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Development and integration of a PLM platform for the management of data in production systems

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ABSTRACT

The automobile industry is pushing the boundaries for better technology and smarter production practices. Due to the need to keep up with today's fast-paced economy, new models focused on top performance and efficiency which are now crafted using rapid prototyping. But this rapid prototyping gave a roadway for the growth of small and medium scale companies which mostly follows one-of-the kind production, is one of the manufacturing approaches to produce customized products based on requirements of customers while maintaining the quality and efficiency as mass production, but due to the one-of-the kind production, problems which are facing by the small and medium scale Industries are critical. The major problems of this type of production are 1.sequencing and scheduling the orders 2. Lack of an Advanced tool which helps to communicate and update the data in real time among the different departments within the company.

This thesis work mainly focuses on these problems and gives a best practical approach for small and medium Scale companies which follows one-of-the-kind Production by implementing the Product lifecycle management technique with other management techniques in an open source object-oriented software called Aras.

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1. INTRODUCTION

2. PLM AND OTHER MANAGEMENT SYSTEMS

In this section, different management systems are analyzed, considering how they help the company to grow and its inside communication.

2.1 Product Lifecycle Management

Product Lifecycle Management more commonly referred to as PLM - is the process of managing the entire lifecycle of a product which is emerging as a new method for industrial companies to manage product development and ‘In-service’ processes from beginning to the end of the product life cycle.

Product Life cycle Management is a systematic and controlled method for managing and developing industrial manufacturing products and related information. PLM offers management and control of the product (Development and marketing) process and the order-delivery process, the control of the product related data throughout the product life cycle, from the initial idea to the scarp yard (Saaksvuori, A. and Immonen, A. , 2004). Figure 2.1 show the connection between PLM with other different sections of the company.

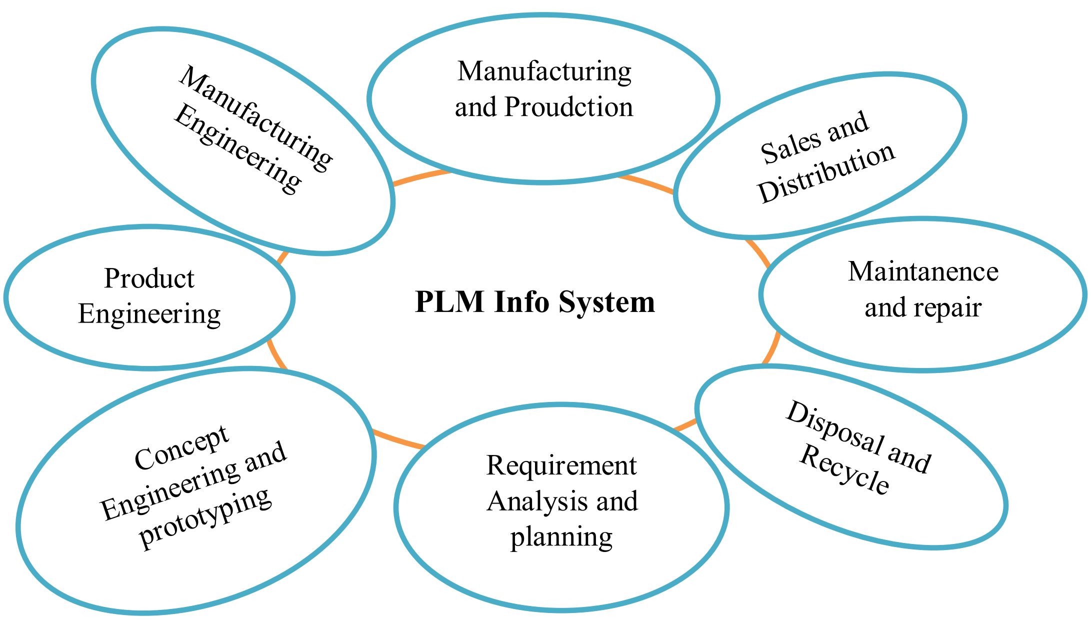


Figure 2.1 Product Lifecycle Management

In general statement, PLM involves the use of a software which eliminates the expensive trial and error that has affected the manufacturers since the industry took a step beyond industrial revolution. PLM integrates people, data, processes and business systems and provides a product information backbone for companies and their extended enterprise.

2.2 PLM as a Business Platform

A Business platform also means that many organizations and individuals must collaborate and do transactions in terms of information during the process. Because this collaboration spans different levels of the organizations, the solution requires seamless integration between the product information and project information in order to allow for a coordinated, collaborative business process. The organizations and individuals are both internal (marketing, R&D, production etc.) and external (testing, outsourced production etc.) who must share information constantly.

Manufacturing is the function that has the greatest benefit from the application of PLM technology (Grieves, 2005). The manufacturing objective is to fabricate a product with precisely defined specifications and tolerances utilizing the least amount of resources. In order to reduce the time to market, manufacturing companies have relied more and more on simulations to early (and digitally) test and optimize the manufacturing process. Simulations are used in both long-term decisions, such as facility layout and system capacity configuration, and short-term decision-making, as for example CNC simulation (Mourtzis, 2013). The term that resume this concept is Digital Manufacturing (DM). It represents the production data management systems and simulation technologies that are jointly used for optimizing manufacturing before starting the production and supporting the ramp up phases (Messaadia, 2013). In this background, PLM is the backbone of the digitalization, simulation and integration of systems.

PLM system are seen as an information system which contains information about a product that must be shared with other manufacturing systems, like MES or ERP, in different plants of the same company. This bi-directional connection between PLM and other systems which shown in Figure 2.2 is critical to enabling a seamless flow of information among the different functional groups involved in product development, particularly engineering and manufacturing (Messaadia, 2013).

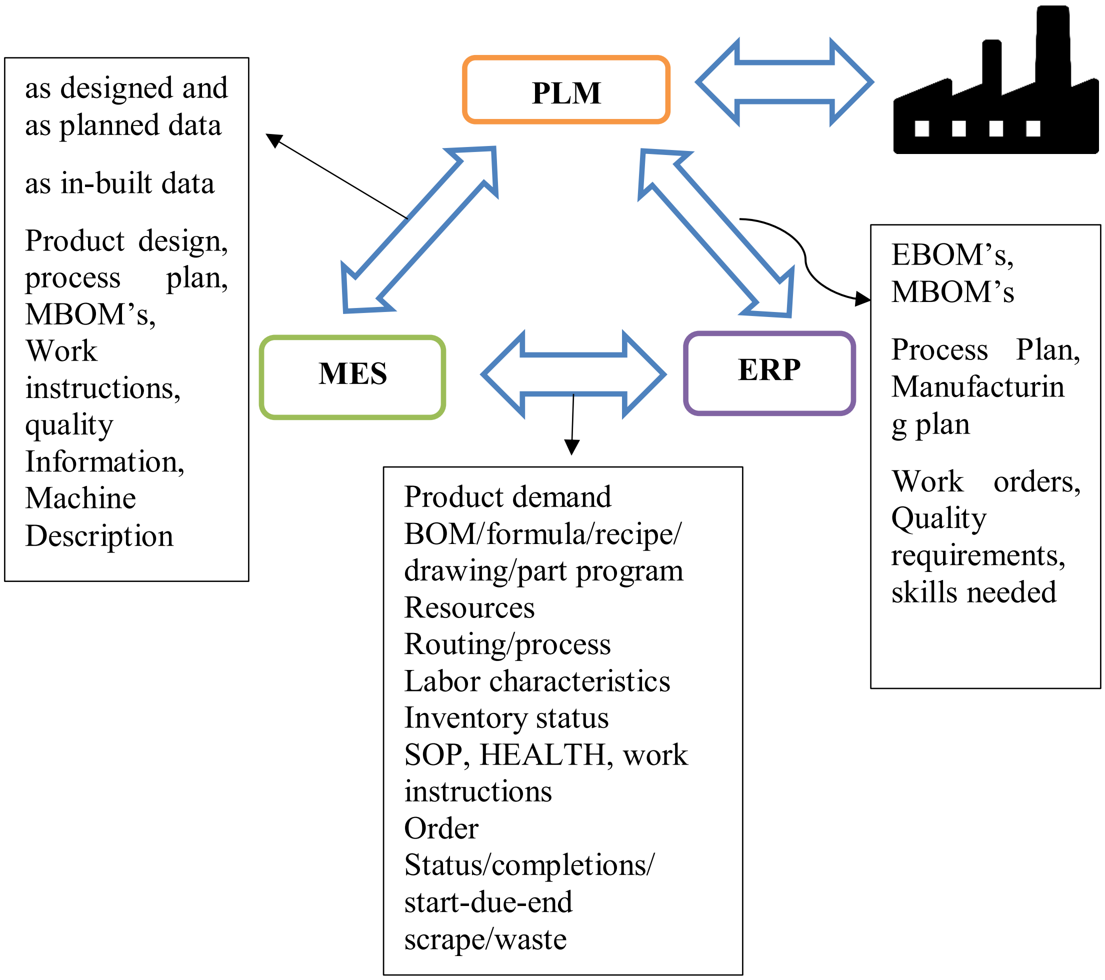


Figure 2.2 PLM as a Business Platform

PLM systems manage a portfolio of products, processes, and services from its initial conception, through design, manufacture and supply, to service and disposal. Throughout the entire product lifecycle (X. G. Ming, 2005), three major objectives are: customer benefit such as product quality and serviceability, company benefit such as product cost and profit, and society benefit such as clean and green environment.

To reach customer benefits, mass customization, time-to-innovation, product quality, and reliability are recognized as the key approaches enabled with technologies e.g., product family design, platform-based design, modular product design, design process modelling and management, design knowledge management, collaborative design engineering, function/ behavior/ structure design, etc. (Gecevska, Cus, Lombardi, & Chiampo, 2015).

2.3 Manufacturing Execution System

Manufacturing Execution System (MES) is an IT tools that enable information exchange between the organizational level of a company – commonly supported by an Enterprise Resource Planning – and the control systems for the shop-floor, usually consisting in several, different, very customized software applications (Meyer, 2009).

A MES has two principal purposes. First, the system must identify the optimal sequence planning considering the constraints of the process, such as the times for processing and setup, and the capacity of the workstations, considering the requirements and the necessities given by the organizational level. Regarding this first purpose, the system also must manage and allocate resources such as the staff and the material necessary for the manufacturing process.

The second aim of a MES is to manage the bottom-up data flow. The data collection necessary for feeding the PLM is triggered by the recent development of low-cost, small, easily available sensors. MES is in-charge of collecting the data gathered on the shop floor, analyze it through proper mathematical techniques, and extract the information necessary to provide an exhaustive picture of the current state of the process. Possibly, the analysis should be performed in real-time, in order to make decisions to control the process with the necessary rapidity. Given this background, MES plays a strategic role in supporting Industry 4.0: it is a platform for transforming data collected on the shop-floor into information, which can feed the simulation models and, in turn, enable Digital Manufacturing.

MES Functionality

The MES doesn't have only a single function but it has different ones that support, guide and track each of the primary production activities as shown in Figure 2.3.Manufacturing Execution System Association (MESA) identified 11 functions of MES (Gerhard Greeff, 2004).

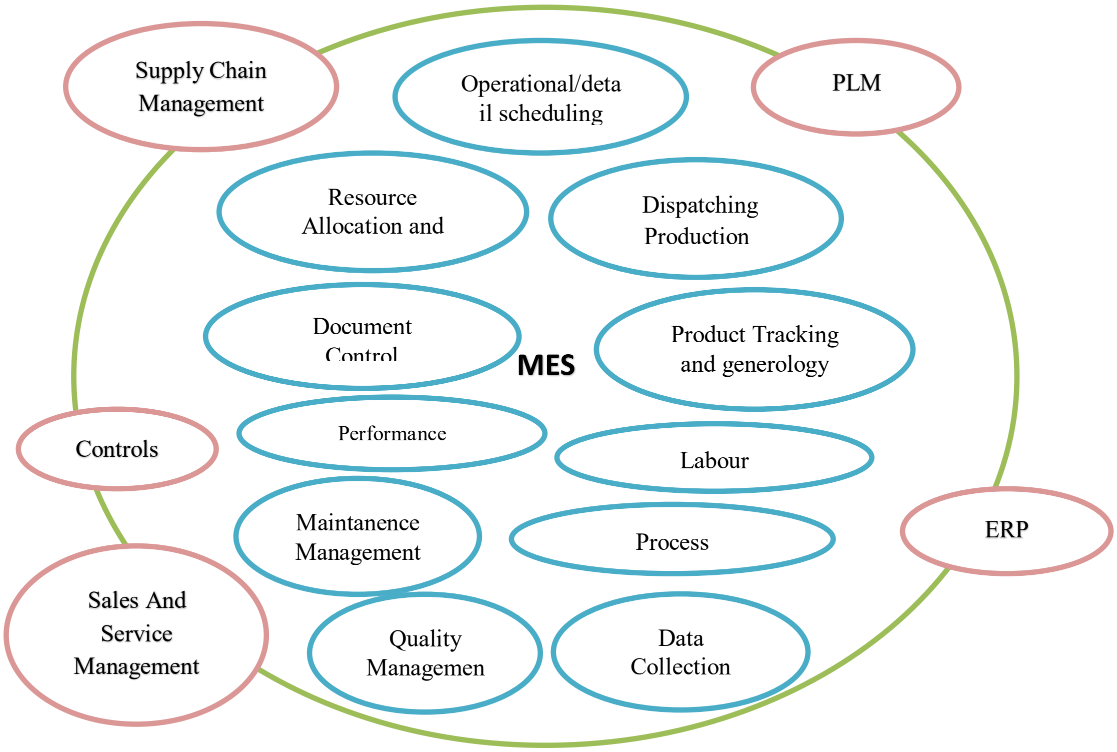


Figure 2.3 MES Functionality

1. **Operational/detail scheduling:**

   Sequencing and timing activities for optimized plant performance based on finite capacities of the resources. It provides sequencing based on priorities, attributes, characteristics, recipes associated with specific production units at an operation. E.g. Shape of colour sequencing which, when scheduled in sequence properly, reduce set-up. It recognizes alternative and overlapping operations in order to calculate exact time or equipment loading and adjust to shift patterns.

