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Souza das Neves, José Manoel; Silva Marins, Fernando Augusto; Kazue Akabane,
Getulio; Kanaane, Roberto
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DEPLOYMENT THE MES (MANUFACTURING EXECUTION SYSTEM) AIMING TO IMPROVE COMPETITIVE PRIORITIES OF MANUFACTURING

José Manoel Souza das Neves

Centro Paula Souza – MSc. Program, Brazil

E-mail: jmneves.fatec@gmail.com

Fernando Augusto Silva Marins

São Paulo State University, Brazil

E-mail: fmarins@feg.unesp.br

Getulio Kazue Akabane

Centro Paula Souza – MSc. Program, Brazil

E-mail: Getulio@akabane.adm.br

Roberto Kanaane

Centro Paula Souza – Msc. Program, Brazil

E-mail: kanaanhe@gmail.com

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ABSTRACT

This work investigates the contributions of the MES – *Manufacturing Execution System* – for improving the competitive priorities of manufacturing. We present a theoretical framework on the information technologies (IT) and its business importance, the contributions of the organizational factors for the implementation of the MES, as well as the main concepts and the possible applications of this tool. The built theoretical framework was decisive to subsidize the research performance in the studied company. It was verified that the MES significantly contributed to the manufacturing related to improvement of cost, quality, flexibility, conformity and reliability. It was concluded that the MES enriched the information quality generated from the plant floor, i.e., information that makes it fast, standardized, reliable and precise. When integrated to the Enterprise Resource Planning (ERP) of the company, the MES filled out a gap, offering information



other to other functional areas of the organization. The interviews, conducted in businesses departments in the company, showed the importance of the products tracking, and the MES implementation was decisive to improve that issue, concluding that the dimension is considered as a competitive priority of the manufacturing.

Keywords: Competitive manufacturing; MES - Manufacturing Execution System; Organizational factors.

1. INTRODUCTION

Global competition has caused changes characterized by manufacturing products with shorter and uncertain life cycles demand, so enterprises have adopted innovative technologies for attending the customers that are requiring fast supply, low cost, and greater customization. The ability to quickly and effectively respond so as to meet the needs of customers has become a competitiveness feature for many companies (DOWLATSHAHI AND CAO, 2006).

In the search of differentiation and increased production processes efficiency, the industrial sector made major investments in the automation of the plant floor in recent years, especially regarding the acquisition of hardware and software to support and to implement sensors, actuators and PLCs (Programmable Logic Controllers), updating the machinery and the supervisory systems SCADA (Supervisory Control and Data Acquisition).

With the new generation of information technologies, specifically the enterprise systems - ERP - Enterprise Resource Planning, this mismatch information between the areas of the company management could be solved and several problems can be avoided.

In this context, maybe the greatest aspect is related to the lack of a crucial link between the information technology systems adopted by the enterprise, like an ERP, whose lack or deficiency is evident between the automated processes with the other areas, ranging from production management (Programming and Production Control, Logistics, Supply), the purchasing area, as well the financial and the human resources areas.

A solution to solve this lack of communication between the productive area and the ERP is to adopt the MES - Manufacturing Execution System that provides the



necessary links to improve these relevant relationships, and improving the competitiveness of the manufacturing process.

Unfortunately there is few published works about the contributions of the MES system use, and this paper is focused on this literature gap. On this way, this research was developed with the intention of contributing to the knowledge expansion about the implementing process of MES, and how it improves the competitive dimensions of manufacturing. The research also aimed to analyze what organizational factors can support the MES implementation, and for that, it is presented a case study in an aluminum rolling company.

So, in short, this paper has aimed answering the following questions: What is the contribution of the implementation of the MES information technology to improve the competitive priorities of manufacturing?

The paper is organized as follows: a short background about Information Technology Systems and, in particularly ERP and MES are presented, and in the sequence are described the research method and the case study in an aluminum rolling company; finally are commented the results and are suggested future works related to the theme.

2. BACKGROUND

Several studies discussed the implementation of the ERP in several kinds of companies, focusing on its advantages, difficulties to its absorption by the professionals, critical success factors, impacts into the organization and its collaborators, the relationship of the IT with the business strategy, the increase of the competitive potential of the companies, and also the possibilities for adopting it in small and medium enterprises (AL-MASHARI AND AL-MUDIMIGH, 2003; BENDOLY AND SCHOENHERR, 2005; GUPTA 2000; NICOLAOU, 2004).

