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Automation of Alloy Making Industry

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Abstract* - *The process of automation of alloy making industry will play an important role in safety of workers in such industries. An alloy making industry mainly is a manual system with risks of explosions. The industry consists of many processes which are currently controlled manually. The main objective of this project is to automate the complete process using different methods of automation. Automation will make the industry safe, robust, cheap, and highly efficient and maintenance free. The advantages of such a system are much more. Industrial automation plays an important role in increasing the yield of a product. Automatically controlling the process using various methods of automation is the basic view point of this project. This project will also minimize work load on workers.

***Keywords* – industrial automation systems, safety requirements, requirements at runtime, weight sensors, Programmable logic controllers.**

I. INTRODUCTION

In many alloy manufacturing industries, automation has not been a part of the industry even today. Automation is a process of reducing human efforts and using machines for performing the operations. Automation of alloy making industry includes complete automation of the industry which works on old methods of alloy making. Although practises have been carried out to automate these alloy manufacturing industries there have not been a complete automated industry. The process utilizes different weight sensors, temperature detectors, and PLC and conveyor system. The conventional system consists of a furnace, powdering machine and filtering system. Different metals in appropriate proportion are first mixed properly in a furnace. The proportion is as decided by the vendor. The furnace temperature is maintained by adding flux to the mixture. Flux may be compounds like carbon, scrap metals like in case of Ferro alloys. The mixture is then heated to the requisite time of about 4 hours. After the heating process a ball of alloy is formed. This ball consists of impurities bound to its boundaries. These impurities are removed manually with the help of hammer. This ball then is crushed and made into small pieces almost the size of granules. These granules are then passed through the powdering machine where they are crushed to form small powdered particles. These powder is then passed through a filtering system for filtering and the remains are then again send back to the powdering machine. The one problem that occurs in the powdering machine is that as the granules are crushed into fine particles there is a high chance of the particles catching fire. To prevent such fire there no controlling action was done previously. As the particles are small and as the pressure being lower the fire spreads at a great speed. This action can cause an explosion blast of several meters diameter. The main cause of the fire is friction between the blades of the crusher and the granules. So there is a need of controlling actions to be taken to prevent mishaps.

Alloys made by the combination of one metal and another metal/non-metal are generally stronger than its components. In other words the properties of an alloy are much stronger than the properties of the individual components it is made of. For example: Steel- the metal alloy made by the combination of iron and carbon has more properties and is stronger than iron itself. A wide variety of methods can be used to produce alloys. Two of the processes commonly involved in its production are the hot and cold processes. But the kind of process used depends upon the complexity of the metal being produced and the metals or non-metals used as its production components. Today alloy manufacturing companies in Dubai use electric induction furnaces unlike what was done in the olden days. In the ancient times, alloys were manufactured with the help of the muscle and flame technique. Automation of alloy making industry includes automating the industry to minimize mishaps. Although complete automation of this type of industry is not possible; efforts have been taken to automate it to most extent. In this position paper, we introduce a safety requirements framework and program the PLC using ladder logic for knowledge representation. We use an educational model of an industrial process plant as a use case for industrial automation systems. The educational model is used for simulation of complex industrial batch process, and consists of different components, such as motors, conveyors, switches, photodiodes and sensors, that are connected to each other and are controlled using programmable logic controller. The usage of the educational model of an industrial process plant for enforcing safety requirements at runtime can be used to illustrate the actual situation of real industrial automation systems, typically involving much more complex and interconnected components. In this work, the elicitation of safety requirements is performing by analysing several scenarios in which high-risk accidents could happen to the system. By observing these scenarios, we collect the safety requirements and model them using programming. These safety requirements later are used as the basis for linking to design time information in order to validate constraints or rules at runtime. The remainder of this position paper is structured as follows: Section 2 shortly summarizes relevant related work, while Section 3 describes the research goal. Section 4 explains the solution approach and details on the use case using the educational model of an industrial process plant. Section 5 discusses the initial findings, summarizes benefits and limitations of the proposed approach the results, concludes the paper and identifies further work in the research area.

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II. RELATED WORK

This section summarizes related work on industrial automations systems and safety requirement approaches at runtime.