2. **Resource allocation and status:**

   Guiding what people, machines, tools, and materials should do, and tracking what they are currently doing or just have done. It provides a detailed history of resources and ensures that equipment is properly set up for processing and provides status in real time. The management of these resources includes reservation and dispatching to meet operation-scheduling objectives.

3. **Dispatching production units:**

   Giving the command to send materials or orders to certain parts of the plant to begin a process or step; it can alter as well as control the prescribed schedule or the amount of work in process at any point on the factory floor. Rework and salvage processes are available, as well as the ability to control the amount of work in process at any point with buffer management.

4. **Document control:**

   Managing and distributing information on products, processes, designs or orders, as well as gathering certification statements of work and conditions. It includes the control and integrity of environmental, health and safety regulations, and ISO information like corrective action procedures.

5. **Product tracking and genealogy**

   Monitoring the progress of units, batches or lots of output to create a full history of the product. Product tracking allows traceability of the components and usage of the end products. Provides the visibility of work all the time and its disposition. Status information includes, who is working on it, components materials by supplier, lot, serial number, current production conditions, and any alarms, rework, and other exceptions related to products.

6. **Performance analysis:**

   Comparing measured results in the plant to goals and metrics set by the corporation, customers or regulatory bodies. It provides up-to-the-minute reporting of actual manufacturing operations results as well as comparison to history and expected result. Performance results include measurements such as resource utilization, resource availability, and product unit cycle time, conformance to schedule and performance against standards.

7. **Labour management:**

   Tracking and directing the use of operations personnel during a shift based on qualifications, work patterns and business needs. It provides information of personnel in an up-to-the-minute time frame. It interacts with resource allocation to determine optimal assignment. It tracks time and attendance reporting, as well as indirect activities such as material preparation or tool room work as a basis for activity-based costing.

8. **Maintenance management:**

   Planning and executing appropriate activities to keep equipment and other capital assets in the plant performing to the overall goal. It maintains a history of past events or problems to help in diagnosing problems. It tracks and directs the activities to maintain the equipment and tools to ensure the availability for manufacturing and gives alarm to immediate problems.

9. **Process management:**

   Directing the flow of work in the plant based on planned and actual production activities. Process management monitors production and corrects automatically or provides decision support to operators for correcting and improving in-process activities. These activities are inter-operational and focused mainly on machines. It tracks the process from one operation to the next and may include alarm management to inform the factory personnel. Process management provides interfaces between intelligent equipment and MES through data collection/acquisition.

10. **Quality management:**

    Recording, tracking and analysing product and process characteristics against engineering ideals. It provides real-time analysis of measurements collected from manufacturing to ensure/assure correct product quality control and identifies problem. It recommends action to correct the problem, correlating the symptom, actions and results to determine the cause. Quality management include SPC/SQC tracking, management of off-line inspection operations and analysis of laboratory information management system (LIMS).

    SQC/SPC: SQC and SPC are statistical tools to detect trends and are essential for plant optimization. They are effectively used and necessary once the plant has reached steady state conditions.

11. **Data collection/acquisition:**

    Monitoring gathering and organizing data about the processes, materials and operations from people, machines or controls. The data are collected from the factory floor manually or automatically from equipment in an up-to-the-minute time frame. It provides an interface link to obtain the intra-operational production and parametric data which populate the forms and records related to production unit.

2.4 Enterprise Resource Planning

Enterprise Resource Planning (ERP) is an enterprise-wide information system that integrates and controls all the business processes in the entire organization. The ERP is an industry-driven concept and systems and is universally accepted by businesses and organizational industries as a practical solution to achieve an integrated enterprise information system solution. ERP systems have become vital strategic tools in today’s competitive business environment. The ERP system facilitates the smooth flow of common functional information and practices across the entire organization. However, without top management support, having appropriate business plan and vision, re-engineering business process, effective project management, user involvement and education and/or training, organizations cannot embrace the full benefits of such complex system and the risk of failure might be at a high level (Addo-Tenkorang, 2011).

From Figure 2.4, It shows that ERP provides an integrated and continuously updated view of core business processes using common databases maintained by a database management system. ERP systems track business resources—cash, raw materials, production capacity—and the status of business commitments: orders, purchase orders, and payroll. The applications that make up the system share data across various departments (manufacturing, purchasing, sales, accounting, etc.) that provide the data. ERP facilitates information flow between all business functions and manages connections to outside stakeholders.

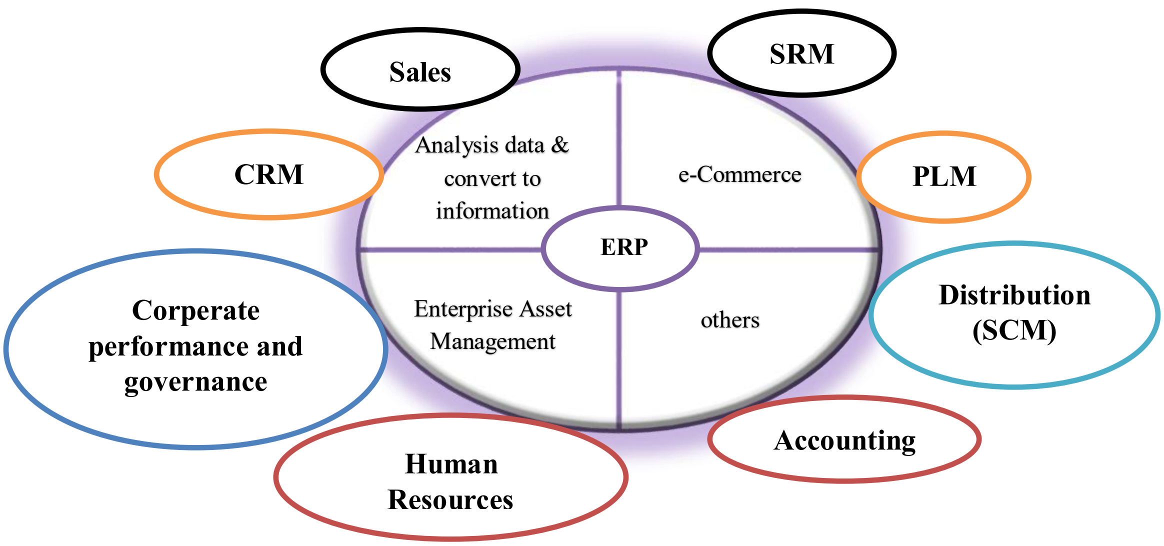


Figure 2.4Enterprise Resource Planning

ERP systems typically include the following characteristics:

- an integrated system
- operates in (or near) real time
- a common database that supports all the applications
- a consistent look and feel across modules
- installation of the system with elaborate application/data integration by the Information Technology (IT) department, provided the implementation is not done in small steps.

2.5 Integration between PLM, MES and ERP

PLM, MES and ERP have traditionally been three very distinct pillars of the manufacturing technology. Now, in the current times where Industry 4.0 is evolving, it is possible to integrate core enterprise systems to achieve timely product delivery and top-notch quality. By closing the loop between PLM, MES and ERP systems as shown in Figure 2.5, manufacturers are hoping to facilitate data sharing between the functional areas of engineering, the shop floor and the front office. The goal is to deliver visibility that will help streamline product delivery cycles, eliminate redundant manual processes and waste, and help proactively pinpoint and correct quality issues before they become too costly and to satisfy customers.

“Manufacturers may be collecting a lot of data, but if they can’t analyse it and turn it into actionable information that affects processes and makes them competitive, it’s not useful,” explains Mike Lackey, vice president of solution management, line of balance (LoB) manufacturing, and extended supply chain at SAP. “That’s why there’s a big movement to integrate the shop floor with the enterprise and PLM.”

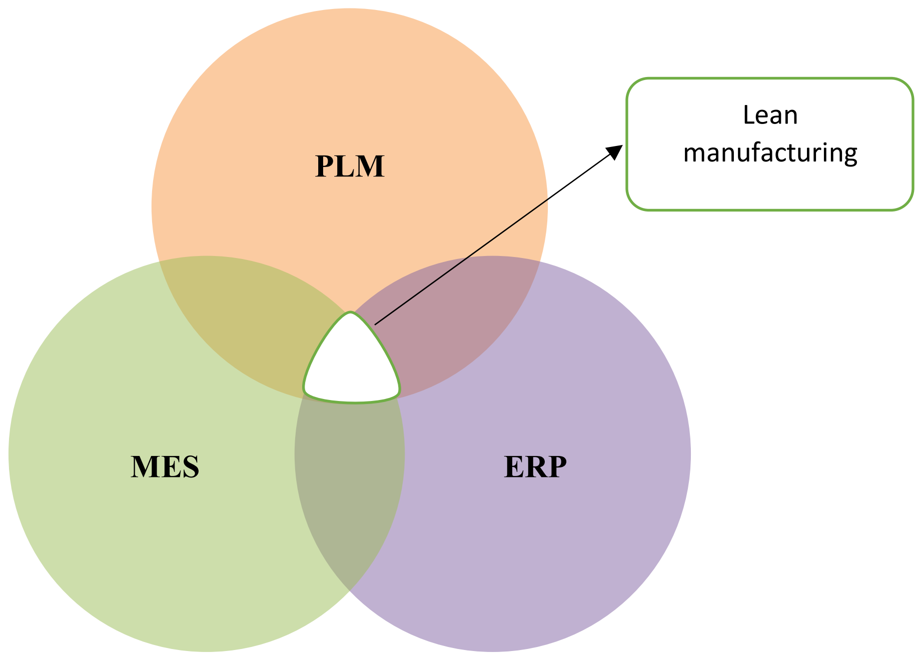


Figure 2.5 Integration between PLM, MES and ERP

PLM-MES Architecture:

Through the PLM, in the design phase, the data of BOM, List of Activities, Product Design, Process plan, check start, check end, Machine Description regarding the product and its activities are generated. In another side, the MES should be able to communicate, to the PLM, reports if a problem related to these data was detected. Data related to the manufacturing system (machines, labour, materials, etc.) should be stored and managed into PLM system. In the other hand, the MES main role system transforms the digital product into a physical product. Figure 2.6 shows PLM-MES Architecture in schematic way.

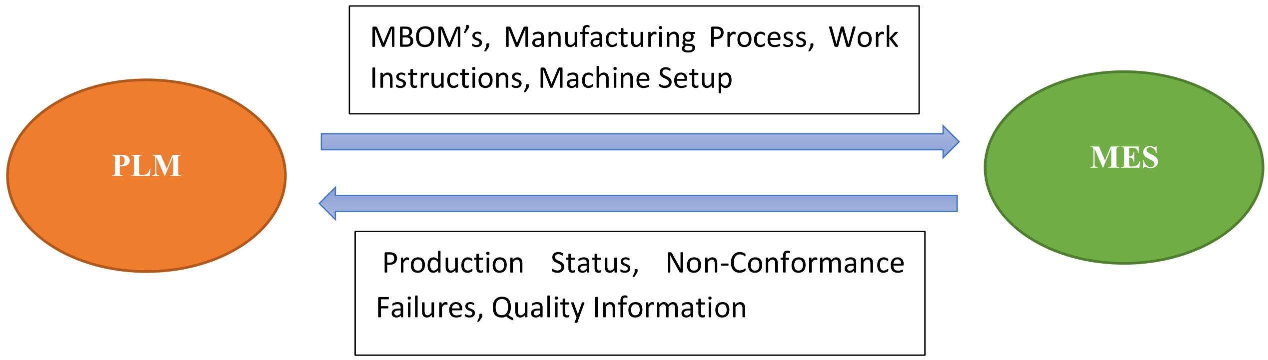


Figure 2.6 PLM-MES

ERP-MES Architecture:

ERP-MES architecture is the classic architecture used in continuous/batch manufacturing. This architecture is based on ISA95 standard to exchange information between enterprise systems and control system without unnecessary time delays in order to optimize the production (Heike Schumacher, 2004). This standard provides the potential to simplify the deployment of ERP-MES integration as shows in Figure 2.7. The problem of ERP-MES architecture is the absence of product data management systems.