Some related applications on Information Technology (IT) Systems literature have gained importance in the business area. So, technologies such as CNC, CIM, MRP and MRPII, and CAD/CAM systems are the main examples, and they are leading the companies, where they were deployed, to a qualitative leap and competitive advantages in the global market. Particularly, in the manufacturing area, the efficient and effective work, as well as the use of information, became essential for an economic vitality and growth of the enterprise (MOLINA AND SANTAELLA,



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2006).

Several providers offer MES systems in the market, which are suitable according to the company needs. They are used in enterprises that have already had ERP systems as well as significant automated processes on the plant floor that will be integrated into the MES system.

The MES system ensures a more efficient management because it allows decision making based on relevant, current and reliable information, allowing you to check what is happening in the manufacturing company. The MES also consolidates the planning and the mapping to the implementation of all production stages, processing applications connected to the control of the production systems, optimizing the production processes, democratizing and integrating information, and in this way the MES provides a global view of production area and in a real time.

Figure 1 shows the desirable schematic view which comprises the integration, the MES, the various organizational levels, from plant floor to business management.

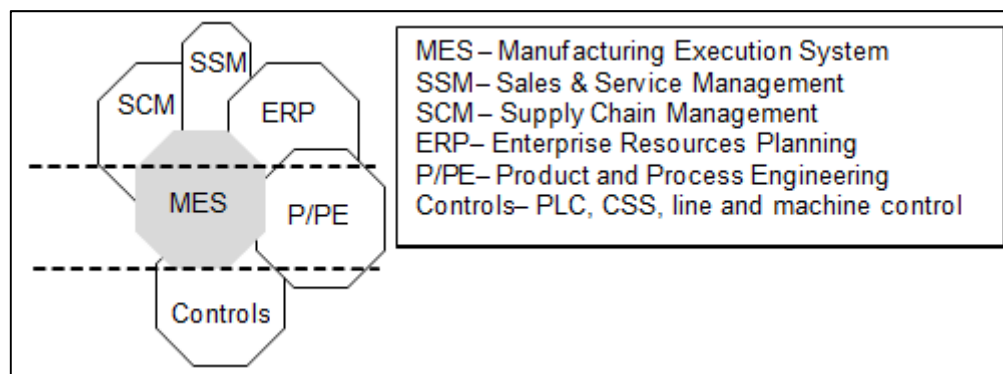


Figure 1: The integration of MES among plant floor ITs and Enterprise Management Systems

Source: SNOIEJ, 2006.

According to HAYES AND WHEELRIGHT, (1984), manufacturing companies have established their business strategies based on a hierarchical structure. As an example, the operational strategy arises from the need to meet the functional strategies that, in the case of the manufacturing area, generate competitive priorities to cope with the market needs (SANTOS, 2000).

Each of the company's strategic areas was embedded with the IT solutions to improve its efficiency and reach its goals. The main feature of these information technologies is to support the fulfillment of the functional areas objectives. So, technologies such as CAD, CAM, CAE, EDI have supported the competitive priorities

of manufacturing, the ERP systems have provided the business management strategy.

