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University-Industry Co-Operation to Promote Industrial Relevance in the Field Instrumentation Component of Control Education

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Abstract: In every manufacturing process field instruments establish the foundation for control. As a result, field instrumentation is an integral part of the control curriculum for engineering disciplines that support process manufacturing. In the Chemical Engineering curriculum most of the hands-on interactions with field instruments occur in the Unit Operations (UO) laboratory. In order to make these interactions industrially relevant, dialogue and active engagement with industry are essential. In this paper we present eight features of our co-operation with industry that have significantly expanded the breadth of the UO laboratory experiences for the Chemical Engineering students and faculty. In addition to providing financial help for state-of-the-art field instruments, our industrial partners have also shared technical resources and know-how that have enabled us to integrate the technology into the curriculum in an industrially relevant way. The most notable elements that distinguish our UO laboratory are the large number of installed field instruments (173), the distributed control system (DSC), the asset management system (AMS), and the high level of active interaction with field instruments. The end result is that our students are developing a marketable skill set directly applicable to the industrial practice of control. Our faculty are benefitting from the co-operation with industry as well by being provided with various opportunities for professional development.

Keywords: Control education, University-industry co-operation, Unit Operations laboratory, Partnerships, Field instruments

1. INTRODUCTION

The collection of measurement devices and final control elements installed on a manufacturing process is commonly referred to as "field instrumentation". The individual components are broadly called "field instruments". Their two main functions are sensing (e.g., flow meters, pressure meters, level switches) and actuation (e.g., control valves). In the hierarchical structure of modern process manufacturing systems, shown in Fig. 1, field instruments occupy level 1. The model in Fig. 1 is known as PERA (Purdue Enterprise Reference Architecture) and its concepts are integrated in two standards for enterprise-control system integration: IEC 62264-3 and ISA 95.03.

Fig. 1 clearly demonstrates that field instruments are the foundation of the control system and every higher-level function in the enterprise hierarchy depends on accurate measurement and actuation. One cannot control what one cannot accurately measure or manipulate. This is why engineering students in disciplines that support process manufacturing need to understand the fundamentals of how field instruments work, how to properly select them, and how to integrate them into an overall enterprise system.

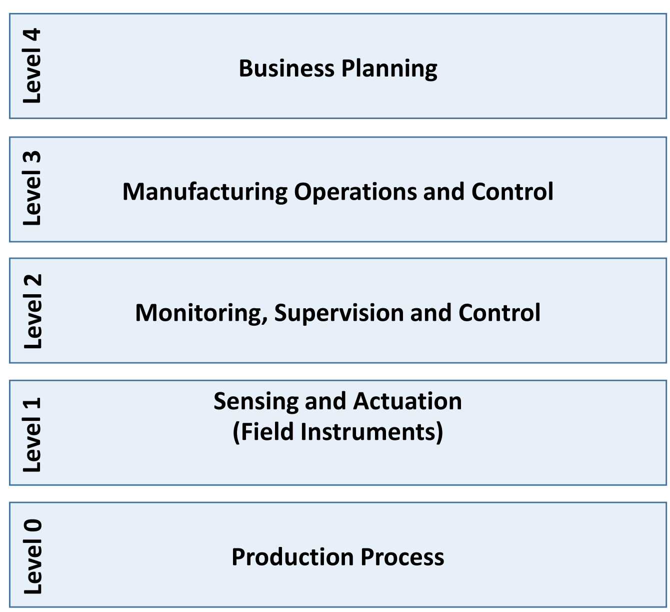

Fig. 1 PERA (Purdue Enterprise Reference Architecture) model for functional hierarchy in manufacturing systems.

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In a control education curriculum survey conducted by IEEE (Cook and Samad, 2009) 85% of the industrial responders ranked filed instruments (sensors and actuators) as the most essential element in process control implementation. In the same survey, 72% percent of the industrial and 61 % of the academic respondents listed "hands-on experience" as the area that needs to be improved the most in order to better prepare control engineers for industrial practice. In a more recent study by the American Institute of Chemical Engineers (AIChE, 2015), 62% of the respondents considered present academic preparation in control and instrumentation at the BS level as not relevant to employment needs.