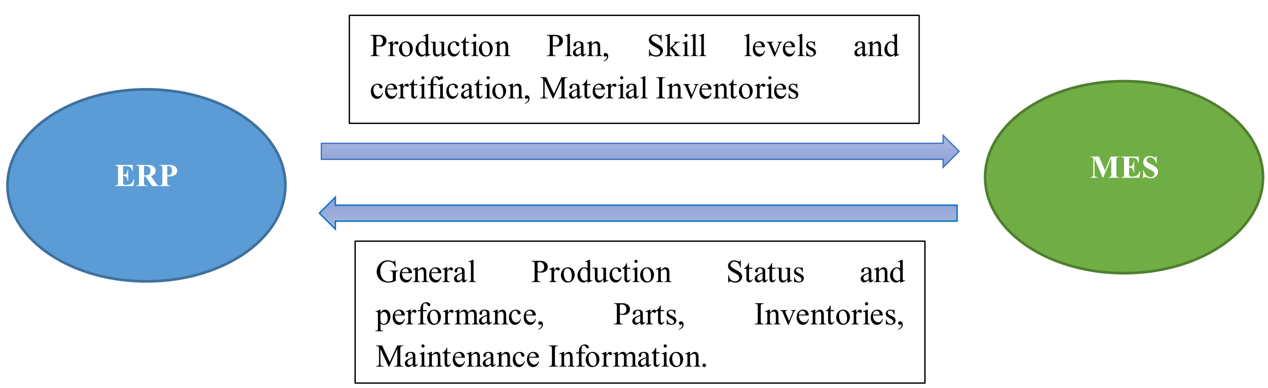


Figure 2.7 ERP-MES Architecture

PLM-ERP Architecture:

The classic architecture used in discrete manufacturing is the PLM-ERP architecture shown in Figure 2.8. In fact, several enterprises typically integrate PLM and ERP to ensure the consistency and use of product/shop floor related information throughout the enterprise and to use common product related data and processes (Siemens, 2010)

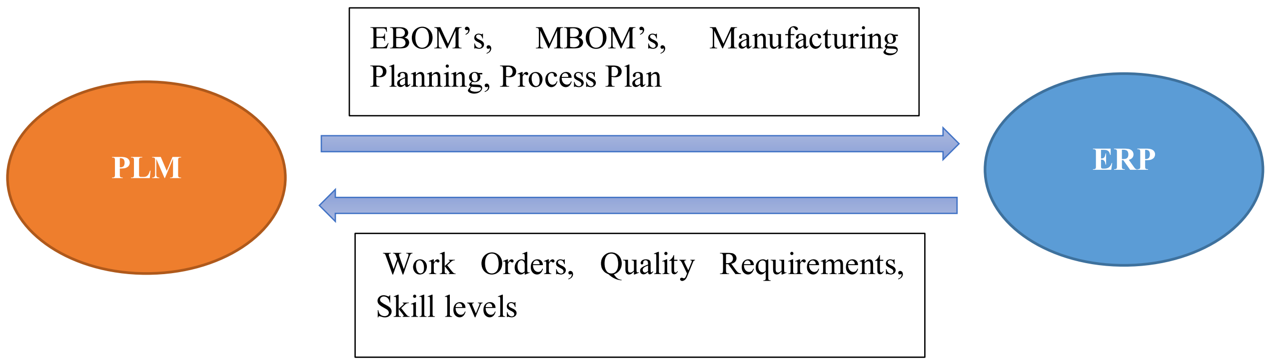


Figure 2.8 PLM-ERP Architecture

3. ONE-OF-A-KIND PRODUCTION USE CASE: EURODIES

In this Chapter, One-of-a-kind Production and its issues will be discussed and analysed in the case of an automotive prototyping company: Eurodies Italia S.r.l.

3.1 One-of-a-kind Production

According to (Xue), One-of-a-kind Production (OKP) also called as Mass customization which is a manufacturing approach to produce customized products based on requirements of customers while maintaining the quality and efficiency as mass production. The OKP products can achieve the customer requirements with low production costs for improving competitiveness of the products in prototyping field.

According to (Tu), the OKP philosophy is characterised as follows:

1. high customisation;
2. successful product development and production in one go;
3. optimal or rational utilisation of technologies and resources;
4. adaptive production planning and control;
5. continuous customer influence throughout the production;
6. incremental process planning;
7. distributed control and inter-organisational autonomy;
8. virtual company structure and global manufacturing

Global Competition among the manufacturing companies forcing them to develop the ability to produce One-of-a-kind production products with high quality and satisfying prices for customers. In simple words, an OKP company can be understand as an advanced job shop which provides different kind of services in a certain domain e.g., Producing different parts for prototyping in Automotive Field, A mould/tool manufacturer etc.

This Global competition among manufacturers caused them to cut the costs which makes them to move their manufacturing bases from developed countries to developing Countries which offers favourable conditions like less labour cost, less material cost, less maintenance cost etc. This leads to the new manufacturing mode called virtual manufacturing. A virtual manufacturing company is a global manufacturing network where the nodes are branches of the company, subcontractors, joint ventures, or partners of the master company (Rolstadas, 1994) . These nodes have been called 'virtual cells' by Tu (Tu) . These cells are dispersed across the globe which is a challenging to the company to operate them in a synchronised way.

3.2 Problem and Issues due to OKP

There are number of issues raised for the requirements and problems in the Virtual Manufacturing, especially in OKP. The requirements and problems includes, which is the best approach to develop a product and its production, highly customised products, need for quickly responding to the customer demands, how to capture marketing opportunities, continuous customer influence on production and optimal solution for synchronising the nodes in virtual manufacturing.

Product development and synchronising the branches of the company are the main two activities for a company. Process planning plays an important role for linking these two activities. Process planning is one of the key parameters in OKP, Process planning has been defined as ‘‘the subsystem responsible for the conversion of design data to work instruction’’ (Link) . A more specific definition of process planning is given as, ‘‘The function within a manufacturing facility that establishes the processes and process parameters to be used as well as those machines capable of performing these processes in order to convert a piece-part from its initial form to a final form which is predetermined on a detailed engineering drawing’’ (T.C. Chang, 1985). In OKP, continuous customer influence on production which requires changes or modifications during product development and production. Conventional process planning theory is a linear process model. It can only run in series, not concurrently. Hence, these conventional process planning techniques need to be developed to support the production planning and control in OKP.

3.3 Prototyping in Automobile Industry

The automobile industry is pushing the boundaries for better technology and smarter production practices. Due to the need to keep up with today’s fast-paced economy, new models focused on top performance and efficiency which are now crafted using rapid prototyping.

As per (automotive-prototype-uses from concept to creation, 2016), Generally, when people think about an automotive prototype, they assume that it represents a single step in the validation process between the initial design of the product and the final production run but in reality, automotive prototyping plays a number of important roles during the design validation process that culminates in manufacturing. An automotive prototype can be used to ensure that to decide on the types of materials that are best for a product, to decide a product can be made, and to evaluate what types of equipment should be used to manufacture the part. In other words, prototyping extends far beyond just a single phase in product development in the automotive industry. Automotive prototypes are integral parts of the entire automotive engineering process that allow engineers to figure out how to make new automotive products that meets consumer needs, to convince stakeholders to invest in a new automotive product, and to ensure that a vehicle will be safe for end users.

There are different types of prototyping depending on the Automotive product development phase. In every phase of Automotive Industry, prototyping plays a major role which generally follows One-of-the kind production (OKP). Generally, Automotive Companies will have an OKP plant as a branch of the company or they will have tie-ups with the OKP Companies which produce different parts of a certain sector. The phases of automotive product development are design validation, pre-development, production process validation, customer testing, safety testing, and manufacturing validation.

a) Design Validation Prototypes

During the design validation phase, product engineers can use an automotive prototype not only to gain greater clarity regarding their designs and to validate that they can be made, but also to "sell" their concepts to stakeholders. A prototype created during the design validation stage is rarely a complete, final model. Instead, rough prototypes made using cost-effective prototyping techniques, such as plastic injection moulding, are used to create a simple physical object. This basic prototype can be used to visualize the concept and share information with the entire project team.

b) Pre-Development Prototypes

Once a design has been validated and there is buy-in from stakeholders and production teams, the early pre-development stage requires a more refined prototype to determine the usability of the product and to smooth over any design challenges. Automotive engineers sometimes refer to this as the "mule stage." During this stage, engineers take donor cars, strip the vehicles down, and place the prototype products in the existing automobiles.

This strategy allows them to see how the automotive prototype will fit in the vehicle and interact with the other parts. It also gives them an opportunity to consider design alternatives that may work better.

c) Production Process Validation Prototypes

After the mule stage, automotive engineering next makes use of automotive prototypes during the production process validation phase at the assembly plant.

CNC machining, metal stamping, and other metal forming, and fabricating techniques are used during this phase to figure out the ideal methods for creating the final automotive product.

These types of automotive prototypes allow engineers to spot possible production problems as well as determine the most cost-effective manufacturing processes. Sometimes during this stage, it might be discovered that a manufacturing technique available at one plant is better suited to handle the production of an automotive product.

d) Customer Testing Prototypes

Gaining valuable feedback from people who will be using a vehicle helps engineers sell their concept to stakeholders, spot possible issues, and decide on the right materials for the final automotive product.

Customer testing that uses an automotive prototype can occur during any stage of the development and production process. The feedback from these studies is used by engineers to figure out how desirable an automotive product is, if there will be any difficulty using the product during normal activities, and if customers won't use the product for any reasons.

e) Safety Testing Prototypes

An automotive prototype is vital for safety testing, which can be performed throughout the pre-production and validation phases to evaluate possible failures of the automotive product during actual use.

This testing is called Failure Mode Effect Analysis (FMEA). During it, automotive prototypes are placed through different scenarios and subjected to extreme conditions to identify any problems that could hamper the use of the product or cause serious safety concerns to consumers.

f) Manufacturing Validation Prototypes

Before an automotive part goes into production, a prototype must be developed for manufacturing validation. The manufacturing validation build uses the intended equipment and machinery to create the final automotive prototype so that finishing touches can be made before production tooling is engineered. A minimal amount of tweaking is performed during this stage in order to finalize the automotive product.

Verification testing can be performed using prototype parts created at this stage to ensure that all parts work as desired. Some of these test vehicles may even be sold to the public.

g) Multiple Roles played by an Automotive Prototype

There is never just one automotive prototype made when developing a new automotive product.

Prototypes play vital roles throughout the ongoing process of developing automotive parts and assemblies. They are constantly refined until a consensus is reached regarding both the product design and the manufacturing methods that will be used to create it.

By having prototypes created throughout the automotive product lifecycle, stakeholders, project teams, and manufacturing production staff can all work together to realize a concept efficiently and cost-effectively.

3.4 Industrial and production processes in Eurodies Italia S.r.l

As per (Calza, 2018), With reference to Figure 3.1 and Figure 3.2, which shows the activity diagram, the entire process performed by Eurodies in order to produce a certain number of components, from the moment in which the order is received to the delivery, is now presented and described. Subsequently, each phase is explained in greater details, with a technical description of the process when needed.

The industrial process for the realization of a prototype bodywork component starts with the delivery, by the costumer company, of the CAD model of the requested piece. Eurodies Italia's engineers, starting from such model, derive the models of mould and counter-mould, more commonly called die and punch (or generally, dies). Such dies will be mounted on the presses for the sheet metal working operations, such as drawing, flanging, etc. The Computer Aided Design software used for this activity is Catia by Dassault Systèmes.

Before building the dies, the model needs to be validated with a simulation. An engineer specialized in simulations uploads the CAD models of die and punch on a software, which simulates the drawing process with a Finite Element Method (FEM) analysis. The software is called Autoform. If the simulation does not highlight critical issues, the models of the dies are approved and sent to the CAM department, where the toolpaths for the milling machines are studied and defined.