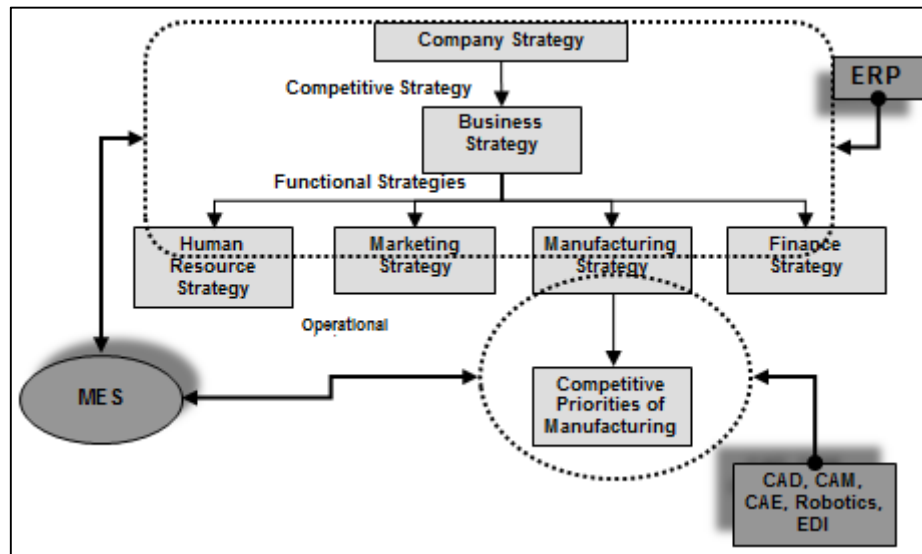


Figure 2 - Integration of business management strategies with the priorities of manufacturing from the IT systems and MES
 Source: Adapted from HAYES E WHEELRIGHT , (1984)

Figure 2 shows the structure of the company's strategies and the acting of the various IT solutions. It should be observed that the IT resources used in functional areas, as well as in the manufacturing area, do not generate available information to the top management. Some occurs with IT solutions for management business that do not reach to manufacturing. The MES system fills this gap, involving all functional areas, and integrating the plant floor to the top of management level of the company.

MESA (Manufacturing Execution Systems Association), an international association of companies which provide integrated MES system, has been defined as a system that generates information and facilitates the optimization of production activities since the costumer order to finished product.

KALL (1999) and CHOI ET AL (2002) define the MES, as a functional layer that integrates ERP systems and controls the plant floor in order to manage the manufacturing production planning in a feasible manner. The MES fills the gap between the ERP system and the automated systems on the plant floor.

According to BLACKSTONE JR. AND COX III (2004), the MES is a system of information and communication for the production environment of a company. The MES has the purpose to monitor and to improve all aspects which influence the production process, in order to achieve high flexibility of production, as well as low

production costs. It has also important features, which allows production records, production reports, product tracking and details of the planning and scheduling process.

For HWANG (2006), the MES is a process information system that collects data, processes and analyzes materials, semi-finished and finished products, equipment, time and cost, at the production site in a real time, i.e. it monitors the work while it is occurring. Concluding, the MES system operates as a hub for distribution of data on the plant floor for all the other enterprise systems.

The MES system include an information center composed of 11 elements or functions (see Figure 3), which are joined to other databases. These include the main functions of the MES (HWANG, 2006; KLETTI, 2007; SNOEIJ, 2006; YU et AL., 2009). The central idea is to measure in order to control so that the performance indexes are used to compare the results of the production lines within the same plant, company or with other known results.

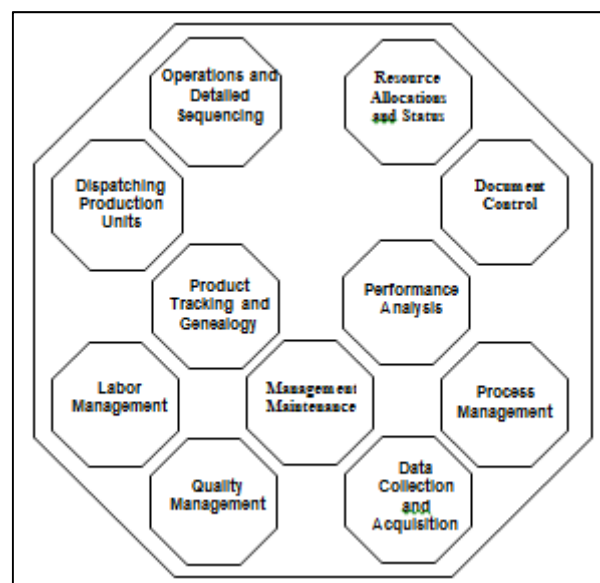


Figure 3: Schematic of relationship between the various functions of MES
Source: SNOIJ (2006)

The functions shown in Figure 3 are integrated with Sales and Devices (MSS), Supply Chain Management (SCM), Enterprise Management System (ERP), Engineering (PPE), and controls, which can generate the mechanisms for production management through a fully computerized information, in a quick, safe and reliable way for the company (VINHAIS, 1998; HWANG, 2006).

