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SPECIFIC RISKS FOR ROBOTIZED APPLICATIONS

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Abstract: *The investment in robotized solutions for industrial processes follows different objectives like productivity, quality or improving the personal working environment. Fulfillment of such objectives creates an important pressure on the producers and increases the market competitiveness. For that, the companies must analyze each application and determine its characteristics and risks. The paper analyses two different robotized applications, welding and palletizing, in order to determine the specific risks impact on automation common objectives. Knowing in advance what and why certain things will happen in a robotized workcell, creates an important advantage, providing full control on the expected results.*

Key words: *industrial robots, applications, risk, palletizing, welding.*

1. INTRODUCTION

Industrial development is one primary path to achieving national economic development and positively impact the political, cultural, and social balance in a society [1].

In the last decade, many companies have increased their investment in computer-related technologies to reduce the time-to-market in the hope of gaining greater market share. They have invested substantially in computer-aided design (CAD) for product design [2] and computer aided robotics (CAR) for robotic workcells process design, in order to decrease the transition time between two different products in the same manufacturing system.

Using simulation, the robot task can be analyzed using a virtual model of the workcell at a time where only a digital prototype of the workpiece exists.

Furthermore, as any modifications are made to parts, the process of incorporating the modifications into simulation is very easy compared to the process of rebuilding an actual workcell. Also it enables users to thoroughly analyze workcell performance, optimize its configuration and debug the process plan.

The acknowledged advantages of simulation can be summarized as follows [3]:

- versatility – computer modeling may be used to represent a wide variety of real-world systems;
- flexibility – computer models may easily be altered to represent different situations of updated information;
- cost effectiveness – experiments using computer simulation enable the performance of a system to be reliably investigated without building the physical system;
- non-disruptive – simulation experiments permit a system to be designed, redesigned and analyzed without disrupting any existing system;
- exhaustive – simulation experiments may be performed under every conceivable set of system conditions, parameters or operating characteristics.

Along with its advantages, simulation also arises, at the same time, newer problems, such as:

- the accuracy of the modeled workcell is not high so it requires a calibration when developed in a physical world;
- the software's errors and programming bugs;
- difficult and time consuming to create an accurate digital model;
- the world has to be static with high accuracy in pre-manufacturing and clamping.

Industrial robots represent the key factor for automation technology. The continuous progress and innovation have reduced drastically the time for a specific task along with the evolution of high-performance robots. The goal for robotized automation is to manufacture a product with adequate quality meaning, either too good nor too poor, as cheap as possible and finished at the scheduled date [4].

In conclusion, maintaining a competitive industry at a national and international level refers to successful combining both technical and managerial aspects of industrial applications [1].

The International Federation of Robotics recently revealed the second highest result ever for the number of newly supplied industrial robots across the world, at 112,203. With 1.2 million industrial robots expected to be working in factories by 2010, ABB company outlined a number of key reasons, showing why it is worth investing in robotic automation.

The main objectives refer to [5]:

- reduce operating costs: with no requirement for minimum lighting or heating levels, the energy consumption can be reduced drastically;
- increase productivity: the robots can work faster, better and continuously, overnight or during weekends, with little supervision necessary;
- improve product quality and consistency: automation has a high degree of accuracy and repeatability so all the products will have the same standard;

- improve quality and work for employees: people will no longer work in dusty, hot or hazardous environments;
- reduce material waste: determined by avoiding the breakages and waste produced by poor quality products or inconsistent finishing.

That is why, using dedicated software, it is necessary to analyze the specific risks regarding robotized applications and how they influence the automation common objectives.

2. ROBOTIZED APPLICATIONS

Industrial robots have been proven to deliver a host of benefits in a wide variety of applications.

Their usage in the manufacturing process facilitates worker physical activity and automatizes production for a significant increase in economic efficiency but radically changing the processes design structure.

Robotized applications include several processes like machine tending, die casting, painting, cutting, press automation, assembly etc but most common are palletizing and welding applications.

Palletizing task is described as a uniform loading process of various products on a pallet. It is used, in general, for products like boxes, bags, pails and the stacking is made with the help of a pre-determined pattern and a given number of layers.

The use of industrial robots in palletizing processes is an important step for industry because it is necessary to promote efficiency of keeping and shipping tasks. Never the less, palletizing is one of the most monotonous and heavy work in the factory. For this reason, it has been developed an important number of industrial robots with different characteristics to meet the costumers' demands and the continuous process development. Nowadays the types of products and the numbers of case patterns that can be automatic palletized are practically limitless [6].

The welding process is defined as a permanent assembly between two pieces. It consists in arc welding and spot welding methods for different situations and applications. The process is based on the heat produced by an arc between a continuously fed consumable electrode and a workpiece. Its importance consists in an important productivity growth and improved product quality.

