a robot is programmed to perform, the start-up and the programming procedures, environmental conditions and the location of the robot, requirements for corrective tasks to sustain normal operations, human errors, and possible robot malfunctions.

An effective safety system protects operators, engineers, programmers, maintenance staff, and others who could be exposed to hazards associated with a robot's operation. A combination of methods has been used to develop an effective safety system.

- Perimeter guarding: A fixed barrier guard is a fence that requires tools for removal. It prevents all access to the workcell from the outside. It provides sufficient clearance for a worker between the guard and any robot reach, including parts held by an end-effector, to perform a specific task under controlled conditions. A typical practical barrier is an interlocked fence designed so that access to the workcell is not possible when the gate is closed.
- Cell doors with interlock device: This is a physical barrier around a robot work envelope incorporating gates equipped with interlocks. These interlocks are designed so that all automatic operations of the robot and associated machinery will stop when any gate is opened. Restarting the operation requires closing the gate and reactivating a control switch located outside of the barrier.
- Light curtains and/or laser scanners: The presence detectors that are most commonly used in robotics safety are pressure mats and light curtains. Light curtains (similar to arrays of photocells) can be used to detect a person stepping into a hazardous area near a robot. If the working space of an operator has a complicated geometry, for better protection, laser scanners which can be programmed according to the application are used.

4. SOFTWARE STRUCTURE

Software development dominates the quality of the engineering process in the line integration projects (Huhn & Schaper, 2006). Simple principles (Flordal et al., 2007) which help to develop the essential skills which are the only guarantee of quality software include:

- Software reliability
- Homogeneity
- Readability
- Maintainability

Software Reliability is the probability of failure-free software operation for a specified period of time in a specified environment. Software Reliability is also an important factor affecting system reliability. It differs from hardware reliability in that it reflects the design perfection, rather than manufacturing perfection. The high complexity of software is the major contributing factor of Software Reliability problems. It is hard to balance development time and budget with software reliability.

Software homogeneity consists in writing the programs while respecting the same logic (writing structure), this also improves its readability.

Software readability is dependent on how easily the software can be decoded. Good readability improves maintainability. Programming should enable browsing affording up-tracking to the source of a fault (Wang et al., 2007).

Maintainability is the essential complement for long lasting performance. Maintainability is a fundamental condition for carrying out efficient maintenance operations and thus for guaranteeing performance. Furthermore, it is a means of rapid adaptation and low costs for future installation developments. Our software architecture is modular, with well-organized system of layers, such as safety,system, robot communication, HMI(Human Machine Interface).

5. CONCLUSION

A fully automatic system consisting of 34 robots has designed and developed by Altinay Robotics Technology. To achieve high performance and correct schedule for such a complicated production lines, great care has to be taken to ensure the quality of the product. Product modularity and standardization are essentials of system integration.

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