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ERP OPERATIONS IN THE INDUSTRY OF SMART MANUFACTURING

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Abstract: *Smart manufacturing is a broad category of manufacturing with the goal of optimizing concept generation, production, and product transaction. While manufacturing can be defined as the multi-phase process of creating a product out of raw materials, smart manufacturing is a subset that employs computer control and high levels of adaptability. Smart manufacturing aims to take advantage of advanced information and manufacturing technologies to enable flexibility in physical processes to address a dynamic and global market. There is increased workforce training for such flexibility and use of the technology rather than specific tasks as is customary in traditional manufacturing.*
The research is carried out with the support of the Technical University of Cluj-Napoca.
Key words: *ERP, Industrial Automation, Process, Lifecycle, Manufacturing, Operations*

1. INTRODUCTION

The following article is regarding a software Enterprise Resource Planning system implementation in Smart Manufacturing. For the time, the research company where I was doing my research assigned me as a member of a team of software consultants for the automotive industry. The company had several projects around Europe and more offices in different countries. The main focus of the company is to develop, test and deliver both technical and research solutions for its customers which developed business mainly in the automotive industry. Nevertheless, the next horizon for the company is to try and expand to different other markets.
The fourth industrial revolution supports mainly the following features:

- Interoperability: the ability of all the existing machines to connect on to the other using the internet of things
- Information Transparency concerns mostly the virtual copies of the existing processes by introducing the digital models in the equation.
- Technical Assistance with two different stages: the first one where machines support humans by presenting them with different "live" measurements and second of all the ability of machines to perform different routine tasks which don't require the presence of a human being.
- Decentralized Decisions: Virtual machines and computers are exceeding their current limitations and are performing different tasks based on algorithms that are currently evolving and learning from the human behavior.

In order to align to the Industry 4.0 enterprise resource planning have been created and have gain a lot of popularity in the last couple of years. This system is mainly an integrated platform of business process which are connected to each other and have a "live" evidence of the existing data in the company at a given time.

The complexity of ERP systems from the market is high due to the fact that different environments are focusing on discrete manufacturing where more than one item combined will result in a finished good compared to other industries which are process driven (pharmaceutical or chemical) where more items combined may need to be weighted in particular and they might need rework at a given time.

Fig.1 ERP Systems

Because of the fact that an enterprise resource planning system will require people to act and work in a different way the first stage of any project is that everybody fully understand the needs of the ERP system not only the existing processes but also the near future developments. Usually the stage of gathering data and analyzing will have to go deep enough to understand the complex processes or the processes which can be different from business to business.

Not having the bigger picture when having to choose from a large variety of ERP may lead to a nightmare if the expectations for the solution will not be well defined. In order to succeed and make the right choice, the whole personnel from both managing and senior technical positions need to be involved. These personnel should be present at the stages that occur when selecting an ERP: project initiation, assistance when gathering requirements, vendor's demonstrations and finally in the short list selection for the vendors.

ERP systems use a database management system which collects all the data from different systems and databases and stores inside in order to be accessed later if needed. The entire ERP system may contain different subsystems described in theory as functional areas or modules: Finance and Accounting, Human resources, Manufacturing, Planning, Supply Chain, Sales, Order Processing, Inventory, Project Management, Customer relationship management.

Fig.2 Industry Automated ERP Operations

Further on, getting into more detail, the process of implementing the solution can be split into different types of project, depending on the client's needs: customization, consulting or support. An ERP implementation project can take up to one year and a half but if there is a need of implementing some new features or some database interfaces that can increase according to the volume of work.

The process preparation stage is the first stage of an ERP implementation project and that concerns in understanding the customer's needs and the business processes that they already have in order to implement those in a more effective way. This is a crucial stage of the project where consulting organizations need to allocate resources from their own company in order to understand the physical processes and offer solutions to the client in order to align those processes to the ones provided by the ERP system. Nevertheless, this stage is also important because the client can be provided with future modernization techniques for the existing processes.

The following Fishbone Diagram was obtained after the first round of discussion with the research client and it has been seen that there is a need of an ERP implementation in the Manufacturing area and the module for Manufacturing Execution was proposed for customizing to the research client.

Therefore the analysis showed that as per Measurement there was a lack of a progress tracking tool for the production area, there were no short term goals inside the facility, there was a lack of accountability, no timesheets for the workers and the progress of each worker was not maintained nowhere. However in the existing plant there can be found a lot useless paperwork with poor prioritization, unforeseen variables were appearing each day and the existing shift did not know actually how many units of the existing material they should produce daily.
Unfortunately regarding the people the conclusions were the following: there were no existing supervisors which conducted either trainings or delegated workload, there was a high lack of communication between departments (Manufacturing, Orders, Quality and Inventory) and there was a high rate of people who were trying to micromanage between the processes.

The existing machines were not communicating as per latest standards (they had a very high latency rate) because of the poor network infrastructure and that was causing a slow working environment.

The current environment was extremely disorganized and that was causing different issues when trying to test the finished product and to check it for errors.

