

INTEGRATED MANUFACTURING LABORATORY AND SOFTWARE TOOLS APPLIED TO AN INDUSTRIAL ENGINEERING UNDERGRADUATE COURSE

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Abstract: This paper describes the experience of using software tools associated with an integrated manufacturing laboratory in an industrial engineering undergraduate course at FEI (Fundação Educacional Inaciana, Brazil). The integrated manufacturing laboratory has got three complete manufacturing cells integrated by computer. The aim of the laboratory is to provide to the industrial engineering student a powerful analysis capability of how to use these kinds of systems to improve product quality and production performance. To do that, computational models are implemented using software tools like Visual Object Net++, Promodel® and WEB support. Finally, the models are validated in laboratory experiments. It was observed that such strategy has been given excellent learning results.

1 INTRODUCTION

In the recent years the production systems has become more and more important inside the industries. The old non flexible manufacturing systems which reduced the productivity and quality of the products have been discarded (Sanchez, L. M., Nagi, R., 2001).

Several new philosophies have emerged in an effort of improving the product quality at low cost. Among these new philosophies are the FMS concept, the computer integrated manufacturing and the management systems associated with production (Groover, M.P., 1980). The FMS concept provides flexibility, cost reduction and fast production (Heizer, J., Render, B., 1996). Nevertheless, teaching these new philosophies to undergraduate students is still a challenge. This task involves a good laboratory structure as theoretical methods of teaching as well. Moreover to make these theoretical methods efficient, software tools have been used successfully.

We have been testing such a strategy in the Integrated Manufacturing Laboratory in our organization (Fundação Educacional Inaciana, FEI – Brazil). The Manufacturing Laboratory is composed by three manufacturing cells each one containing

three articulated robots, three CNC machines and three conveyors. Though equipments have didactic characteristics they work much close as industrial equipments. The aim of the laboratory is not teaching industrial automation or robotics but mainly performance evaluation of production systems. The impact of layout changes and setup time reduction are some of studies carried out in the laboratory.

To the modelling of production systems and its performance evaluation Petri nets theory were introduced into the undergraduate course allied to analytical performance analysis. Completing the scenario, numeral performance analysis is performed using the simulation software Promodel®.

Finally, a WEB support was provided to students from Moodle platform. It provides a fast communication channel with the students through forum discussion sessions, material publishing and online evaluations.

2 THE MANUFACTURING LABORATORY

As previously mentioned the integrated

manufacturing laboratory is well equipped for its purpose. Figure 1 below shows a partial view of the laboratory.



Figure 1: The integrated manufacturing laboratory.

Considering the characteristics of the equipments the actual stage of the laboratory allows several studies into the automation systems, manufacturing problems, times and methods and production management. Some subjects actually bearing by the laboratory are: evaluation of layout changing in production systems performance; times and methods researches; product project and development; production planning and program.

The next session presents the software tools which are used either in direct or indirect form with the integrated manufacturing laboratory to provide high level of excellence in learning industrial engineering.

3 SOFTWARE TOOLS DESCRIPTIONS

To develop the industrial automation subject to the industrial engineering students several software tools are used together.

These software tools may be divided in three groups: the equipments software of the integrated manufacturing laboratory; the modeling software applied to performance and evaluation of the manufacturing and web support. These software tools are described in details below.

3.1 Software of the CNC Machines

The integrated manufacturing laboratory has got three CNC machines: two CNC mills and one CNC lathe. The software tools applied to mills and lathe are similar in functionality. Both of them have got a friendly user interface and allow fast programming

and evaluation results. The programming language is the well known M and G codes.

3.2 Articulated Robot Software

The articulated robot has got five degrees of freedom and each articulation is driven by a servomotor. Programming the points of the robot trajectory is often made through a programming terminal. On the other hand, program optimization, visualization and management are easily done by a friendly software interface.

3.3 Petri Net Software

To guarantee a powerful analysis of the manufacturing systems some modelling software tools were introduced into the undergraduate course. The first one is the Visual Object Net ++ which is a Petri net simulator. Petri nets are a very efficient tool when dealing with discrete event systems (Zurawski, R., 1994), (Zurawski, R.; Zhou, M., 1994), (Sun, T.-H., Cheng, C., Fu, L., 1994), (Girault, C., Valk, R., 2003).

A dynamic simulation of the discrete manufacturing is a fast and simple task when using Visual Object Net ++. Moreover, Visual Object Net ++ is a free of charge software.

3.4 Promodel® Software

The Promodel® software provides a full analysis of the manufacturing performance concerning time machine utilization, movement times, and statistic analysis, among others (Harrell, 2003).

3.5 Moodle® e-Learning Software

To improve the communication between students and professor such as material publishing and online evaluation as well an e-learning software is extensively used into the course. The practical experience reveals that this strategy is very efficient and well received by the students. The Moodle e-learning software still has a lot of additional tools like discussion forums and video publishing (Cole, 2006).

