A Miniaturized Model of the Industrial Solid Material Process Control Plant

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1. Introduction

In the past decades, a very centralized policy of the government has divided the country into two regions of development, namely the more industrialized western region and the less industrialized (and even less developed in many aspects) eastern region of Indonesia. The gap between the two regions has been widening in the last years of the twentieth century due to the occurrences of riots and civil wars in many places in the eastern region following the downfall of the New Order regime in 1998. Nevertheless, the new policy of autonomy gives a strong motivation to the eastern region of Indonesia to industrialize more rapidly. In fact, the eastern region of Indonesia is much richer of natural resources than the western region. However, the industrialization process in the east is held back by the lack of basic infrastructure and qualified human resources.

The city of Makassar is named as the gate to that eastern region. Almost all airlines and cargo ships en routed from the west to the east make a stop in Makassar. Naturally, more advantageous than other area in terms of infrastructure and human resources, Makassar has become the center of the rapidly growing industries in the east. This city is the home of Hasanuddin University, the largest and the oldest university in the eastern region of Indonesia. Recently, the Hasanuddin University Faculty of Engineering is planning to move to a new campus that is designed to accommodate a new way of teaching and learning process called the "Laboratory-Based Education" (LBE).. This new method is expected to enhance a better link to the surrounding industrial environment.

A few of industrial plants in the eastern region of Indonesia have been around since the Dutch colonial era. These industries are ranging from the oil and forest products industries in East Kalimantan, just across the straits of Makassar from the city of Makassar, up to the nickel mining industry of PT. INCO in Soroako, 14 hours driving to the northeast from Makassar. After more than a half century of independence of the country, the mining industries in East Kalimantan have expanded to include the coal and natural gas, and the refinery plants run by national oil company PT. PERTAMINA and its multinational contractors such as TOTAL, MOBIL OIL, ARCO, BRITISH PETROLEUM, etc. The agro-industry has grown extensively from mostly forest products industry to varieties of fishery products and plantations e.g. cacao (chocolate factory) in South Sulawesi, coconut (cooking oil products) in North Sulawesi, etc. In the land of Papua, a new city of Timika (a.k.a. Tembagapura, *tembaga* means copper) has been created to home a gigantic copper mining industry.

Closer to Makassar, there are two large cement industries within 100 km driving distance outside the city, namely the state-owned PT. SEMEN TONASA in Pangkajene Kepulauan (Pangkep) area and another privately owned PT. SEMEN BOSOWA in the district of Maros. Even in the vicinity of the city of Makassar, a flour milling industry of PT. BERDIKARI is in operation just next to the international harbour of Sukarno-Hatta, a steel industry of PT. BARAWAJA is located outside the city's only toll way, and varieties of medium-scale industrial plants are

operating in the Industrial Estate of Makassar (KIMA, *Kawasan Industri Makassar*). PT. PLN – a state owned and the only electrical power company – has its generating plants all over the places, ranging from the large hydro-power plant in Bakaru up north, a natural gas power plant at Sengkang about 6 hours driving north-east from Makassar, up to all kinds of small, medium and large steam and Diesel power generators. These plants are supposed to be interconnected and controlled by an electrical power load control center in Makassar.

All industries in the eastern region of Indonesia have neither training center nor R&D facilities to develop the skills and expertises of their technical people, especially in the process control technology. For many reasons, a training center specially built and located in the plant is not affordable for these industries. They only rely on the vendors of the related equipment who provide training programs as parts of the procurement contract or as a sales promotion activity. Of course, this kind of training programs is not the kind that the industries need.

On the other hand, the universities and other higher education institutions in the region who have capability and potential to provide training programs and R&D facilities for the industries only serve the academic purposes to meet the standard engineering curriculum. Most of the time this is not directly relevant to the specific industrial needs in the region.

We believe that the introduction of the LBE teaching and learning method in the engineering curriculum of Hasanuddin University will develop a better link between the academic world and the industrial world in the eastern region of Indonesia.

2. Process Control Technology

The process control technology has been developing for over 50 years since the end of the World War II. Before the implementation of the very first process control systems in industries, the manual process control systems had been used for almost a hundred years in Indonesia. In many factories existed since the Dutch colonial era in tea and sugar plantations, oil and coal mining industries, etc., the manual process control systems used human operators to take measurement of all parameters and variables, and to adjust set-points of the physical plants. These human operators are the main parts of the process control systems.