Last, the materials were disposed in random areas and forgotten after time due to the fact of a non-existing planning. Besides this, there were high lacks in both inventories and in the procurement department (and the third party supplier) which supplied the raw material that was going to be used in the production of the automotive part.

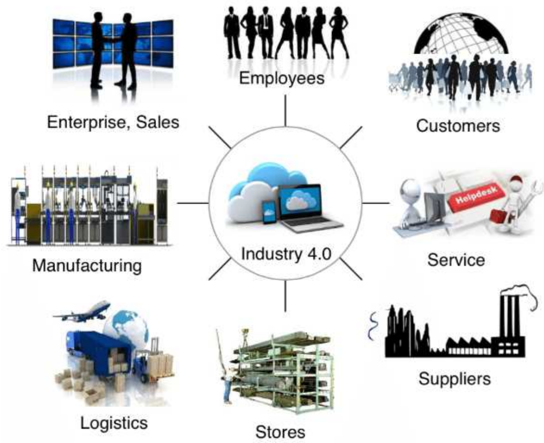

Fig.3 Industry 4.0 Advantage Connections

Unfortunately after a couple meetings at the research's location the project shifted from a normal implementation and research project to a deeper customization project. That being said, the research customer understood the gaps that he was facing and was willing to address those gaps and solve them with this new project. Therefore he decided in having a customization process for the Quality Visual Non Conformities of the parts that were being taken out of the production line and tested according to the existing limitations of the industry.

The next stage of the research project was to asses, design and test the new functionality that the customer needed. The design stage did not take a lot of time, however the testing stage of the project was highly detailed for the internal testing teams in order to spot all the errors which may rise from the actual code. This was also managed through a Fishbone Diagram.

Fig.4 State of the Art Smart Manufacturing

The software testing stage was divided into different categories as follows:

- Requirement Errors:

Here the errors have been assessed if they were inconsistent, incomplete, infeasible or ambiguous.

- Design Errors:

These errors might have appeared because of the following causes: incorrect translation of requirement specifications, incomplete translation of requirement specifications, inconsistencies within the design specifications or inconsistencies between the design specifications and requirement specifications

- Coding Errors

The coding errors could have been: computational expression errors, errors due to the data declaration of some local variables, subprogram interface errors or control flow logic errors

- The error from the first testing stage might have left still some undiscovered errors due to incomplete or erroneous testing
- The last stage of the testing process was regarding to the new errors which may have been introduced as a result of change for the previous errors or there may still have been some yet undiscovered errors

Having this all coded, the research project went back to its original track and was turning back to the implementation phase. All of the design work was being documented and the problem of the location appeared in the project's timeline. After seeing all the work that the ERP software was capable of doing the client was willing to increase his productivity and maximize production with a new and efficient cost.

However the project customization was more problematic than it was though. Even to the ERP basic implementation was design to meet the client's needs, the organization was forced to find workarounds each day a part of the change management department to face the unique needs of the customer.

2. DEPLOYMENT

The research project started with the scope of delivering the Manufacturing Execution module from the ERP vendor but after half a year it has transformed into a research project which was delivering a total of 8 modules and was integrating all the existing processes in order to save time and expenses from the company. Besides the simple order tracking from the actual raw material into the finished good which was the basic need of the client, modules which were tracking the revenues from the invoices to the final printed receipts from the finance module to the actual procurement where all the suppliers and third party clients were maintained were in the scope of implementing.

All of the systems were being synchronized and when changes appeared any errors should have being legitimately and transparently eliminated.

Concerning the module Manufacturing Execution, high standards were expected. (Ohno,1988) The actual production line was connected through different IT cabinets to the network infrastructure and the maximum latency for the communication between systems was two seconds. The ERP System was divided into three different layers:

- Physical layer: This one was used for the operators were they physically pushed button when the part was leaving their stations and they were able to choose between two different options (complete ok or complete not ok)
- Plant Connectivity Layer which was a Microsoft tool developed for the interface between the machines (programmable logic controllers) and the upper decision making layer. This layer was just compiling the data which came from two bit code from the physical layer to ASCII format which was human readable data. After the conversion the data was transformed through a set of conditions and if the data was according to the standard needed it was moved forward.
- Decision making layer was the one who was taking the decisions based on the data that was passed forward from the lower layer and it was identifying the kind of operation and the station where the part came from. Based on that, different workflows were triggered like: start of production line, start of common operation, complete of common operation, error checking operation, overcheck operation, end of line operation, traceability operation, external assembly parts operation, quality parts operation and palletisation operation.
- ERP layer was the one that retrieved all the data regarding the existing shop orders and the existing parts.

Based on that, there was a clear picture of each production area and what was it doing at every moment. Each station was identified in the Manufacturing Execution Module by a name and a code and it was possible to see when the station was working properly or not.

The Manufacturing Execution module was working according to an MRP which contained the actual inventory control and the production planning forecast. The MRP takes as an actual input both the master production schedule and the bill of material as will transform these as an output in a schedule of these materials which will be used in the production process. These will eventually transform into the finished good product.