4 CASE STUDY

This section presents a case study in using the

integrated manufacturing laboratory and the software tools early presented in successful manufacturing experiments.

4.1 Problem Description

The proposal of the experiment implemented into the laboratory is to integrate all hardware and software tools available to solve manufacturing problems like productivity increases based in different layout possibilities using virtual and physical simulations.

The students investigate two different layouts, in line and flexible, with focus in non operational times, like movement times (Groover, 1980). The solution is (i) modelling the layouts using Petri, (ii) distribute the equipments based on the models and (iii) measure times involved. Finally, (iv) they calculate lead time and others important results to conclude what is the best layout.

All stages are closely accompanied by the tutors via personal attendance of the students and e-learning software. Concerning the e-learning software, the utilization of the discussion forums and the file exchanges are strongly suggested by the tutors.

Figure 2 shows the Petri net models which represents the discrete events mentioned above. Figures 3 and 4 present the Promodel® models of line and flexible manufacturing layout.

After analyzing the computational models generated by Visual Object Net++ and Promodel® some procedures are taken into account by the students. First of them is to compare the computational results with the previous analytical results generated. The second procedure is to apply production manufacturing concepts to change the initial purpose into a new one. Again, the first model is compared to the old one and conclusions about the performance emerge.

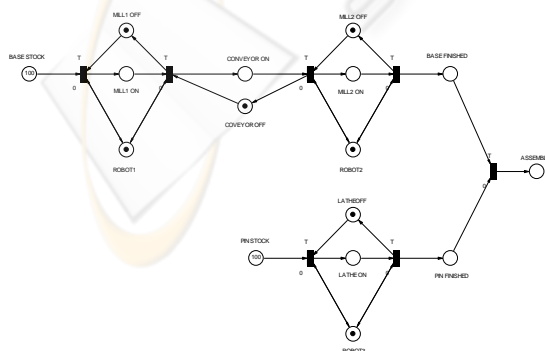


Figure 2: The Petri net line manufacturing model.

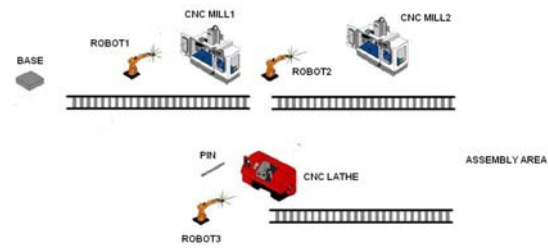


Figure 3: The Promodel® line manufacturing model.

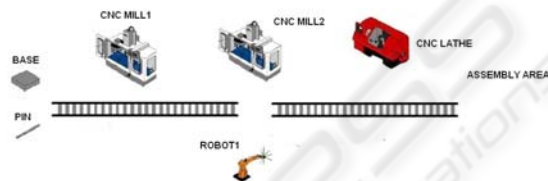


Figure 4: The Promodel® flexible manufacturing model.

4.2 Future Trends: Kyatera Net, ERP and MES

The WebLabs are labs where experiments, equipments and real systems can be controlled remotely through the Internet. They are built to allow sheering of ideas and equipments among researchers from different Labs, thus they are a way for new corroborative researches (e-collaboration) and e-learning. The scenario is as follow. The WebLab user access the Lab URL and by clicking out virtual buttons he/she controls the equipments, shows the results on screen and get the real time images from Lab.

We intent join this WebLab to Kyatera. Kyatera is a network of researchers, interconnected through a fiber-to-the-lab optical network dedicated to research, working remotely from their institutions in a cooperative way, created by Fapesp (the São Paulo State foundation for research funding). Its mission is mobilizing firms, institutes of research, universities, and funding agencies to develop technological innovations and to generate scientific knowledge.

We intent also to introduce the Enterprise Resource Planning (ERP) and the Manufacturing Enterprise Systems (MES) into the laboratory. These two subjects are perfectly applied to the integrated manufacturing laboratory and consist in an important step to make the laboratory a complete industrial system.

The production planning and control will be introduced so after all the analytical studies early mentioned. At the end of this implementation we will have a complete Information Technology

supported laboratory.

5 CONCLUSIONS

This paper presented a successfully experience of integrating hardware through software technologies in an integrated manufacturing laboratory. The aim is to provide a full industrial environment to industrial engineering undergraduate course.

The experience shows that this concept has improved learning and student's motivation as scientific researches as well.

The web bearing provided by Moodle® e-learning tool stressed the contact between students and professors and also improved the discussion and information exchange.

It was observed that several proposals has been emerged from the students towards using continuously the laboratory structure for research purpose proofing one more time the efficiency of the strategies inserted into the course.

The Kyatera net which is a fast net connecting research laboratories consists in future trends to the integrated manufacturing laboratory. It is an ambitious task that together ERP and MES will launch the course into a high level stage.

Finally it is clear that a good laboratory structure bearing by all sorts of software tools has made students join professors to construct an excellence industrial engineering course.

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