The introduction of the pneumatic controllers in the plants began the automatization of the process control systems. The role of human operators is still important in this case, but they were no longer distributed in all sub-systems of the plants like before in the era of manual process control systems. These human operators worked in a control center full of instrumentation panels. They performed all supervisory control and data collecting tasks through the panels at the control center 24 hours a day, 7 days a week. The introduction of electronic systems and the Information and Communication Technology (ICT) to the automatic process control systems later on was the next stage of the "evolution" of the process control technology.

The most common industrial plants involve measurement and control of water and liquid **level**, gas and air **pressure**, powder (fine particles), liquid and gas **flow**, **heat exchange** and **temperature**, and also other more specific parameters like **pH**, **salinity**, **humidity**, **oxygen content**, etc. To maintain these parameters at certain set-points, combination of controlling devices or actuators like **valves**, **pumps**, **heat-exchangers**, **heating elements**, **blowers**, **furnace**, **fans**, **boilers**, etc. are used in a plant. Thus, an ideal physical plant model should include those parts. In conventional plants, simple single-loop PID controllers can be used, but in complex modern industrial plants, state of the art of process control technology is unavoidable. Even in most industrial plants in the eastern region of Indonesia, Programmable Logic Control (PLC) systems or Distributed Control Systems (DCS) has replaced the old Supervisory Control and Data Acquisition (SCADA) systems. The next generation of process control systems including the Advanced Process Control (APC) systems consist of Self-Tuning Regulator and Adaptive Control Systems, Fuzzy

Logic Controller (FLC), Neural Network, and Multivariable Control and Model Predictive Control (MPC) are expected to enter the market soon. This is not to mention the application of Information and Communication Technology (ICT) in the process control systems, such as web-based control systems, on-line control systems, Man-Machine Interface (MMI) systems, multi-media etc.