Fig.5 Smart Manufacturing Industry Machines

By the time when the Manufacturing Execution module has done the exact amount of parts that were decided in the Production Planning module, the Manufacturing Execution module launches a handshake process where it notifies the Production Planning module that the order is finished.

When the order is finished the Production Planning module will increase the amount of parts on the Inventory Module by the quantity that the previous order was assigned. If everything is according to the scheduled timesheet, the finance module will also contribute with an actual quotation for the new parts, quotation which is being calculated based on a formula inside the Finance and Controlling Module.

When an implementation this size is being operated, the research manpower and the vendors try to consolidate more than one system into a single secured and verified structure which usually will have its data protected. That being said, it is more advantageous to use the same ERP system which will provide multiple modules and link them a whole piece. It is also recommended to use in this approach because the interfaces and the communication between the systems already exists and it this particular functionality was tested by the company which has created the ERP system. Nevertheless, the company which has created the system will provide support and maintenance for the products which were already release.

However, by the time that the research project was finished implementing, there was a need for a future upgrade for the Manufacturing Execution interface with the user. The upgrade of the system was working according to the scope but by the end of it, the extended Visual Non Conformity enhanced functionality was not working anymore. Facing this, the both the research manpower and the client company had to involve themselves into back-to-back meeting with the ERP creators to face and solve the new and existing issues. The newly errors appeared because of some mismatches from the upgraded version of the code with the enhanced coding solution that was provided for the customer.

The postmodern era of ERP appears for the first time into Gartner's theories in 2016. He currently states that all of the existing ERP systems will evolve and move towards the future into cloud based applications and most of them will be coupled between themselves and therefore everything will be accessed in a more simple was. His theory is that the ERP systems will still exist but they will be reduced to a software which can provide most of the core solutions for a system like this and all the other functions will be enhanced by a different solution that may only enhance parts of the existing core.

However, currently there is no existing procedure and a design that covers the most existing business functions within a plant and even an industry or the ones that would be considered secondary. In the same literature, it is said that each company will have to strictly and clearly define their strategy, which can be based on their existing procedures and processes. By this being said, it is highly probable that some of the existing businesses will make public some of their functions inside the cloud environment and some will remain packed inside the firewall. Each company will have to decide, if the case needs it to, which part of the business will remain private and which can be public inside the cloud environment.

Also, a new aspect of the postmodern ERP systems will be the speed and flexibility that the cloud environment provides with respect to the reaction of unforeseen changes in different modules. The new and improved upgrades or releases will be more that easy to access from a cloud based system. Besides this, most of the companies will be able to search and choose the cloud computing solutions which will suit better to their internal needs.

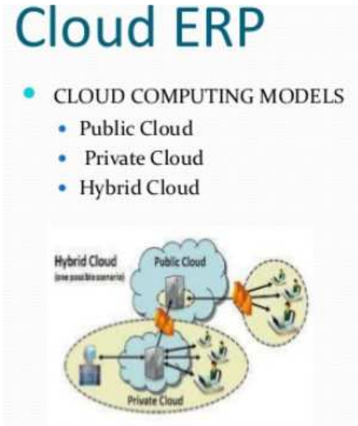

Fig.5 Future ERP

As a negative aspect, the postmodern era of ERP may begin the release of a new market for startup companies which will release new ERP solutions. Having that said, the new generation of consultants that will work with this solutions will face day-to-day challenges from providing sustainable solutions to their customers and posing challenges when needed to have interfaces with different other IT solutions.

3. CONCLUSION

Following the 'third wave of IT', the mechanism of transmitting information is radically changing the nature of "things": IT is now becoming a fundamental part of the product. Product functionality is improving thanks to embedded sensors and processors in products and to a product cloud, designed to store and analyze product data.

This system allows the exchange of information between the product, the maker, the final user, its operating environment and other products or systems.

The development and adoption of connectivity technologies is a crucial element of smarter manufacturing. The new smart, connected products, along with the massive usage of unstructured information coming from IoT and Big Data, wants a whole new technology infrastructure within a company.

Industry structure has to be reshaped, redefining its boundaries, and new skills are required, e.g. software development, systems engineering, data analytic, online security enterprise.

The aim is to create intelligent networks along the value chain, connecting people, processes and data and generating new best practices. This research was achieved with the support of Technical University of Cluj-Napoca.

4. ACKNOWLEDGMENTS

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OPERATII ERP IN INDUSTRIA DE PRODUCTIE INTELIGENTA

Rezumat: *Producția inteligentă este o categorie largă de producție, cu scopul optimizării generării la nivel de concept, a producției și a tranzacției cu produse. În timp ce procesul de fabricație poate fi definit ca procesul multifazic de creare a unui produs din materii prime, producția inteligentă este un subset care utilizează controlul calculatorului și niveluri ridicate de adaptabilitate. Producția inteligentă urmărește să profite de tehnologiile avansate de informare și de fabricație pentru a permite flexibilitatea proceselor fizice pentru a aborda o piață dinamică și globală. Există o pregătire sporită a forței de muncă pentru o astfel de flexibilitate și utilizarea tehnologiei, mai degrabă decât a sarcinilor specifice, așa cum se obișnuiește în fabricarea tradițională.*

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