The integration of the management system with the operating systems is crucial for the companies whose primary business is the manufacturing, since the key information such as financial activities and accounting, inventory management and asset management, are taken from the plant floor data.

3. METHOD

In this research, the goals were to investigate the implementation of the MES system in the production process of an aluminum rolling company and to assess the resulting improvement of the competitive priorities of manufacturing, having as supporters the organizational factors.

This research is guided by qualitative research making use of interviews, through semi-structured questionnaires submitted to the main professionals working in the deployment of MES system.

The method of case study concerns the study of a problem seen through multiple perspectives and in its original context. The research was conducted by the method of a single case study, and the object of study consisted of a multinational company, market leader in aluminum products.

The case study enables the development of new theory and the increased understanding of real and contemporary events (SOUZA, 2005). The single case study conducted in this research allows a better depth research and is commonly used in qualitative research (MIGUEL, 2007). As recommended MIGUEL (2010) research had a greater depth investigation.

The main way of collecting data was through semi-structured interviews, additionally, the research method included visits to the factory and plant floor observation. Internal documents were consulted and selected to elaborate the questions for the interviews.

4. CASE STUDY

The studied company is a multinational, market-oriented and global leader in rolled aluminum with respect to revenue, production volume and market share. The company has its headquarter in Atlanta - USA, and through its subsidiaries and affiliates located in Asia, Europe, North America and South America in the areas of mining of bauxite, alumina refining, power generation, production of primary



aluminum, in rolled aluminum and aluminum recycling, as well as it has invested in research and technology.

It is a leading global supplier of aluminum rolled products, the largest single buyer of aluminum and the world leader in aluminum recycling. It has a presence in four continents, 11 countries, with 34 operating units, and approximately 12,900 employees worldwide. The company is the largest on laminates in the world and one of the biggest producers of primary aluminum in Asia.

The productive capacity of its plants is divided into the following main products: plates, sheets, discs, sheets, billets, and finishing chemicals, beverage cans, household utensils, civil construction, and in the automotive, transportation and packaging segments.

The interviews were conducted with seven professionals from the studied company, with a great experience and involved in the implementation of MES.

5. PROBLEMS OF THE STUDIED COMPANY AND MES IMPLEMENTATION

The implementation of MES in the studied company began in the early 2005 in the remitting area, but effectively began operating in 2006. The MES was implanted, at the same time, in three production lines for plates and recycling products in order to provide a unique solution for the plant.

Considering the cold mill, the MES project started in 2007, and its operation at the plant began in October 2008. The MES replaced the existing system that was based on an Oracle system; its implementation is still running and it is being made in a web environment.

There was an interest, in the area of remelting, in the installation of the MES, because the sector is very much automated and works with very large machine cycles, with at least 2 to 4 hours each. Particularly the hot-rolling mill requires that several variables that have to be set in order to have more stability in the final product.

It was verified that the problems like lack of an adequate interface with the automation resources, the need of performing nonconformity tests and the defect analysis, among other problems were creating many difficulties and complexity for the operator. With the MES, the operator can insert information data in the system



without too much difficulty and without spending a long time. In fact, all areas started to have facilities for real time analysis, as for example, informing whether the forecasted production time was used or whether some product nonconformity was observed in the period.

The remitting area is responsible by the process, its reliability and the people training. There was already an automation structure focused on the process, but machine interruptions had occurred and the information, like the stop machine indicators, of these facts were not accurate. In the metallurgical process cycles, there is the need of giving to the metal a rest during some time, depending on the its size, kind of alloys, or even depending of its position on the production list. The cold rolling mill needs a lot of information such as chemical composition limits of thickness and width, as well as a lot of information for each batch to be produced. Often, the equipment requires around 20 to 30 different parameters to machine setup in order to make a specific product, and it is very difficult to machine operators perform a manual data entry.

The remitting area produces in batches, not in a continuous process, and a production order comes from the customers needs. The ERP chooses which line will be used for manufacturing the product and what product characteristics, while the MES contributes with the information where is located the product (which furnace stage) and information in which will be the next product to manufacture. The MES does not choose the product position in the manufacturing order, but it monitors the progress of the manufacturing order chosen. Monitoring the operators' decisions, it checks if the batch has satisfied the efficiency standards, and if this does not occur it reprograms the production in order to increase the efficiency over time.