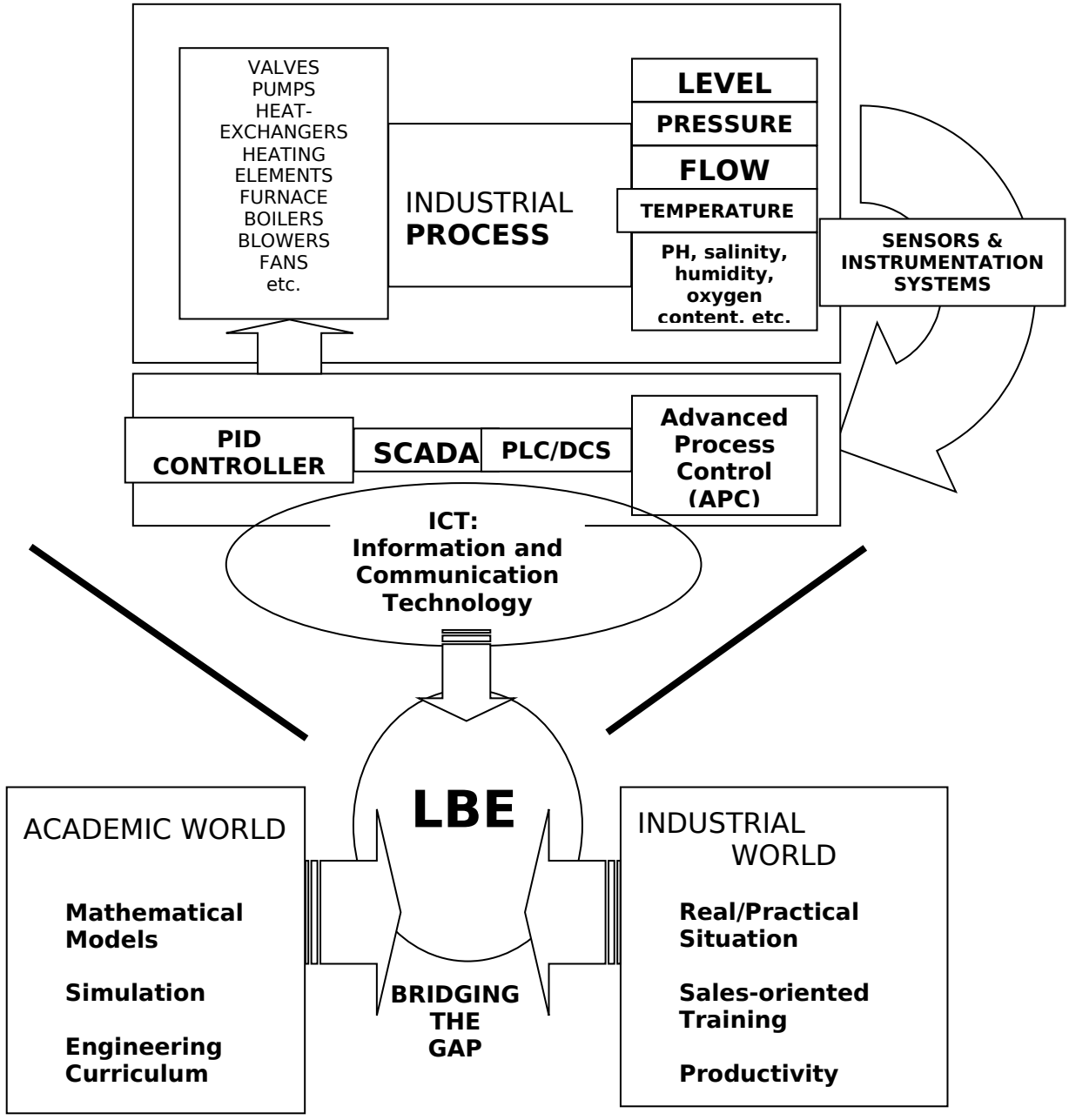

Figure 1: The role of LBE in bridging the gap between the academic world and the industrial world

In the academic world, students and trainees learn about the process control technology by relying on rigorous mathematical models of the plants in various simulation and analysis using all available methods and tools. This method of learning meets the standard of engineering curriculum in higher education institution, but most of the time does not give the students and trainees hands-on engineering experience, which eventually does not develop the students' and trainees' engineering sense and intuitive understanding on the real plants necessarily required in the industrial world. On the other hand, the technical people in industry find it difficult to comprehend a new progress in

process control technology, because they rely on training programs offered by the vendors, contractors and suppliers just to comply with the bidding process of procurement. These training programs are actually offered as a method of sales promotion, not a knowledge-based program. This development of the LBE teaching and learning methodt is an effort – state of the art - to close the gap between the mathematical-oriented training programs of process control technology in the academic world and the sales-oriented training programs offered by the vendors of the technology in the real industrial world (see Figure 1).

3. The Proposed Model Plant

In 2004, *Syntek Group*, a Malaysian-based company specializing in Process Control Training Systems (PCTS) presented their products at Hasanuddin University, Makassar. The theme of their presentation: "*Our product is Process Control Knowledge*" [1] had inspired the Department of Electrical Engineering to establish another central theme for its Control Systems and Instrumentation Laboratory (*Laboratorum Sistem Kendali dan Instrumentasi*, LSKI) i.e. Process Control Technology, in addition to the other theme previously established: Industrial Automation and Robotics. New required courses related to those themes, such as Process Control Technology and Industrial Automation, were introduced in the Department's 2005 Curriculum. A doctoral dissertation was proposed in this field by one of the Department's staff. The Ministry of Mining and Energy approved a proposal to equip the LSKI with a 2.5 billion rupiah worth of PCTS, now is in the process of procurement. Another set of PCTS is also being procured for the laboratory in the new campus. All those PCTS equipment represent industrial process control systems related to the liquid and gas materials, and none of them is representing solid material processes. As a matter of fact, no laboratory equipment in the market is related to the process control systems of industrial solid materials [2].