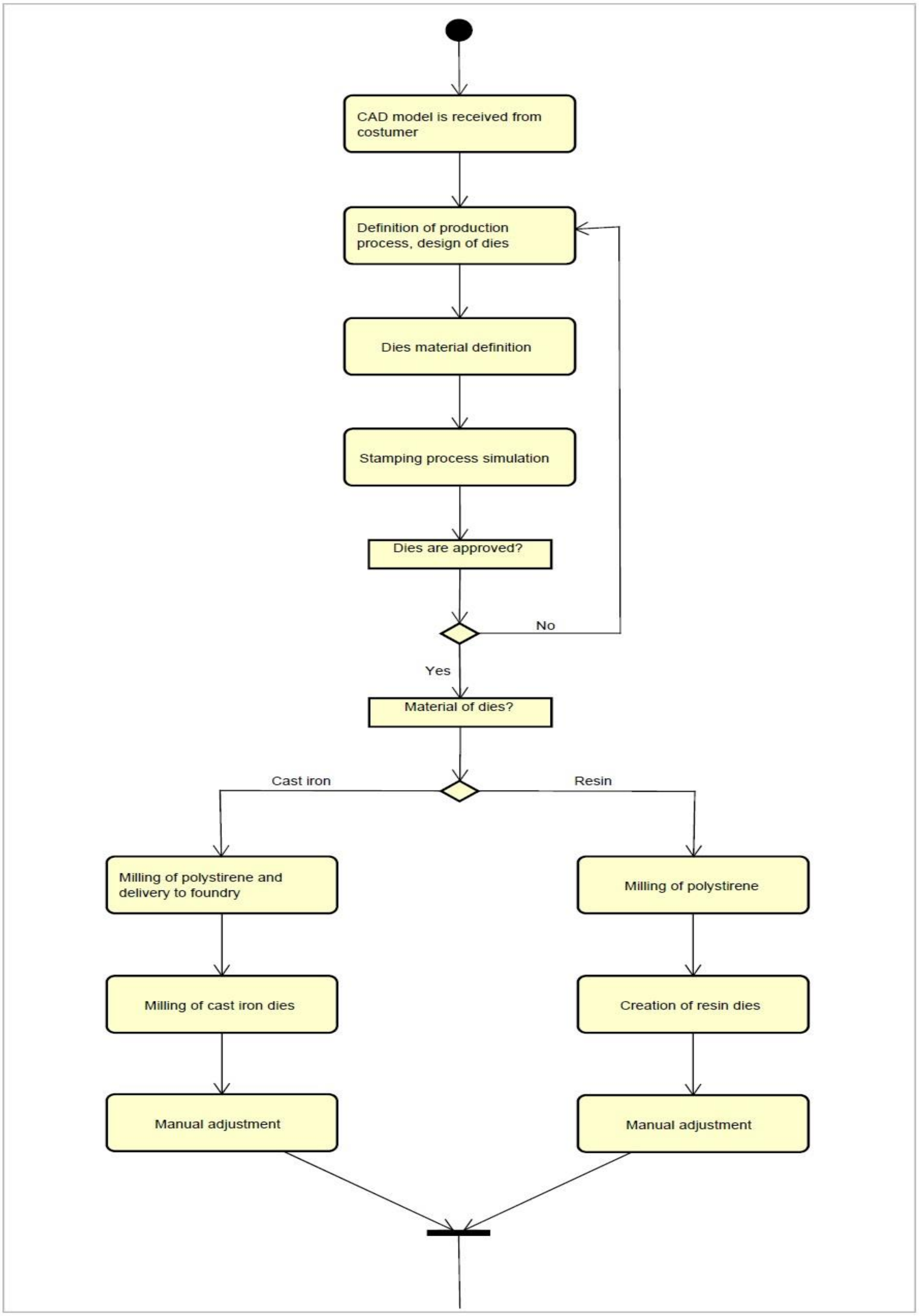


Figure 3.1 Activity diagram of industrial processes in Eurodies (first part)

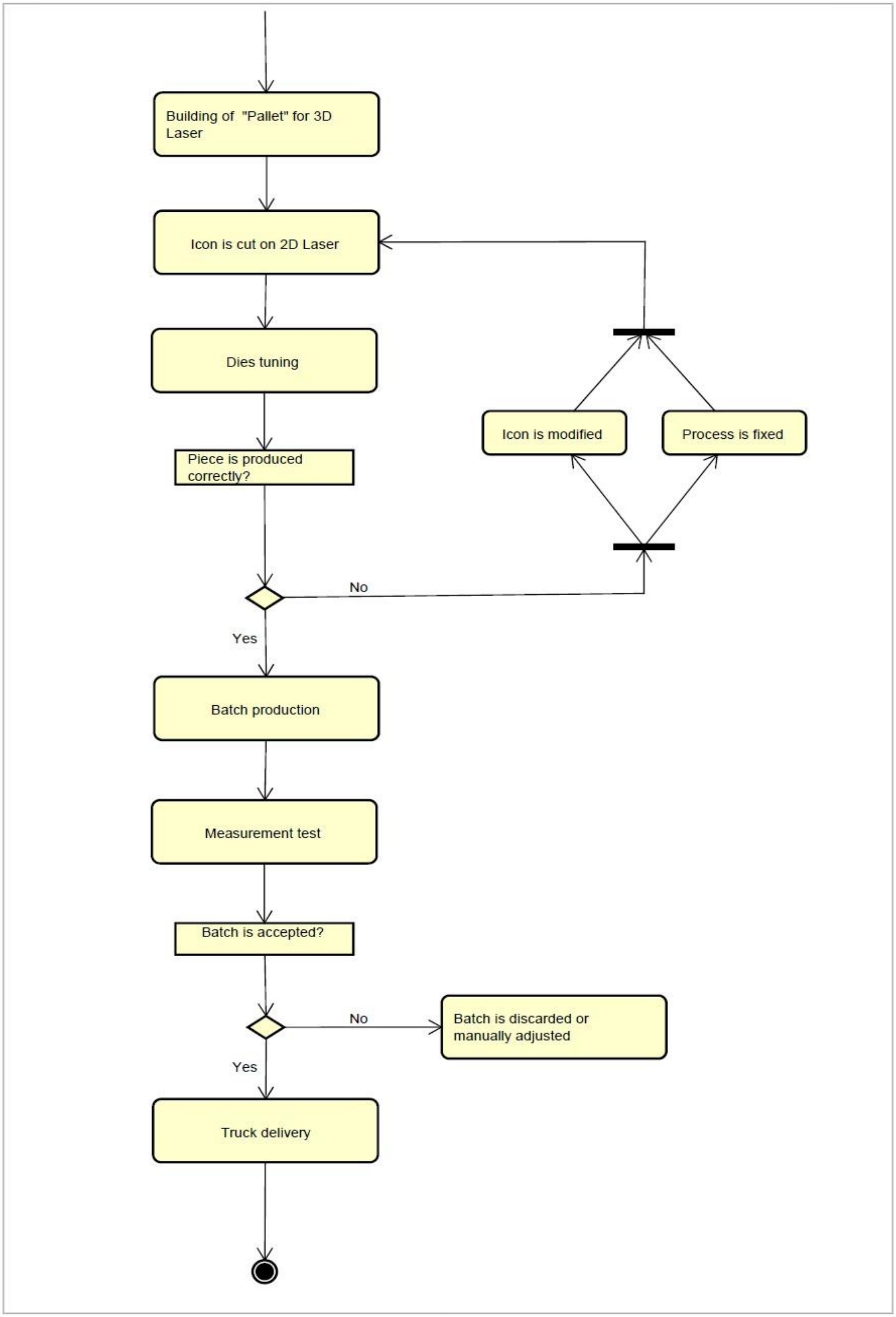


Figure 3.2 Activity diagram of industrial processes in Eurodies (second part)

Dies are built in polystyrene, utilizing a CNC 5-axes milling machine. The polystyrene dies are then sent to a foundry that, with an expendable-mould casting process, transforms the polystyrene shape in the permanent cast iron tool. The cast iron used for this operation is not high quality, since in this case the priority is to keep costs low, rather than make a very durable die set.

The rough cast iron dies are delivered from the foundry to the Avigliana plant of Eurodies, where they are worked in different CNC milling machines. The first operation is called spianatura (flattening) and it is necessary to make the bottom of both die and punch perfectly flat, in order to obtain a flat surface on which the dies can be laid for subsequent operations. This operation is often outsourced to third companies, since it a very costly one in terms of machine-hours, but it is not particularly complex. The flattened dies are then delivered back to Eurodies, where several large milling machines continue their construction. Such milling machines have different levels of power and precision: for the first roughing a powerful, yet less accurate machine is utilized; for the subsequent pre-finishing and finishing the choice falls upon more precise machines (usually the newest), which guarantee better dimensional tolerances.

Finally, die and punch are finished off by hand (with files and sandpaper) by specialized operators, the so-called aggiustatori.

Once the tools are ready (tools, or tooling, is the generic term for the dies), the punch is transported to the metal carpentry area, where the so-called pallet is built. In this context, the pallet is a support for the semi-finished piece, on which the component will be laid after drawing, for the laser trimming operations. Figure 3.3, below, shows a finished pallet. In the subsequent phase, die and punch are mounted on a hydraulic press as shown in Figure 3.4, which will be used for the drawing operation. Nevertheless, before undergoing the drawing process in the press, the metal sheet must be trimmed in the two-dimensional laser to obtain the appropriate shape, determined in order to avoid possible wrinkles and defects. The rectangular blanks of metal sheet are cut in laser machine with two degree of freedom (plane movement), and the positioning of the metal sheet in such machine is performed automatically with a suction cup manipulator and comb manipulator. The shaped metal sheet that is the result of such operation is called blank outline or “icon”.

Figure 3.3 Pallet

Figure 3.4 Mounting of die and punch on the hydraulic press

The blanks are cut by the 2D laser, according to the appropriate blank outline and are transported into the presses area, where they undergo the first press operation, that is, drawing. After the drawing operation, the semi-finished items are moved to the 3D laser area and laid on the pallet. Here, 5-axes CNC robots cut the metal sheet according to the "laser paths" designed by the engineers of the laser office, obtaining the final measures of the piece and creating slots and holes.

Following the activity diagram, after drawing we find a decision node. In fact, for very simple pieces, the drawing operation is enough to obtain the final geometry, with just a finishing laser trim: in this case, the first and only press operation is called "dry drawing" (imbutitura a secco), and it is performed without blank holder. In components with a more complex geometry, other press operations become necessary. For example, a redrawing may be needed (an operation that “fixes” the precise dimensions and the final geometry of the component, often performed on the same dies used for the drawing, with different tool pressions); or one or more flanging operations, needed to obtain the areas of the components that have a bending angle greater than 90 degrees).

With reference to the Figure 3.5, looking at the activity diagram it can be noted that among press operation it is almost always necessary to perform a 3D laser trim. Summing up, a component that is “averagely complex” to produce needs a sequence of operations similar to the following: blank outline cut on the 2D laser, drawing, 3D laser roughing trim, redrawing, flanging, 3D laser finishing trim as shown in Figure 3.6

This sequence is not the same applied to all the components that are produced by Eurodies, since prototypes are always new and different by definitions, and working cycles show important variations.