A. Industrial Automation Systems

Complex industrial automation systems need to be flexible to adapt to changing business requirements and to become more robust against failures during runtime. Many authors have used an example of an educational model of an industrial process plant to simulate complex industrial batch processes, such as the processes typically implemented in like refineries, alloy manufacturing, or pharmaceutical plants. It consists of furnace used for making the actual alloy. The amount of metallic powders to be added to the furnace is determined by the programmable logic controller. Ratio of the metallic powders is given by the vendor and this ratio is adjusted by programmable logic controller according to any one weight. The furnace is also provided with a temperature sensor for temperature representation. The temperature sensor is just for reference. This educational model of an industrial process plant is also used as use case in this paper to demonstrate the proposed requirements t of safety at runtime for industrial automation systems.

B. Safety requirement approach

The crusher is where there is a hard requirement for safety instrumentation. The crusher is also known as the powdering machine. The main purpose of this machine is to crush granules into small powdered particles. Some approaches have already been proposed at software runtime for safety measurements. The crusher is provided with a photodiode. Photodiode is very sensitive to light energy and gives signal the moment it sees spark. The plc programming will be such that as soon as the spark is detected the supply of carbon dioxide, which also will be provided inside the crusher, will start automatically. Also other safety precaution will be; as soon as spark gives a signal the crusher will stop immediately; thereby preventing further damage.

C. Further Automation

The next system is the filtering system. The output of the crusher will be held in a large tank at the base of which there will be a valve operated by plc. The tank will also be provided with level sensors. As soon as some level is detected the filtering system will be turned on and the valve will be opened. A level sensor for high level detection is also provided which will stop the crusher in case the level rises above the limit. Conveyor belts provided at the base of filtering system will help the process in packaging. The conveyor belt will be activated as soon as there is a supply from the filtering system. The programming of the plc is done according to the requirements.

III. RESEARCH GOAL

This section describes the research goal and main research issue we want to discuss in order to enforce the safety requirements and increase the accuracy at runtime. Safety requirements usually are derived at design time using a set of different scenarios. However, the need to enforce that the safety requirement items are really fulfilled during runtime is still a big open question. We formulate our research goal as *how to establish a set of steps and rules to enforce and ensure that the safety requirement items we have derived in the design time are really followed and fulfilled at system runtime*. We use the educational model of an industrial process plant as our use case; this use case can easily be generalized for larger industrial automation systems. The main goal of this paper is to automate an alloy making industry to maximum possibility. This includes automating mixing flow of the inlet metallic powders, safety instrumentation for fire detection and automating packaging system. Although the crushing of alloy output from the furnace remains manual, there will be attempts to make those automatic too. Programmable logic controllers are used for this purpose. Industrial automation is largely based on PLC-based control systems. PLCs are today mostly programmed in the languages of the IEC 61131 standard which are not ready to meet the new challenges of widely distributed automation systems. Currently, an extension of IEC 61131 which includes object oriented programming as well as the new standard IEC 61499 are available. Moreover, service-oriented paradigms where autonomous and interoperable resources provide their functionalities in the form of services that can be accessed externally by clients without knowing the underlining implementation have been presented in the literature. In the supervisory control theory, methodologies based on formal models have been developed to improve the coordination of concurrent and distributed systems. In this paper, an event-driven approach is proposed to improve the design of industrial control systems using commercial PLCs. Programmable industrial automation can help meet the socioeconomic needs for increased productivity and job enrichment in labour-intensive industries. Characterized by production flexibility and ease of setup for new products, programmable automation is especially adaptable to manufacturing a variety of products in variable lot sizes at mass-production costs. Programmable, automated hardware/software systems existing in industry today include numerical control of machine tools, computer-aided design and manufacturing, production information and control, and industrial robots. These systems are being advanced by ongoing research and development activities; one major activity entails the application of robots with sensors to material-handling, inspection, and assembly operations. The ultimate goal of programmable automation is an essentially unmanned, computer-integrated automatic factory.

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IV. SOLUTION APPROACH

In this section, we present the description of the proposed solution approach to address the overall research goal introduced in the previous section. The solution approach is presented using the educational model of an industrial process plant, which consists of heterogeneous components that are connected to each other. From this model, we derive safety requirement that are required to prevent the model from damage. Current industrial automation systems are becoming more and more complex, and typically involve different phases of engineering, such as design time and runtime. System requirements, which are usually elicited during design time by engineers, currently are not sufficiently represented at runtime, like the runtime enforcement of safety requirements for industrial automation systems. Such kind of enforcement usually is very hard to model and predict at design time. Hence, the need exists to capture and manage safety requirements at design time and runtime, since safety requirements of industrial automation systems may lead to high risks if not addressed properly. In this position paper, we introduce safety requirements enforcement. The understanding of the general description of the educational model is essential for an easier understanding of the safety requirements we describe later. The illustration of the educational model as an image of the real running system is shown in Figure 1.