For more than 15 years there has been an on-going discussion of whether the technical skills imparted on the undergraduate engineering students in universities are relevant to the industrial practice of control. Many control professionals agree that there is a growing gap between what is taught and what is practiced, Shinskey, (2002) and Alford (2006). To close this gap it is essential that industry be involved in the education process.

In the debate on industrial relevance of control education, it is important to acknowledge that universities cannot react to every trend in the fast moving industrial world. The main mission of the universities is to provide students with a broad based education in the fundamentals of their chosen subject, and not simply teach them the most popular current methods. On the other hand, universities have an obligation to provide education that is marketable to the industries they serve. The above arguments may seem mutually exclusive but laboratory courses provide the perfect setting for reconciling them. Laboratory development is an ideal vehicle for meaningful involvement of industry in the education process. The ripples in the existing curriculum are minimal while the benefits to the quality of education are enormous.

In the Chemical Engineering curricula the Unit Operations (UO) laboratory is well recognized for its hands-on educational value. It is the natural place where exposure to industrial practice and new technologies should occur. At Rose-Hulman Institute of Technology we have an active co-operation with industrial partners to make the UO laboratory environment very similar to that of a modern production facility. Students examine fundamental UO principles while interfacing with state-of-the-art field instruments and control system. In the course of their exploratory work students gain first-hand experiential knowledge and appreciation of the capabilities and intricacies of modern instrumentation and control technology. All this makes the technical skills developed by our students relevant to industrial practice and those students are highly sought after by employers in the process manufacturing industries, such as chemical, oil / gas, pharmaceutical, biotechnology, food / beverages, water / wastewater, semiconductor, etc.

At the same time our industrial partners have a vested interest in seeing students who are well educated in the fundamentals along with being well versed in the latest technologies. By investing in laboratory co-operation with universities, industry is effectively investing in its own future, making sure that there is a steady stream of young engineers who are well educated in the fundamentals and are also able to immediately start working with existing technology on process control implementation projects.

The co-operation with industry is beneficial to university faculty as well. It helps them keep their skills current with industrial practice and significantly improves the relevance of their courses. Faculty also have the opportunity to engage in industrial research and tackle challenging problems faced by industry. Furthermore, visible industrial engagement can bring more credibility to faculty in the eyes of students.

2. THE CHEMICAL ENGINEERING UNIT OPERATIONS LABORATORY AT ROSE-HULMAN INSTITUTE OF TECHNOLOGY

At Rose-Hulman Institute of Technology the Chemical Engineering Unit Operations Laboratory occupies two interconnected spaces: a two-storey high bay lab (10 m x 20 m) and a single-storey low bay lab (10 m x 15 m). It houses 15 pilot-plant size experimental rigs. Each rig illustrates the fundamentals of a particular unit operation, such as heat transfer, distillation, membrane separation, fluid flow, etc. Each experiment is treated as a plant area and is functionally isolated from the others. Eleven of the experiments are operated with an industrial distributed control system (DeltaV by Emerson). A total of 173 field instruments are interfaced with the control system. A high level summary of the installed field instruments is provided in Table 1. The data from all field instruments is recorded at all times in a centralized data historian. Students operate the experiments and access the data historian through remote operator stations located in close proximity to each rig. A dedicated control room with a view to the laboratory space houses the computer infrastructure of the control system. A typical experimental layout is shown in Fig. 2.

Fig. 2 Shell-and-tube heat exchanger experimental area.

The enrolment in the Unit Operations laboratory course is usually between 60 and 70 students per term. Each term lasts for 10 weeks. Students work in groups of three. Each group has six 4-hour long sessions to work on a particular experiment and complete the objectives of the experimental