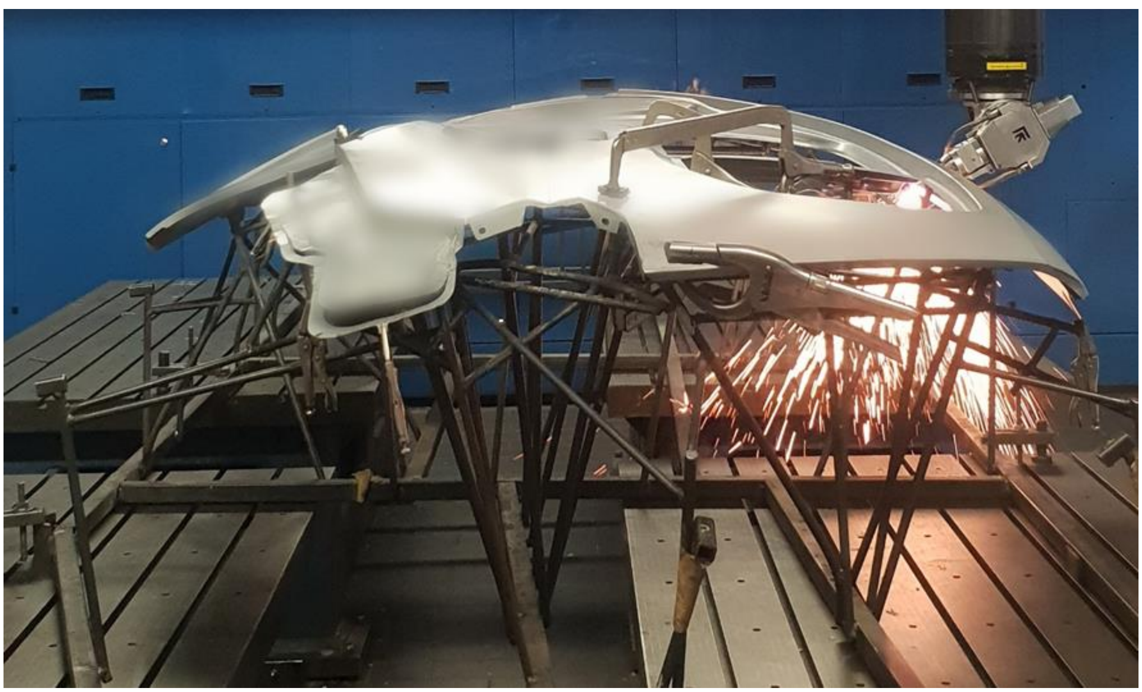


Figure 3.5 3D laser trimming operation

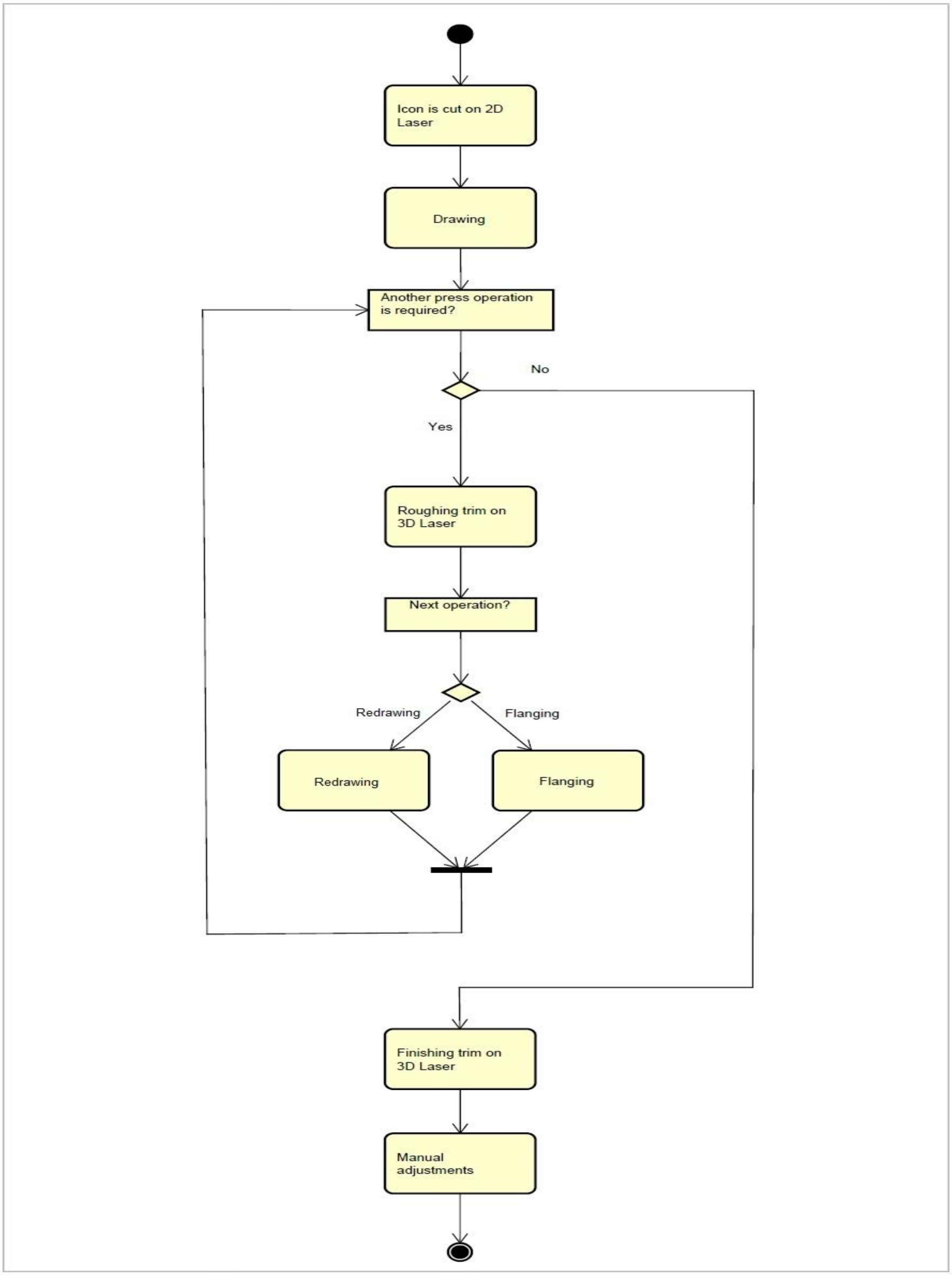


Figure 3.6 Activity diagram of the prototype component production phase

3.5 Critical Issues in Eurodies

The job performed by Eurodies Italia is extremely variable and difficult: it is difficult to forecast the production trend, and there may be problems and mishaps that prevent the plant from having a linear production.

The main reason for this is the type of product made by the company. The production of prototypes makes the industrial phase much more complex, with respect to the series production. This is proven also within Eurodies itself, which has also few orders of "small series" components: these never show problems and it easy to forecast the trend of production, the productivity of employees and the quantity of material waste.

On the contrary, the production of prototypes is characterized by an extremely variable production rate, with high material waste, despite the great experience of the specialized employees.

The problems that the company has to face have mainly two reasons: the type of production (prototype-making) that causes great difficulties in sequencing and scheduling of orders, and the dimensional growth that Eurodies has had in the last years. The fact that the company has grown from around 40 to around 160 employees, without a real company reorganization and a change of work methodologies and of information transfer, created many inefficiencies.

It may also be thought that the second reason is somehow linked to the first: the continuous necessity to focus on production did not allow Eurodies to utilize time and resources for a work methodologies reorganization.

Another problem shown by the company is the separation between design phase and production phase. When the design of the dies is approved by the responsible person, his role is over, and the designer does not receive any feedback on possible problems caused by the dies during production. Furthermore, press operators do not receive the results of the simulation that should theoretically indicate which zones of the piece are the most critical.

The lack of information flow in both directions leads to a lack of continuous learning by the designer who, without receiving feedback on his work, cannot modify his work methodology or make the simulation more reliable. For the operators, the lack of information about the results of the simulation makes the job harder, since they do not know what to expect from the first press hit.

Another problem that should be considered is the absence of data collection during production. The only relevant data, in Eurodies Italia, is the quantity of pieces produced at the end of the shift. No data is collected about the exact quantity of defectives or of material waste. No information is stored, about the main problems that the operators had to face during the shift: such information, if available, would be useful to understand how to increase the effectiveness of the dies for the next order of a similar component. Recently, Eurodies has understood the importance of creating statistics on errors and defectives that are detected in the production phase, in order to be able, among others, to look for correlation between the errors themselves and the utilized material or the shape of certain pieces.

They are considering ways to collect this information without interrupting or slowing down the operators' work, especially the ones working at the presses. It is not an easy task, because there is no availability of a reliable and affordable technology to automatically detect defects.

As we discussed in previous chapters about PLM, MES and ERP, the best solution for the above problems in the Eurodies Italia is to introduce a flexible and adaptable PLM software with the integration of MES and ERP, which deals with the various aspects and problems occurs in OKP based companies like Eurodies Italia.

4. ARAS PLM PLATFORM

According to (Aras, s.d.), The Aras PLM Platform is open, flexible, scalable, and upgradeable and adapts to our unique business processes now and in the future.

PLM Platform means that many organizations and individuals must collaborate and do transactions in terms of information during the process. Because this collaboration spans different levels of the organizations, the solution requires seamless integration between the product information and project information in order to allow for a coordinated, collaborative business process. In this Chapter, we will discuss about the Capabilities and availabilities in ARAS Software.

4.1 PLM Capability and Availability in ARAS:

Here we will discuss about the list of possibilities and available properties that we can do in Aras which enhance the transaction of information among different levels of the organization.

a) Item Types

An **ItemType** is a business object managed by Aras Innovator. It is the template or the definition for the items that are created from it. In Object Oriented programming terms, ItemTypes are similar to class definitions. The items that you create from it are the class instances.

Almost everything in Aras Innovator is defined through an ItemType. ItemTypes define: Properties, forms or views available for an item, the lifecycle associated with the item, Workflows associated with the item, Permissions, relationships, server and client methods and events to run on the item, and much more.

ItemTypes are designed to hold as little information as a name, or as much complexity as is required for the most involved business objects.
When creating an ItemType, we will see a set of header properties, and a set of tabs as shown in Figure 4.1and Figure 4.2

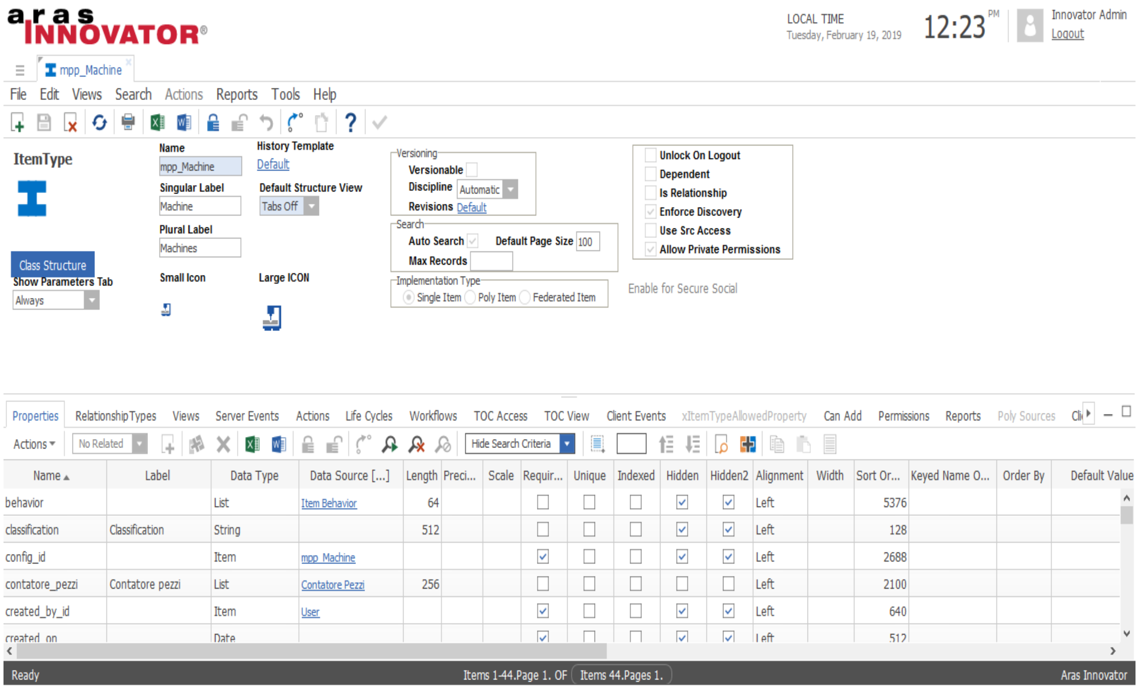


Figure 4.1 Item Type 'Machine'

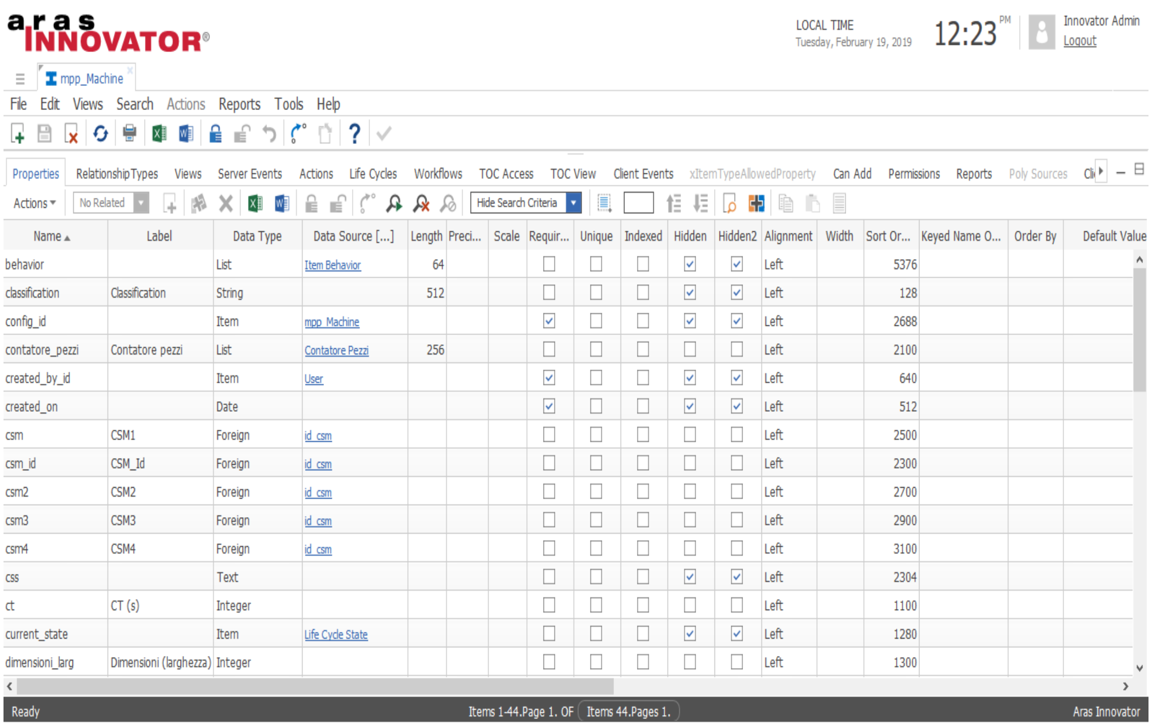


Figure 4.2 Properties of Item Type 'Machine'

b) Documents

Manage all the documents involved in the creation of products.

Centralize Your Documents: During the lifecycle of a typical product many documents are created containing critical information which needs to be shared and forms part of the product record. The creators and users of these documents are usually spread across many functions and locations making the management of these documents a significant challenge.

Controlled and Secure Access: Document Management with Aras includes version and change control for files in multiple formats in a secure, searchable repository. Users across multiple teams and locations now have easy access to critical information required for the projects they are working on.

Key Features:

- manages all types of documents and file formats, including Microsoft Office, PDF, drawings, TIF and more
- associate documents directly to products or projects
- secure storage in optionally distributed and replicated file vaults
- simple and advanced full text search modes
- document lifecycle status management, versioning and user access control
- comprehensive revision and version control and change control workflows.

c) Parts

Manage the creation, Release and change of new and existing parts.

Losing the parts battle? Managing the orderly creation, release and change of parts is a key challenge for organizations. New parts are critical to delivering innovations and meeting customer requirements. But poor control of part introduction can raise costs and cause delays throughout the organization.

Create Parts and Reuse parts in ARAS

Parts Management provides complete control over the lifecycle of parts including automated workflows to manage the approval processes. Links to CAD models, drawings and documents are automatically maintained. Classification schemes may be implemented to support search and reuse.

