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Manufacturing cell reengineering for teaching Mechatronics Engineering

Reingeniería de celda de manufactura para la enseñanza de Ingeniería Mecatrónica

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Abstract

Next, the reengineering of a manufacturing cell is presented, as a didactic intervention in the teaching of Mechatronic Engineering, this redesign is proposed from a previously proposed cell and in which a FANUC R-2000iA/210F industrial robot is incorporated. And with this modification to the cell, students are expected to develop linkage projects with the industrial sector of the State region. The results obtained by the teaching work team are the reengineering, simulation and proposal of educational intervention practices in which students reinforce the expected skills during their professional training and thus achieving the physical integration of the teams, bringing future engineers to the real contexts of professional development. The impact and relevance of reengineering is based on the fact that the graduation profile of mechatronics engineering establishes the synergy of mechanical, electronic, control and automation elements, to technologically improve companies in the region.

Manufacturing cell, Mechatronics, Reengineering

Resumen

A continuación se presenta la reingeniería de una celda de manufactura, como intervención didáctica en la enseñanza de la Ingeniería Mecatrónica, este rediseño se propone a partir de una celda ya propuesta con anterioridad y en la cual se incorpora un robot industrial FANUC R-2000iA/210F, y con esta modificación a la celda, se espera que los estudiantes desarrollen proyectos de vinculación con el sector industrial de la región del Estado. Los resultados obtenidos por el equipo de trabajo docente, son la reingeniería, simulación y propuesta de prácticas de intervención educativas en las que los estudiantes refuercen las competencias esperadas durante su formación profesional y logrando de esta forma la integración de forma física de los equipos, acercando a los futuros ingenieros a los contextos reales de desarrollo profesional. El impacto y pertinencia de la reingeniería se fundamenta en que el perfil de egreso de la ingeniería en mecatrónica establece la sinergia de elementos mecánicos, electrónicos, de control y automatización, para mejorar tecnológicamente las empresas de la región.

Celda de manufactura, Mecatrónica, Reingeniería

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Introduction

Derived from the challenges and inequalities of competitiveness at regional and national level, the labor sector of the Puebla Tlaxcala Metropolitan Zone (ZMPT), puts pressure on the industries of the manufacturing sector to promote regional development, so for higher education institutions focused on the engineering areas, it is a priority to provide a comprehensive education to future engineers, which should handle technological and human resources that allow them to compete within these markets and strengthen their professionalization.

In recent years, some economic indicators in the State of Tlaxcala have shown a positive evolution as some companies have focused their efforts on increasing productivity through the use and exploitation of new technologies.

The integration of areas within the company, as well as the development of projects that link technology transfer between higher education institutions and processes are possibilities to increase productivity, thus encouraging students to integrate the systems that are available in the Academic Program replicates the intention of contributing to the improvement of enterprises.

Reengineering of the manufacturing cell as a didactic intervention

The didactic manufacturing cell, designed, developed and implemented since 2019 in the Mechatronics Engineering Academic Program, presents several areas of opportunity, since a key element that impacts its performance is the element manipulation element, normally awarded to a robotic arm.

With the intention of improving the academic impact with the use of the manufacturing cell, it is proposed to use a FANUC R-2000iA/210F robotic arm, which belongs to the latest generations of robots that can support a heavy load, in addition to presenting great performance, safety and manipulation by students.

According to the design and technical research carried out previously, the mechanical, electrical and electronic elements that integrated the cell and that were the most suitable to allow the implementation of the cell are the following (see Table 1).

	Elements	Features
1	Modular "L" Conveyor	16-gauge, 16-gauge, ¼ Hp, 220-440 Vac, 3-phase motor.
2	Programmable logic controller	PLC S7-1200
3	Robotic arm	Motoman NX100 HP3
4	Numerical control lathe	CNC EMCO 250 Bar capacity: 25.4 mm Axes: 3 Power: 5.5 kW Max. RPM: 6,300 Turning diameter: 85 mm Turning: 250 mm Machine length: 255 mm
5	Electric panel, frequency inverter and start and end sensors	

Table 1 Elements that integrated the didactic manufacturing cell
Source: Own elaboration

According to the dimensions where the manufacturing cell was installed, the modular conveyor (belts) was 100 mm wide by 2000 mm long and 900 mm high.

With the support of the Solid Works software, an "L" configuration was proposed in order to load and unload the material to be machined in the CNC lathe, since the FANUC R-2000iA/210F robot arm is integrated in this stage.

The movement of the belts can be carried out in both directions, through a transmission gear and a safe and efficient return system is used, since the positioning depends on the mechanical model.

The flexibility of the manufacturing cell allows the configuration of different processes and thus diversify the possibilities of didactic interventions in the learning of students through the development of practices.

The conveyor modules have lateral guides to support the optimal path of the parts on the belt and facilitate their detection by means of the sensors.