In the hot-rolling area, the existing manufacturing modules of the ERP were without appropriate adjustments, and so they did not meet the information needs and the appropriated integration level with automation. Therefore, for it to be able to provide the same MES functionality, and offer the same level of integration with the automation, several adaptations would be necessary.

The implementation of the MES enabled increased accuracy of the input data on the ERP. One example was the production of monthly closings, which was made very slowly and, therefore, the production data and the observations on the process



in real time made by the operators that could avoid production errors are sometimes lost.

6. RESULTS

This section reports the results of the performed qualitative research based on theoretical aspects and the case study. In this section, it is presented the improvements observed in the studied company areas with respect to their competitive priorities of manufacturing, as well as are identified the organizational factors that can adequately support a MES implementation.

In the theoretical framework available in the literature, seven competitive priorities of manufacturing were identified (Costs, Quality, Delivery, Flexibility, Reliability, Product Conformity, and Manufacturing & Strategic Business Integration). These priorities, and the actions that are implemented by the company areas, are tacitly established between the employees and the managers in the studied company, i.e., produce the set out quantities (and achieve the goals) have precedence in relation to these priorities.

Interviews with those managers responsible for the manufacturing areas shown that the concern for cost reduction and conformity attendance were clear, it also showed that had a large integration in the manufacturing through the use of IT resources. In fact, the whole managers training process and their involvement in the design and the implementation of MES, it was made by the manufacturing area, by the IT department, and by the MES developer (external).

There was a significant decrease in gas consumption in the remelting area, not only by the performance of the MES, but also by other lean manufacturing tools applied. With the double-checking of the data entry of raw materials made by the operators and verified by the MES system, there was a reduction of the non-conformity of the manufactured products. This reduction increased the reliability of the area, and through a data log of product manufacturing, enabled the tracking of the whole process in a retroactive period of up to two years. With the reduction of failures in the setup of the equipment, the quality of the product area had a significant improvement. Table 1 shows these improvements in the remitting area.



Table 1: Improvement of competitive priorities in the remelting area – NEVES (2011)

Priority	Remelting	Observations
Costs	a) Reduced consumption of natural gas (Approximately 5%). Natural gas is the second largest cost to the company. b) Rework reduction	The reduction was also due to the implementation of other quality tools with the MES that contributed to the reduction of gas.
Quality	a) Reduction of failures in the setup. b) Reduction of errors in the introduction into the furnace of the chemical composition of the plates.	Only contribution of MES in order to implement double checking.
Delivery	There was no change.	
Flexibility	Increased the flexibility of changing a production line to another.	Only contribution of MES
Reliability	a) Registration data are available online, with the possibility of tracking the entire process. b) More transparent information	Only contribution of MES
Product Conformity	Reduction of non-conforming signs.	The reduction was also due to the implementation of other quality tools with the MES.
Manufacturing integration with strategic business	Existing in the whole process. It is essential for business.	

The hot-rolling mill area had, as its goals, the reduction of the production costs and improving the productivity with the implementation of MES, as well as it could obtain a better lineup of the equipment with a consequent reduction of gas consumption. There was also a significant reduction of rejection in the products leaving the mill, and with the reducing the setup time from 10 to 15 seconds per product (plate) was increased the area productivity and its flexibility. The best ability to track and control the production, in addition to the online availability of performance indicators (charts, productivity, and use level) quickly led to a greater reliability in the area. Table 2 shows the improvements with the implementation of the MES in the hot-rolling mill of the studied company.

Besides that, in the hot-rolling mill area, it was performed a further study on the implementation of the MES, which offers more accurate quantitative information about the competitive priorities of manufacturing. In an interview with the hot-rolling mill manager, it was observed that there was a reduction in gas consumption in the transformation process of the plates coming from the remelting area.

After the implementation of the MES, it was reduced the use of gas from 24.4 m³ per ton of coil production to 23.7 m³ in the first year, and to 22.6 m³ in the second year. These numbers show a total reduction of 252,070 m³ of gas use in the first year of implementation of MES, and of 690,120 m³ in the second year. This reduction



generated savings values of US\$68,500 in the first year and of US\$188,000 in the second year.