Key Features

- configurable properties and lifecycle stages
- approved manufacturers/alternate/substitute parts
- target weight and cost
- CAD and document integration
- flexible classification and search
- version and revision control.

d) Bill of Materials

Product structures through the lifecycle

Getting Control of your BOMs

Bringing complex products to market and maintaining them through their life is a multi-step process. It requires managing bills of material (BOM) not only across mechanical, electrical, and software disciplines but in the extended supply chain as well.

The challenge of managing multiple BOM representations leaves organizations struggling to improve quality, reduce time-to-market, and manage costs.

Complete BOM Visibility with ARAS

BOM management with Aras Innovator helps organizations connect and manage multiple sources of information in a single database. Easily create and maintain structured, multi-level bill of materials for each stage of the product lifecycle. Easily synchronize EBOMs and MBOMs for clear visibility into cross-disciplinary change statuses through, design, manufacture and service.

Key Features

- alternate/substitute parts
- options (variants) and configuration rules
- BOM red-lining and compare
- target-estimated-calculated-actual weight and cost
- multiple BOM views

e) Process Plan:

Aras Manufacturing process plan is an integrated approach to managing manufacturing data and processes in PLM. With the emergence of the Industrial Internet of Things (IoT), companies with complex products are looking for better ways to integrate their manufacturing operations. But with today's disconnected systems, authoring and reconciling MBOMs, process plans and work instructions, and ensuring synchronization with evolving product designs can be time-consuming and error-prone.

Aras Manufacturing Process Planning provides an integrated approach to managing manufacturing data and processes in PLM. It supports graphical and concurrent process plan as shown in Figure 4.3 and Figure 4.4, MBOM and work instruction authoring plus real-time automatic EBOM/MBOM reconciliation.

Aras Manufacturing Process Planning:

- manufacturing Process Planning [MPP] is a new Aras application built from the ground up to address:
    - integration of manufacturing data and processes in PLM.
    - graphical Process Plan, MBOM and Work Instruction authoring
    - EBOM / MBOM reconciliation
    - version controlled process plans detailing operations, steps, parts consumed, resources utilized, skills, documents referenced etc.

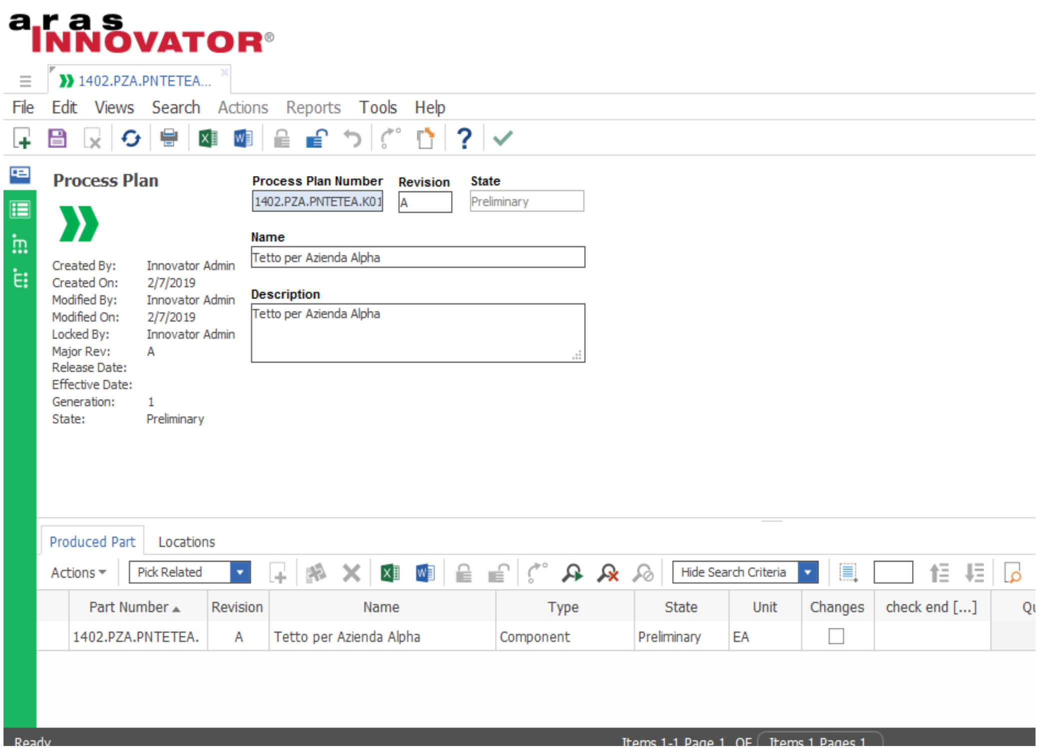


Figure 4.3 Aras Manufacturing Process Plan

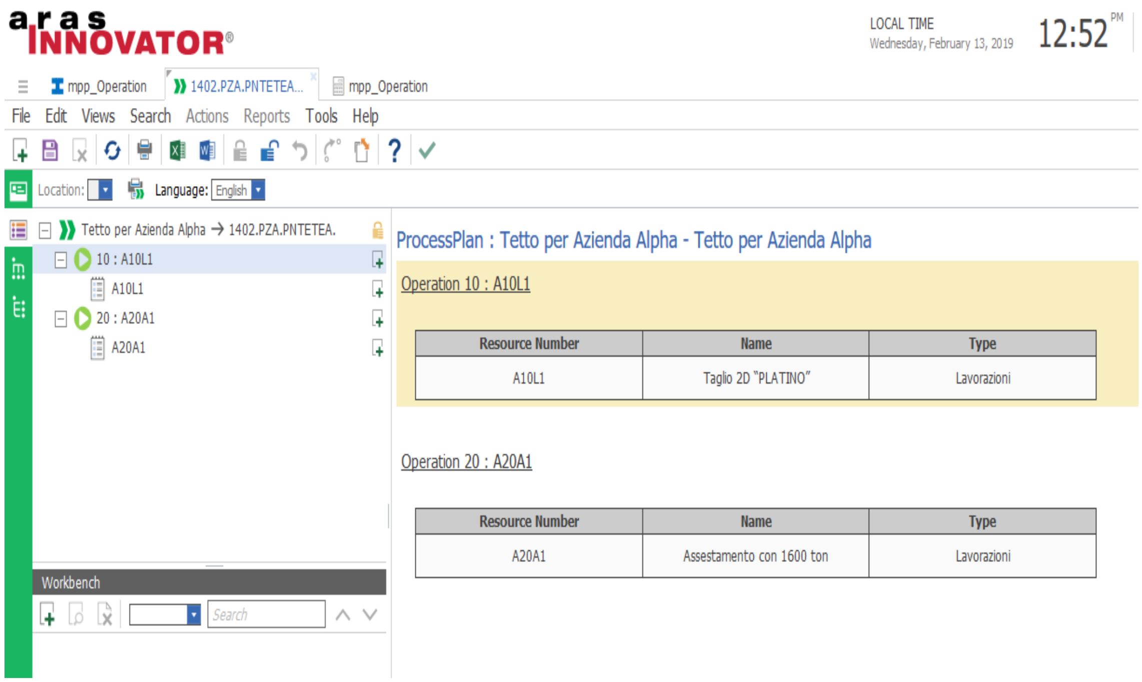


Figure 4.4 Structure of Operations in Process plan

Key features of Process Plan:

- it's a Controlled process plan,
  - with Operations and Steps
  - with Consume Parts
  - utilize Resources
  - reference Documents, Skills, etc
  - with Produced Parts / Assemblies
- Aras follows Concurrent Work Instruction authoring
  - we can Synchronize Process Plan elements with instructions
  - we can Include text, media and tabular content
  - we can able to Publish our projects to PDF or web.

f) Change Management

Manage Complex change processes

Getting Change Under Control

As product complexity increases and organizations become more reliant on their supply chains, managing the change process and communicating change status across many groups inside the organization and into the supply chain is an increasing challenge.

Ineffective or poorly managed change processes can leave organizations struggling to improve quality, reduce time-to-market and manage costs.

Streamline Your Processes

The change process in Aras Innovator manages all change requests, assessments, plans, and orders to a product or system. It also ensures users throughout extended supply chain have easy visibility into the engineering change status through the product lifecycle, where change histories are automatically captured and recorded.

Key Features

- standard best practice templates: CMII, Simple ECO or Custom
- part and document change processes
- flexible and adaptable to the needs of your business
- automated impact analysis
- effectivity and release date
- escalation and delegation, group voting, weighted voting, executive veto.

g) Projects

Manage all aspects of our product lifecycle.

Managing Complexity

Against a background of evolving requirements, unforeseen technology challenges and pressure to control costs and timescales, managing new product development projects and programs can be very challenging. Leading organizations achieve success by combining proven project management approaches, stage-gate methods and comprehensive risk management.

Complexity, Simplified by ARAS

Project Management enables organizations to manage new product development and engineer-to-order processes for complex projects that require global collaboration. By linking deliverables to project tasks, completion status and control are significantly enhanced.

Key Features

- project templates based on PMI principles provide best practices
- stage-gate processes

- project collaboration workspaces
- forward, backward and milestone scheduling
- interactive dashboard summarizes entire project portfolio
- intuitive, easy-to-use scorecards, KPI metrics and reports
- Gantt charts.

h) Component Engineering

Gain Control Over the component Processes

Component Search is Tough

Organizations that use externally sourced components face tough challenges. These include managing the complete lifecycle of components used in their products from selection through acquisition, compliance reporting and eventual end of life.

Control Your Components in ARAS

Component Engineering simplifies electronic component selection, approval, sourcing and compliance processes. Engineers and procurement specialists have instant access to complete, current technical data, as well as obsolescence and compliance information, on hundreds of millions of board-level components from leading manufacturers around the world.

Key Features

- basic and parametric search
- component attributes, technical data, latest and historical datasheets, alternates
- colour indicators – preferred manufacturers and parts
- end of life (EOL), Product Change Notice (PCN) and Product Failure Notice (PFN) alerts
- RoHS, REACh and conflict mineral compliance
- IPC 1752A material declaration.

i) Technical Publications

Simplify how we can create and manage documents

Disconnected Technical Publication Processes

When creating technical publications such as catalogues, maintenance manuals, regulatory filings and training manuals, many legacy technical publishing systems require that data be pulled from multiple sources, a slow and error-prone process.

With disconnected data sources and difficulty finding the most relevant and up-to-date information, such documents typically require a long lead-time, are prone to errors, and are expensive to produce.

Create Smarter Documents

Built on the Aras Innovator platform, Aras Technical Documentation is a content authoring tool that takes a new approach to the creation of technical publications by using PLM content directly.

Developed in partnership with Orio (formerly Saab Original Parts), the web-based solution cuts out rewriting time and eliminates opportunities for error by using referenced PLM content in a modular fashion. Additionally, notifications of engineering change orders (ECO) can automatically trigger document updates, ensuring that publications use the most relevant, up-to date information.

Key Features

- uses embedded/referenced PLM content to populate documents
- document assembly managed through user-defined templates
- links to engineering change orders can trigger updates in associated publications, either individually or in batch updates
- web-based solution means no client installs
- WYSIWYG editor supports publishing in XML, HTML and PDF

j) ALM Integration

Leverage ALM Systems

As software-enabled products become the norm, companies are facing the challenge of managing the lifecycle of "systems". An emerging component of their strategy is the integration of an existing Application Lifecycle Management (ALM) system managing software source files and binaries with enterprise-wide PLM capabilities.

Enterprise ALM Connections

PLM with Aras can be combined with an existing ALM environment, creating a complete system view of multidisciplinary products fully integrated into enterprise processes including BOM and change management while source code is managed in the ALM system.

Key Features

- integrates software deliverables into system/enterprise product structures and change processes
- extends enterprise processes and capabilities including engineering BOM management, enterprise change and integrated project management to ALM users

4.2 ARAS PLM PLATFORM FOR EURODIES ITALIA S.R.L

. As discussed in chapter 3.4 about the production process in Eurodies Italia S.r.l, Here, we discuss on designing a layout of Production Process to present it in Aras PLM Platform.

Considering Eurodies Production Process, designing a layout in a sequential fashion is key factor. When there is an order for a product which have to go for production in Eurodies, it have to undergo through various Activities in a sequential fashion which are defining in Process plan (Explained in chapter 4.1) in ARAS PLM Platform. For every Activity, a particular machine in a family of machines which again have sub-family of machines is used. There are also different type of check starts for every activity depending on the check start Id.

So, we must have data in Aras about list of machines which are classified into families and sub-family of a machine, list of check starts corresponding to Check start Id. To make Aras PLM Platform as user friendly, we also developed a list of activities called Lavorazioni with the corresponding activity Id, which helps the Designer/planner of process plan for a product to choose an activity in process plan with all the properties of a respective activity in just one-click.

List of Activities and its properties from Figure 4.5 and Figure 4.6, Every Activity will have properties like

- Lavorazioni_Id (Activity Id)
- Processo (which is a code for type of process)
- Tipo (is an operation Number)
- Tipologia Macchina (family of a machine)
- Sottotipologia Macchina (Sub-family of a machine)

- Check start Id and different check starts related to corresponding Id.