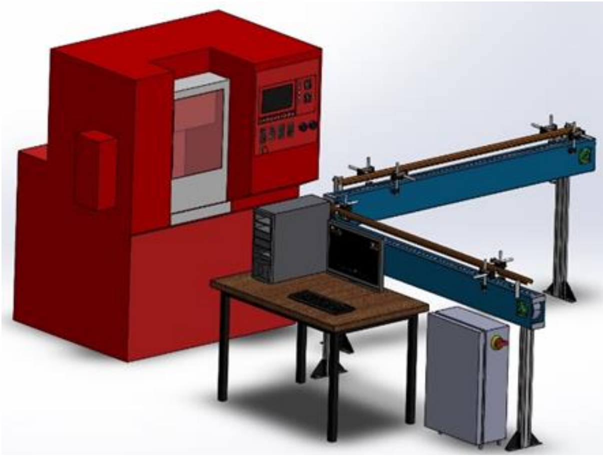

Figure 1 Original design of the manufacturing cell
Source: Own elaboration

Implementation of the reengineering

The original design of the manufacturing cell was in operation for approximately 3 years, in which positive results have been obtained, however this year we had the opportunity to perform a reengineering with the adaptation of some mechanical, electrical and electronic elements and mainly the implementation of the FANUC R-2000iA/210F robotic arm.

The reengineering, in addition to the technical elements, was rethought to achieve substantial improvements in the didactic interventions that allow students to achieve the necessary technological training during their stay at the University and allow a direct impact on the successful labor insertion of the graduates (see figure 2).

In this way, it was considered that in addition to the use of designs and simulations with software, the cell will allow them to generate models and implement technology transfer projects as close as possible to the real industrial context.

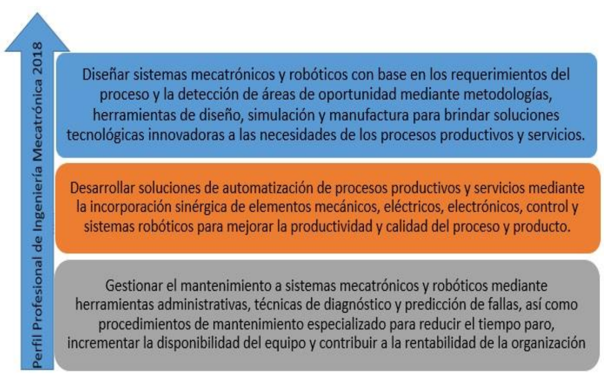

Figure 2 Benefits of reengineering in the Mechatronics Engineering graduation profile
Source: Own elaboration

Once the academic and labor sector analyses were carried out, the integration of the elements was redefined, and the cell is currently made up of the following elements (see Table 2).

	Elements	Characteristics
1	Modular "L" Conveyor	Table top, 16 gauge and ¼ Hp motor, 220-440 Vac, 3-phase
2	Programmable Logic Controller	PLC S7-1200
3	Robotic Arm	Number of axles: 6 Load capacity: 165Kg. Maximum horizontal reach: 2650 mm. Repetition accuracy: 0.18 mm. Controller: RJ3iB
4	Numerical Control Lathe	CNC EMCO 250 Bar capacity: 25.4 mm Axes: 3 Power: 5.5 kW Max. RPM: 6,300 Turning diameter: 85 mm Turning: 250 mm Machine length: 255 mm
5	Electric panel, frequency inverter and start and end sensors.	

Table 2 Elements that make up the reengineering of the didactic manufacturing cell
Source: own elaboration

Modular "L" conveyor

Consisting of #14-gauge black sheet slats, the single hinge conveyor with straight chains for heavy loads and vacuum-hardened stainless steel pins.

The conveyor has advantages of high strength, and the slats have low noise level and friction coefficient, do not absorb liquids and have good chemical and wear resistance. The dimensions are 2m long by 10cm wide and 0.9m high. It has 4 photoelectric sensors of the C2DP-11P series with a census range of 110 mm, PNP.

The system control is done with a programmable logic controller PLC SIMATIC S7-1200 with CPU 1214C with 14 digital inputs type sink/source at nominal voltage of 24 VDC at 4 mA and 10 digital outputs type relay, voltage range of 5 to 30 VDC or 5 to 250 VAC with a maximum current of 2 Amp. and 2 analog inputs type voltage (unipolar) with voltage range of 0 to 10 V and resolution of 10 bits.

EMCO 250 CNC Lathe

This semi-industrial equipment has a 12 tool turret, with a maximum turning diameter of 85 mm, maximum turning length of 225 mm and robotic interface, although it does not have support for raw material, the robotic arm that is being implemented can take and remove parts from the chuck.

Robotic arm

R-2000iA robot series with large capacity (average 165Kg), wide working space (horizontal reach, 2650 mm) and slim profile design, with RV reducers and repeat accuracy of 0.18 mm, RJ3iB controller, easy I/O connections and teach pendant for easy programming.