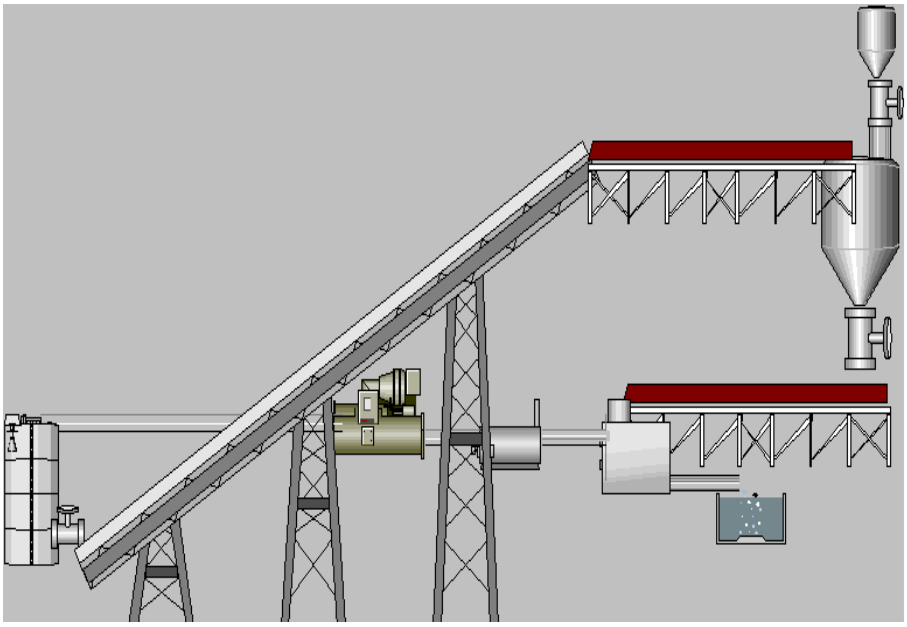

Figure 2: The preliminary design of the Industrial Solid Material Process Control Plant Model (*Courtesy of Andani [2009]*)

A good percentage of our alumni work in the industry in the surrounding eastern Indonesia region. The result of our survey has shown that most industries in the Eastern Indonesia region implement some sort of solid material processes like processes in the mining industries (nickel, copper, coal, etc.), in the flour milling and packaging and in the cement industries. Thus, in order to

represent the industrial world in the surrounding area more proportionally, the LSKI is proposing to develop a mini-plant model of an industrial process involving solid materials.

Figure 2 shows the rough sketch of the proposed mini-plant model. The model is an iconic model of a typical solid material processing unit in industries. The solid material used in the mini-plant is dry sand, and the basic implemented processes are soaking and drying into a certain moisture or percentage of water content. Using this mini-plant, students and interested faculty members can develop many research activities, and based on these activities a productive teaching-learning environment could be enhanced.

At the output portion of the mini-plant users can make several measurements, including the measurement of temperature, moisture, level and pressure, which are typical measurements in processes involving solid materials in industries. At the input portion, on the other hand, the users can apply control signals such as the opening of a valve, the speed of the belt conveyor, the speed of the stirrer, the furnace's heat-transfer, etc. These input-output measurements of the mini-plant will allow both students and faculty members to create reasearch projects on the instrumentation and monitoring systems. They will also be able to design a feedback control system by connecting the output monitoring system back into the input through a control algorithm such as PID control, neuro-fuzzy algorithm, adaptive algorithm, etc.

4. Concluding Remarks

Recently, Hasanuddin University has decided its road map of research activities to feature 2 (two) areas in techno-sciences, namely (1) the natural resources management and mitigation, and . (2) renewable energy resources, supported by 3 (three) other areas, namely (3) biodiversity and the climate changes, (4) food sustainability and (5) infrastructure development ([3], page 15-17). In line with the road map, this paper has presented the line of thought continuously and consistently followed by the Department of Electrical Engineering, especially, in this case, the Control Systems and Instrumentation Laboratory (*Laboratorum Sistem Kendali dan Instrumentasi*, LSKI) to develop its 2 (two) research themes, i.e., (1) *Process Control Technology* and (2) *Industrial Automation and Robotics*.

In the area of Process Control Technology - since 2004 - LSKI has proposed and has been granted various laboratory equipment and training systems to enhance the Faculty of Engineering's initiative to promote the Laboratory-Based Education (LBE) teaching and learning method, as one of the essential parts in preparation to move physically to the new campus. All those equipment and training systems represent the industrial process control systems involving liquid and gas materials. Our survey has shown that the majority of industries in the eastern region of Indonesia have processsing units of solid materials. However, laboratory equipment and process control training systems representing industrial processes of solid materials are not available in the market. This very fact has encouraged us to focus on developing a process control training system involving solid materials. The preliminary design of a mini plant model of such a process has been discussed in this paper, as well as in a dissertation written by one of our staff and several other research activities.

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