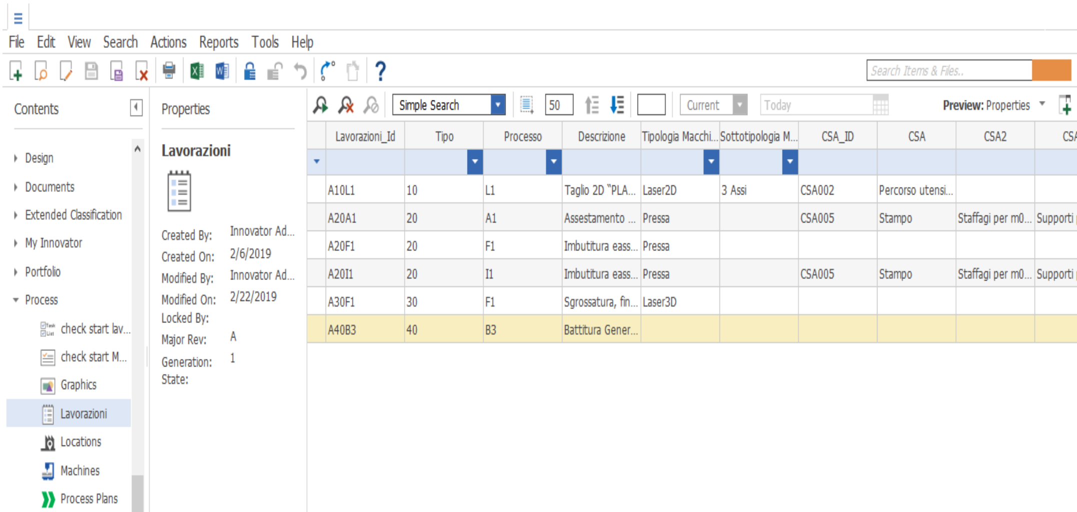


Figure 4.5 Properties of 'List of Activities'

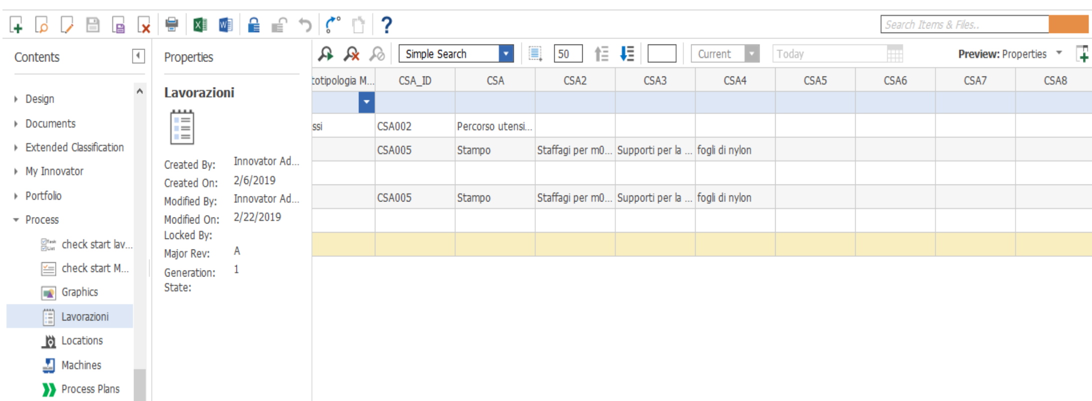


Figure 4.6 Extended Properties of 'List of Activities'

When we are populating the data in Aras, it Should be user friendly for the operator. For this purpose, we created a list of check starts with a check start ID for Activities as shown in Figure 4.7, from which operator can choose list of check starts while populating List of activities with a one click. This is very helpful to operator while populating the data, it reduces the effort and time for an operator.

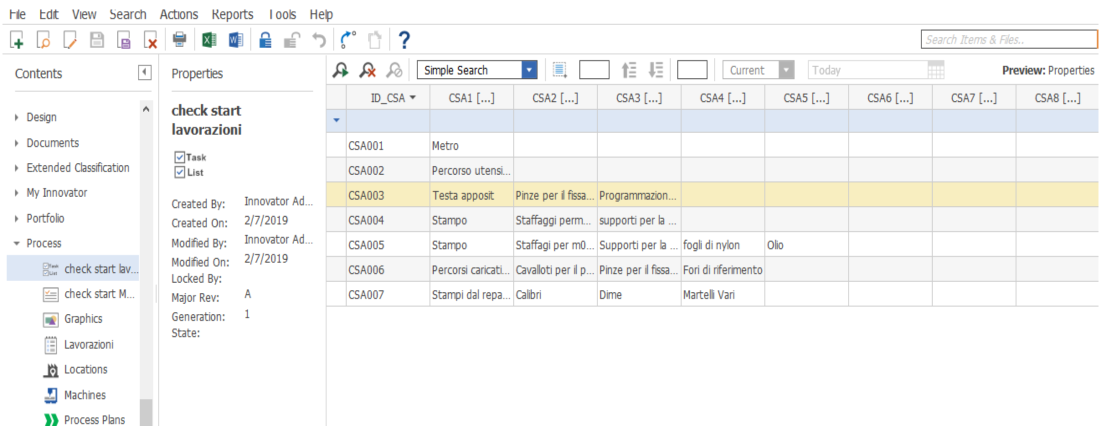


Figure 4.7 List of Check start for Activities

List of Machines and its properties

To create a list of machines in ARAS, we have to know about 'Item type' which we discussed in chapter 4.1. From Figure 4.8 and Figure 4.9,we can the properties which are associated with list of machines are:

- ID_M (Id of a machine)
- Tipologia (represents the Family to which the machine belongs to)
- Sottotipologia (represents the Sub-Family to which the machine belongs to)
- Marca o Denominazione (Represents the Company of a machine where it's manufactured)
- Portata (Capacity of a machine in tons)
- CT (Cycle time in seconds)
- Dimensioni (Dimensions of the machine)
- Contatore Pezzi
- CSM_Id (Id for Check start of a machine)
- CSM1, CSM2, CSM3, CSM4 are different check starts for a machine

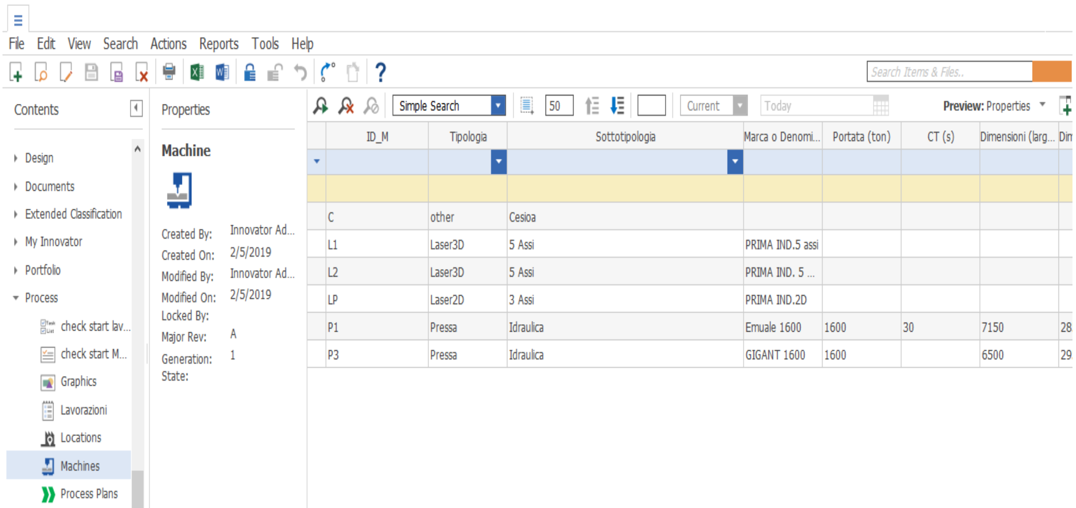


Figure 4.8 Properties of ‘List of Machines’

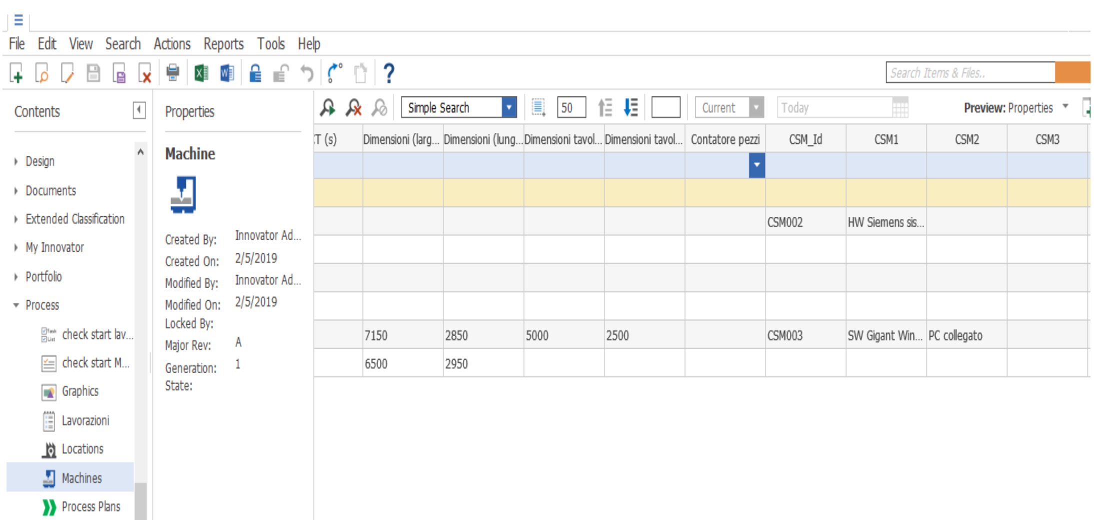


Figure 4.9 Extended Properties of ‘List of Machines’

As we discussed before, when we are populating the data in Aras, it Should be user friendly for the operator. For this purpose, we created a list of check starts with a check start ID for Machines as shown in Figure 4.10, from which operator can choose list of check starts while populating List of Machines with just one click.

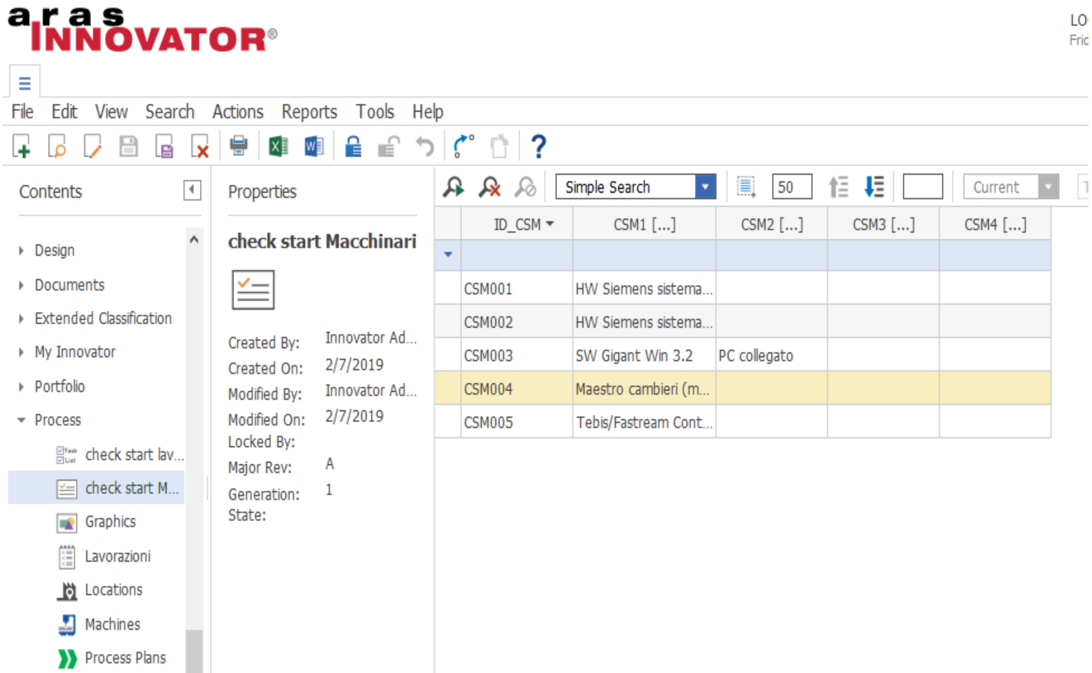


Figure 4.10 List of Check start for Machines

Customizing and Generating a Process Plan sheet for a product

Now, all the ingredients to prepare a process plan for a product are ready. But we didn't Customize the Process plan sheet as per Eurodies Requirements. So now we will look customizing the process plan. When Designer/planner is populating the data in process plan, it should be easy and simple to add the activities for every operation by selecting the activities from 'list of Activities' which we created before. So, we customized the process plan by connecting the 'list of Activities (is an Item Type)' with the resources of process plan shown in Figure 4.11.