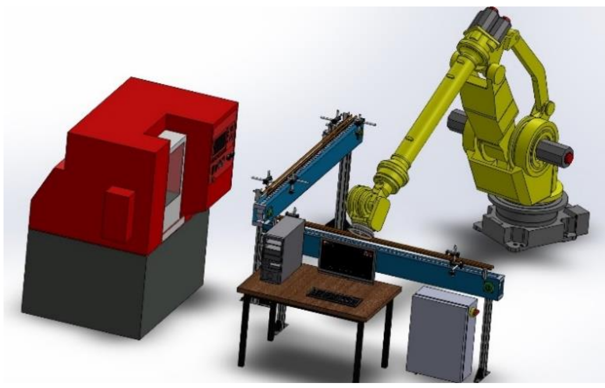

Figure 3 Re-engineering of the manufacturing cell
Source: Own elaboration

Computerized control station

To perform the communication and coupling of the equipment of the manufacturing cell, there is a physical connection with real time cards and RS232 connectors, in addition to managing the communication protocol of the equipment. The physical characteristics of the computer equipment are 4G of RAM memory, 2T hard disk, i7 processor, 22" monitor, network cards, keyboard and mouse (see figure 4).

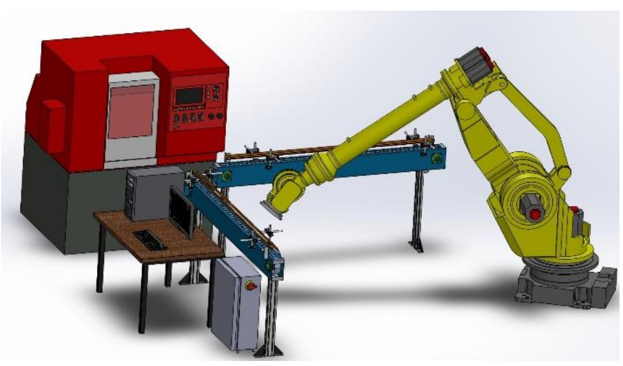

Figure 4 Manufacturing cell with the incorporation of new industrial elements
Source: Own elaboration

Results

Once the reengineering is implemented with the installation of the FANUC R-2000iA/210F robot, the manufacturing cell becomes a semi-industrial automation cell, since its programming would allow to speed up and maximize the repeatability levels of the process being carried out (see figure 5).

Figure 5 Real image of the reengineering applied to the manufacturing cell
Source: Own elaboration

In terms of educational benefits, the university's initial investment could result in a return on that investment since the manufacturing cell could not only be applied as an educational intervention, but also to provide training for some companies in the region (see Figure 6).

Figure 6 Lateral view of the reengineering applied to the manufacturing cell
Source: Own elaboration

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The implementation of the didactic manufacturing cell allows to carry out practices that currently integrate two or more subjects (see figure 7) and at the same time promotes the development of specific competencies of mechatronic engineers that are currently requested and required by the regional labor market.

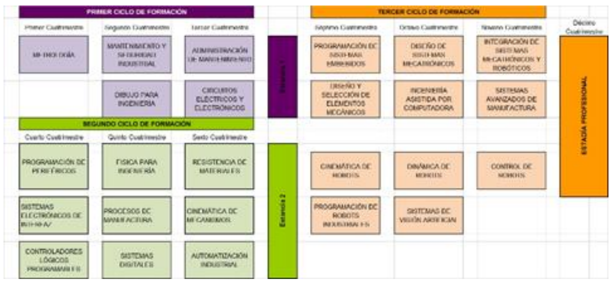

Figure 7 Use of the manufacturing cell in the subjects of the Mechatronics Engineering curriculum
Source: Own elaboration

Another academic benefit that has been obtained is the use of the manufacturing cell by other engineering courses at the University (industrial engineering, automotive systems engineering), as well as the proposal to offer courses and/or workshops through the continuing education program to companies and educational institutions in the region.

Acknowledgment

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Conclusions

Among the main results obtained so far are the possibilities of linking the educational institution with the industrial sector of the region, as well as improving the probabilities of labor insertion of the graduates, since having a context as close as possible to real industrial processes is fundamental for the optimal and pertinent development of future mechatronic engineers.

Although the development of competencies with computerized models has been useful in teaching-learning activities, the implementation of practices with semi-industrial applications (spot or arc welding, assemblies in general, extraction and transfer of materials), allow the emulation of the behavior of productive processes very similar to real situations and having this semi-industrial equipment is of great benefit in the professional competencies of students and graduates.

The design, development and implementation of the didactic manufacturing cell and now its reengineering, allows us the possibility to perform practices that integrate two or more subjects, strengthening the specific competencies of mechatronic engineers that are currently required by the regional labor market.

With these elements, it will be possible to reinforce the linkage of the UPTlax with the business sector and institutions of higher and higher education in the region, as well as to improve the supply of continuing education and the operation and maintenance of the manufacturing cell.

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