Starting from these two applications, we will analyze the risks using ABB RobotStudio simulation, off-line and on-line programming software regarding collisions, productivity and product quality.

2.1. Palletizing application risks

Regarding the technical solution, the palletizing process is a very simple one. The industrial robot requires an adequate gripper in order to be able to handle the specific products and the system, generally, needs in-feed and out feed conveyors and pallets.

Using ABB RobotStudio we analyzed a palletizing application with two robots: ABB IRB 660 for product palletizing and IRB 7600 for pallets manipulation (Fig. 1).

The process is carried out using two pallets: the products are picked up from the in-feed conveyor by the industrial robot, model IRB 660, and placed, using a simple pattern, on the first pallet. After the pallet is complete, the industrial robot, model IRB 7600, lifts the pallet and places it on an out-feed conveyor. During this period of time, the palletizing robot continues its operation, loading a second pallet. In this way the process is continuous and it optimizes the robots utilization.

Fig. 1. Complex palletizing system.

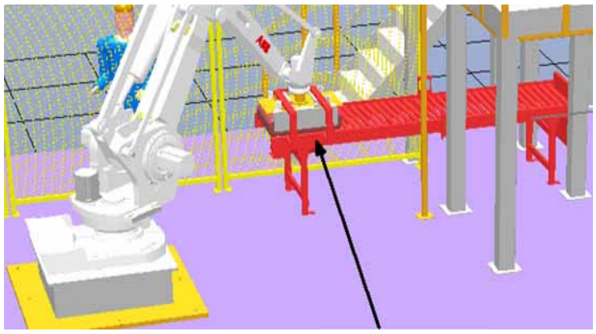

Fig. 2. Example of collision between gripper and conveyor.

Palletizing collision risks are present on a minimum level. They are generated when the product is picked up from a conveyor (collision between robots tool and the conveyor) or when the robot executes the handling operation (collisions with systems components) (Fig. 2).

The productivity risks refer to reducing or excluding the non-functional times and are present at a medium level. This situation is caused by the operations synchronization so the robots will work continuously and it also consists in how the robots technical characteristics are used in order to serve several conveyors.

Regarding product quality, it depends on the gripper characteristics so it can handle different product sizes or shapes.

The most common gripper types are [7]:

- clam shell mechanical gripper: it consists of two mechanisms that clamp to the product sides.

They are ideal for packages that are tightly packed and have a curved shape.

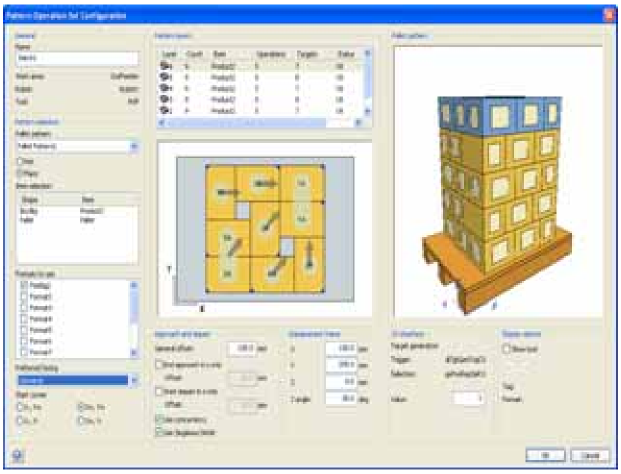

Fig. 3. Pattern operation and configuration.

- fork gripper: is a very flexible tool and is designed for products that require pick up from the bottom. It works best with bags that do not have a sufficiently flat surface for pick up from the top and/or the product in the bag is very loose or fluid. This kind of gripper can pick up nearly every type of packaging.
- bag gripper: is a hybrid of the clam shell and the fork gripper. It holds the bag from the sides but also utilizes tines that extend under the bag. This allows the gripper to hold between three to four surfaces of the bag. This construction method offers a high security clamp and is quicker and lighter (in weight) than the fork gripper model.

Challenges appear at products like bags because it depends on the bag type and how the product in the bag is packed. There are many differences between case palletizing and bag palletizing but these two elements will affect the cost and efficiency in operation. The bag modeling is nearly impossible in simulation environment but the problem can be solved through the use of a proper gripper type which works with every type of bags.

It also depends in using a dedicated software module so the products will be arranged in different generated patterns (depending on product sizes) or mixed product in-feed formats.

Such solutions are very helpful and ABB provides it with a dedicated module like PickMaster (Fig. 3).

2.2. Welding application risks

Robotized welding is a complex application regarded from the technical solution point of view and also from the process characteristics.