The various control loops to be provided in this model are as follows:

1. Ratio control for appropriate weights calculation.
2. Temperature control for appropriate flux calculation.
3. Spark detection for preventing hazards fire to occur.
4. CO_2 supply control loop activation in case of spark detection.
5. Filtering system for controlling fine particles into the packaging system.
6. Conveyor and weighing system for final packaging.

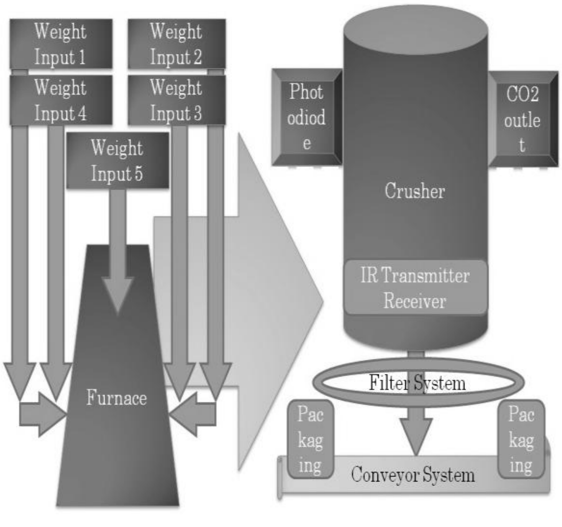

Fig. 1 A Basic Layout of the Complete Alloy Making Industrial Process.

V. CONCLUSION

The requirements of complex industrial automation systems, e.g., safety requirements, cannot easily be modelled and predicted at design time. Some safety requirements can be derived from the initial needs of the users or other stakeholders, but some other safety requirements can be derived only during or even after the systems runtime. Hence, there exists the need to capture and manage safety requirements both at design time and at runtime, since not properly addressed safety requirements of industrial automation systems may lead to high risks and even severe damages to people and environment. In this position paper, we proposed a method to enforce safety requirements at runtime by using a photodiode and supply of carbon di oxide gas to prevent hazardous fire. We initially evaluate the proposed approach using an educational model of an industrial process plant for enforcing safety requirements at runtime to illustrate the actual situation of real industrial automation systems. Initial results show that the analysis of different scenarios of possible failures of the industrial process plant model at runtime allows for a more efficient and effective management of runtime safety requirements, which are not easily predicted or modelled at design time. Perceived benefits of the proposed approach are the possibility of using the approach to check whether safety requirements are really applied and fulfilled during the system runtime. The paper outline a model for types and levels of automation that provides a framework and an objective basis for deciding which system functions should be automated and to what extent. Appropriate selection is important because automation does not merely supplant but changes human activity and can impose new coordination demands on the human operator. We propose that automation can be applied to four broad classes of functions: 1) information acquisition; 2) information analysis; 3) decision and action selection; and 4) action implementation. Within each of these types, automation can be applied across a continuum of levels from low to high, i.e., from fully manual to fully automatic. A particular system can involve automation of all four types at different levels. The human performance consequences of particular types and levels of automation constitute primary evaluative criteria for automation design using our model. Secondary evaluative criteria include automation reliability and the costs of decision/action consequences, among others. Examples of recommended types and levels of automation are provided to illustrate the application of the model to automation design. Automation design is not an exact science. However, neither does it belong in the realm of the creative arts, with successful design dependent upon the vision and brilliance of individual creative designers. (Although such qualities can certainly help the "look and feel" and marketability of the automated system). Rather, automation design can be guided by the four-stage model of human-automation interaction we have proposed, along with the consideration of several evaluative criteria.

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We do not claim that our model offers comprehensive design principles but a simple guide. The model can be used as a starting point for considering what types and levels of automation should be implemented in an Industrial process. The model also provides a framework within which important issues relevant to automation design may be profitably explored. Ultimately, successful automation design will depend upon the satisfactory resolution of these and other issues. Further work will include an improvement of the model, compatibility, cost reduction as well as complete automation. We will define and use more example scenarios to derive additional safety requirements, which we then plan to classify into classes of scenarios and types of safety requirements to make the safety requirements easier to handle. We also plan to optimize the PLC programming used for various control loops. Finally, we will perform comprehensive empirical studies to measure the improvement provided by the proposed approach.

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