Table 2: Improvement of competitive priorities in hot rolling area – NEVES (2011)

Priority	Hot-rolling mill	Observations
Costs	a) Better furnaces scheduling, gas consumption reduction. b) Elimination of discards in the wrong setup for the reverse rolling mill. c) Reducing the time of data appointment for operators (1.5 min/pointer/plate).	Improvements achieved only with the implementation of MES
Quality	a) Reduction of rejection in the reverse rolling mill. 1.7% to 0% rejection. b) Improving the quality of information on the plant floor.	
Delivery	There was no change.	
Flexibility	Reduced setup time from 10 to 15 second per card laminated.	
Reliability	Traceability and control of production, besides the online availability of the performance indicators (charts, productivity, use level) more quickly.	
Product Conformity	Reduction of coils nonconforming.	
Manufacturing integration with strategic business	Existing in the whole process.	

With the implementation of MES in the setup of scalping machine, the time was reduced from 6 to 5 hours, and this reduction is due to the automatic registers allowed by the MES. Before the operator made these registers manually.

Since the MES implementation, the hot-rolling mill began to receive data on the products to be laminated, performing automatically the equipment setup and significantly reducing the possibility of errors, in fact there were no further rejections due to setup. Besides the improvement of competitive priorities of manufacturing, it was unanimously reported by the three areas that a great gain was the possibility of tracking the entire process, from the its beginning (receive the product orders) including the handling of raw material (remelting area), the finished products manufacturing (hot-rolling mill and cold mill areas), and the final delivery to the customers.

7. FINAL CONSIDERATIONS

The few studies, available in the scientific literature, did not characterize the importance of the MES systems for the manufacturing area, and they showed that, in general, the implemented MES systems have not relationship with the enterprise management systems. During this research, it was evident the fact that ERP is not a



system designed to help in the manufacturing process improvements, mainly the automated and computerized processes of the plant floor.

The case study also allowed verifying that the implementation of the MES in the studied company improved the competitive priorities of the productive areas, as well as allowed identifying the organizational factors, which can support this implementation.

A relevant contribution of this research was an increasing the perception of the MES as a system of integration of manufacturing with the system of business management. The vision of the consulted areas of the studied company showed the importance of the MES system related to the reliability of the information about production processes and the information dissemination across the functional areas of the ERP.

The MES was identified to be a complement to ERP systems and focused on the manufacturing areas, allowing have traceability on their processes. In fact, this research showed that traceability can be a competitive advantage for the company because, with it anyone can immediately identify the entire route of a given product, from raw materials coming from suppliers to the final product sent to the client. Additionally, this ability to track the product position by the Web allows the final client knows where is his order.

By the case study, it was found that several organizational factors were important to support the implementation of MES, such as: organizational culture, organizational learning, teamwork and training. Also, it was observed that in all implementing process, the support of senior management was very significant to secure funding the acquisition system (including the interfaces, the hardware and the people training) that allowed obtaining the returns on the investment due to the performance improvements.

Therefore, the IT resources of the company, including the MES, should be integrated with the company's business organization to ensure efficiency and the achievement of strategic objectives.

In the case study, for the successful implementation of the MES and to reduce the impacts on the people who were directly connected to the system, it was fundamental the formation of teams comprised by leaders and area operators who



were responsible for the IT resources and the MES developer. These teams were multiplying in the areas where the MES was implemented creating a value network to obtain positive results with the system implementation. The observations and results obtained, using MES, were converted into procedures and new knowledge for the company's collaborators. Also these experiences meant that the company has created a own process of organizational learning in the implementation and in the use of MES.

Other contributions to the business generated by this research are linked to the importance of the MES for the manufacturing area and its importance in integrating with the business and the organization.

The case study had shown the improvement of productivity with the MES and the reliability of data and information available. The possibility of having a digital database allowed the traceability of the products. With the support of WEB technology, the company can compare the projected manufacturing time with the real-time obtained, and with these information can improve the decision making process on manufacturing and the equipment utilization.

Usually, the MES consolidates the planning and maps all production stages, it allows improving the production processes, and the MES disseminates reliable and important information, integrating the factory as a whole and in real time.

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