It requires additional components (besides the welding gun) like:

- safety welding gun holder;
- wire feeder system mounted on the robot;
- source of electric energy;
- sources of shielding gas (for MIG/MAG welding);
- positioning devices;
- process support tools (torch cleaner, tool center point calibration, wire cutter).

Thus, welding collisions are present at a maximum level. There are two major reasons that cause the collisions: the reduced distance between the welding torch and the pieces components and the small angles required for a circular welding belt.

In order to detect collisions errors, an exhaust pipe was analyzed (Fig. 4). A collision set was created in RobotStudio, composed by the welding gun and the piece, respectively the fixture devices (for holding the pipe components in position).

After the simulation there was identified the following errors [8]:

- collision between the gun and piece (Fig. 5): in order to make a circular belt welding, the gun must positioned between two components of the piece. Due to very low value angle, the gun comes into collision with the first component, when it is positioned to continue the weld on the second component. Such collisions are common in welding processes, especially when welding belt is made at an angle less than 90°.

The consequences conduct to a piece or torch deterioration risk and the subsequent positioning errors.

- collision between the gun and the fixture devices that holds the piece in position (Fig. 6): the clamping elements are arranged on the piece in order to create a high stiffness at the time of the welding process and their location is usually near the welding belt. Thus, the robot trajectory must be precisely calculated by introducing a safe distance between the welding gun and the clamping elements. Verification of the restriction imposed is served using "near misses" function which allows the introduction of a safety value and warn the user when this value is reached.

Collisions risks are also caused by the fact that the robot movements must be synchronized with the ones of the positioner for a complete circular welding belt.

The productivity risks refer to the technical characteristics of the robots and the systems equipments. It also depends on the time consumed for cleaning and calibrating the torch and the trajectory necessary to complete the process. RobotStudio provides the necessary information regarding productivity with "cycle time" function which calculates the amount of time needed to complete a process.

Fig. 4. Exhaust gas piece and fixture devices.

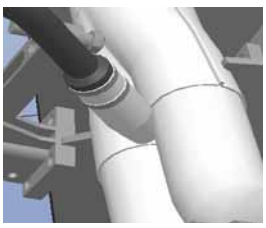

Fig. 5. Positioning error.

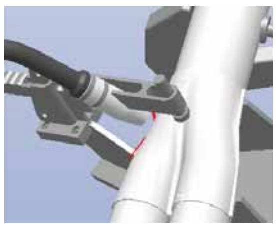

Fig. 6. Trajectory error.

The application quality depends on the hardware and software welding equipment. For example, ABB offers the Advanced Weld Control, a combined process control and "through the arc" joint tracking system integrated into robot controller. It is designed to track welding joint variations due to cast components or other pre-process problems and will in an automatic mode monitor and track the weld joint during welding.

A software solution is provided with ArcWeld Powerpack, an integrated module for RobotStudio and Virtual Arc software.

ArcWeld Powerpack is a dedicated tool for generating arc weld programs, using CAD geometry for creating weld location and robot positions. Virtual Arc software completes the ArcWeld Powerpack providing full control of MIG/MAG process in an off-line environment. It offers important functions like, setting the system parameters (power source, welding speed and wire feeder), application characteristics (define the piece material, plate thickness, joint configuration, weld position), process parameters (wire type and diameter, shielding gas), etc. [9].

As a result, the welding process can be fully controlled as well as the productivity and product quality.

3. CONCLUSIONS

Investment in robotized solutions is a difficult process because its cost is relatively high. Although many impediments have been excluded along with off-line programming and the development of CAD tools, industrial robots utilization generates specific application risks that affect general objectives. This leads in fulfilling only a part of the considered objectives and increases the time or even loosing the investment money.

The analysis shows the characteristics of welding and palletizing processes in order to identify the specific risks and their impact on the expected results.

First, the process complexity increases the impact of common risk types. For the palletizing process, the impact risks are minimal, depending only on the robot trajectory, and it can be easily detected and excluded. Using dedicated software modules, the quality and productivity can be improved by decreasing the time for generating the optimum pattern.

For the welding process, the collision risks are present on a high level and affect the productivity, causing a large number of scrap parts, increasing the material consumption or lowering the product quality.

Second, the applications demands different amount of money for investment. While palletizing requires a simple technical solution, like an adequate industrial robot equipped with a gripper, welding needs a wire feeder equipment, electric energy sources, process support tools etc. At the same time, for a good quality, welding must be controlled by a series of hardware and software solution that increases the investment value.

Knowing what can be expected of an application and how complicated it is producers can choose between different robotized processes and asses which one generates the highest profit and it is exposed to the lower risks. None the less, after the risks are identified, a strategy for reducing or eliminating the risks or its impact can be developed before the actual investment.

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