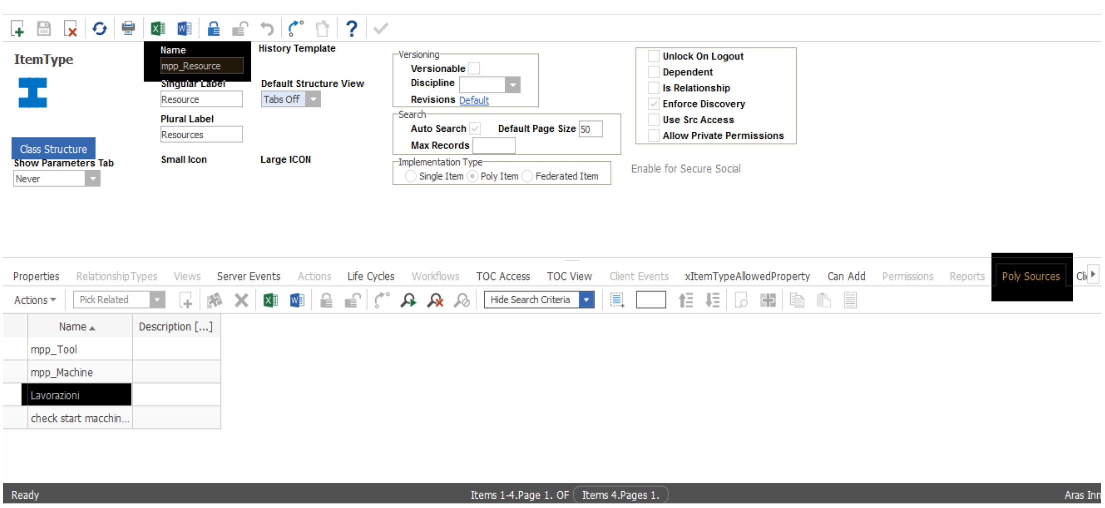


Figure 4.11 Connecting Lavorazioni (list of Activities) with resources of process plan

Now, we will see how to create a process plan for a product and add an operation to the process plan and respective activity which shows various properties of an operation.

- Go to Process in TOC and click on Process Plan as shown in Figure 4.12 and Figure 4.13.

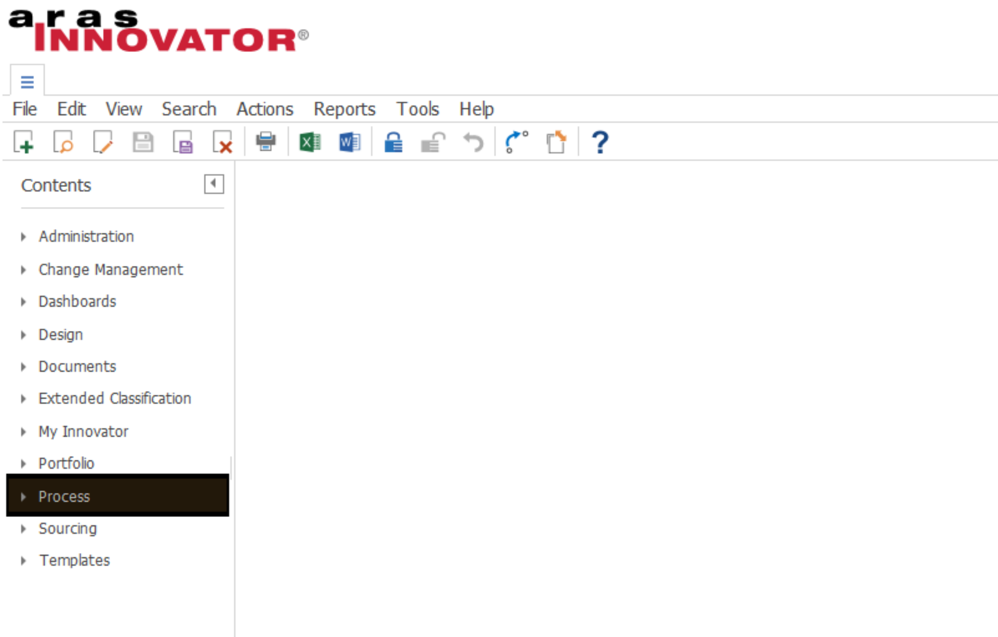


Figure 4.12 Process

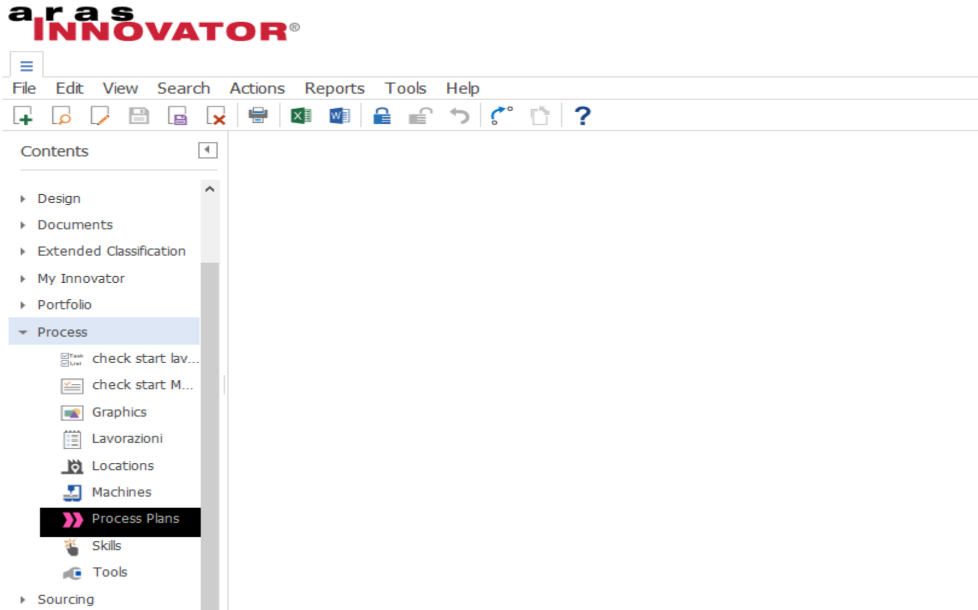


Figure 4.13 Process Plan

- Click on New Item as shown in Figure 4.14 and give the details of process plan like process plan Number, Name and description as shown in . Also add a produced part/product and then save it and then click on Show Process plan as shown in Figure 4.15.

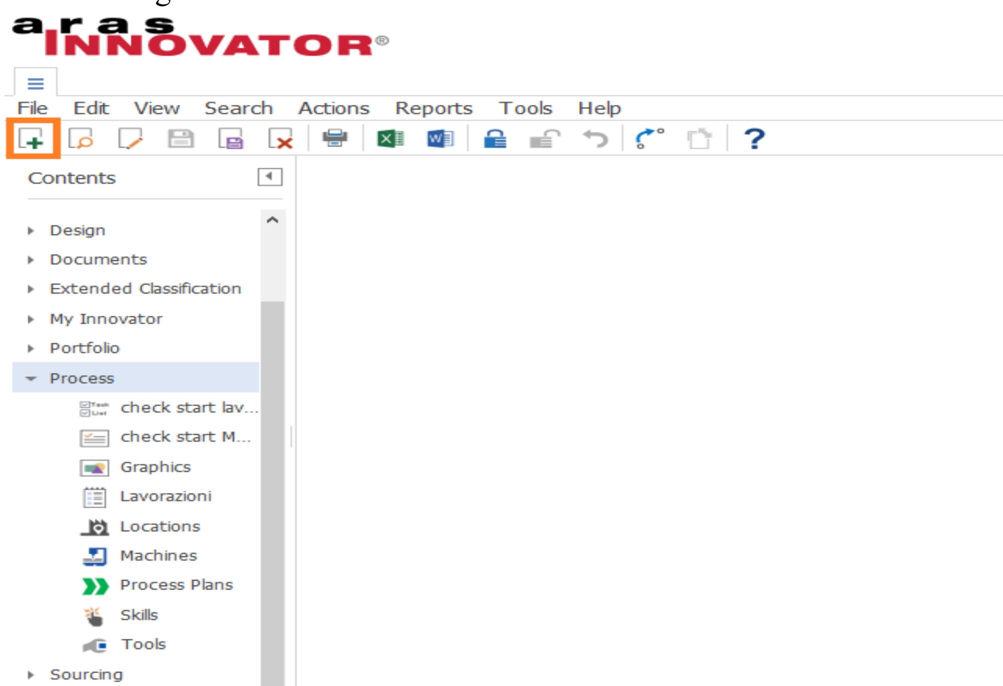


Figure 4.14 New Item

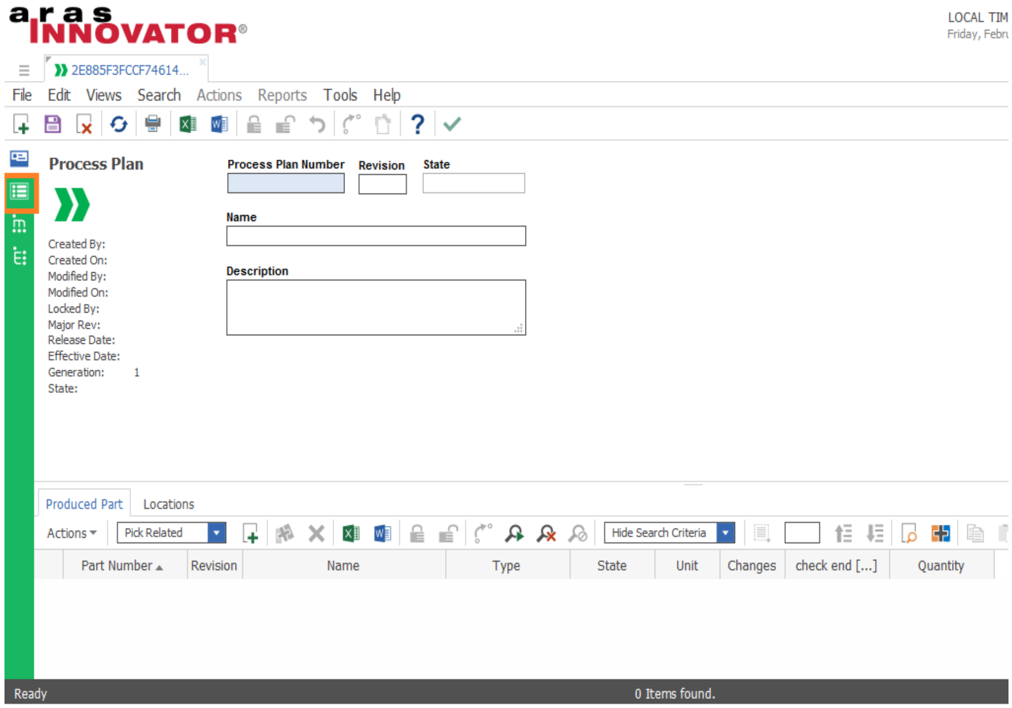


Figure 4.15 Show Process Plan

- To add operation in process plan, Right click on the screen and select add operation. Enter the details of operation name and number.
- Figure 4.16 and Figure 4.17 shows how to insert an activity in an operation. Preparing process plan and choosing activities is simpler and easier in Aras.

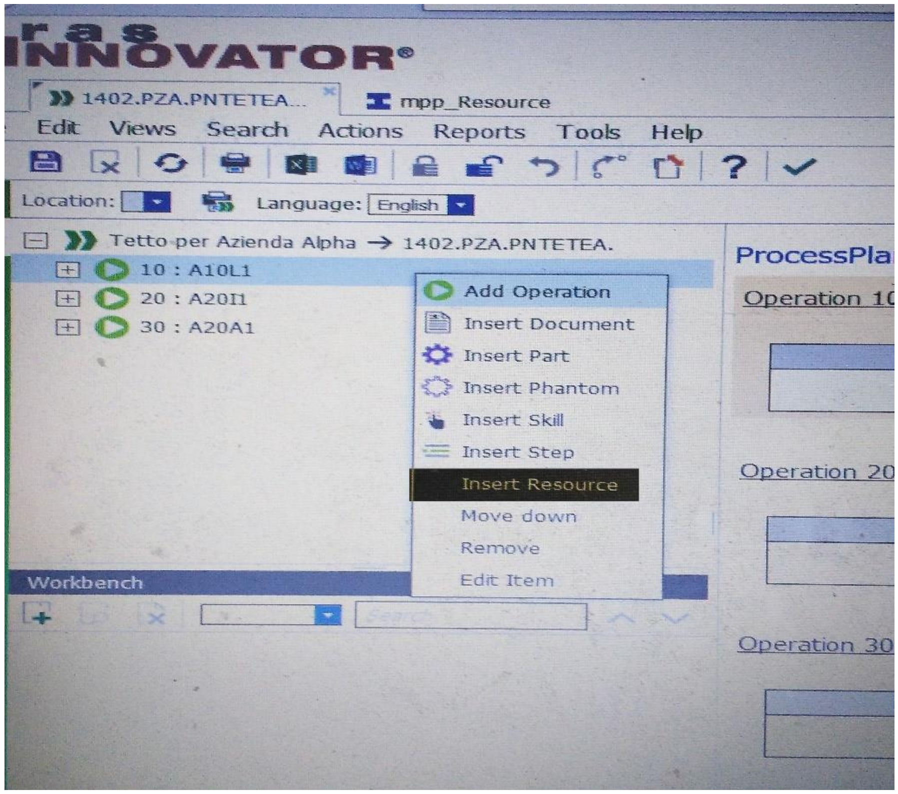


Figure 4.16 Insert Activity in an operation

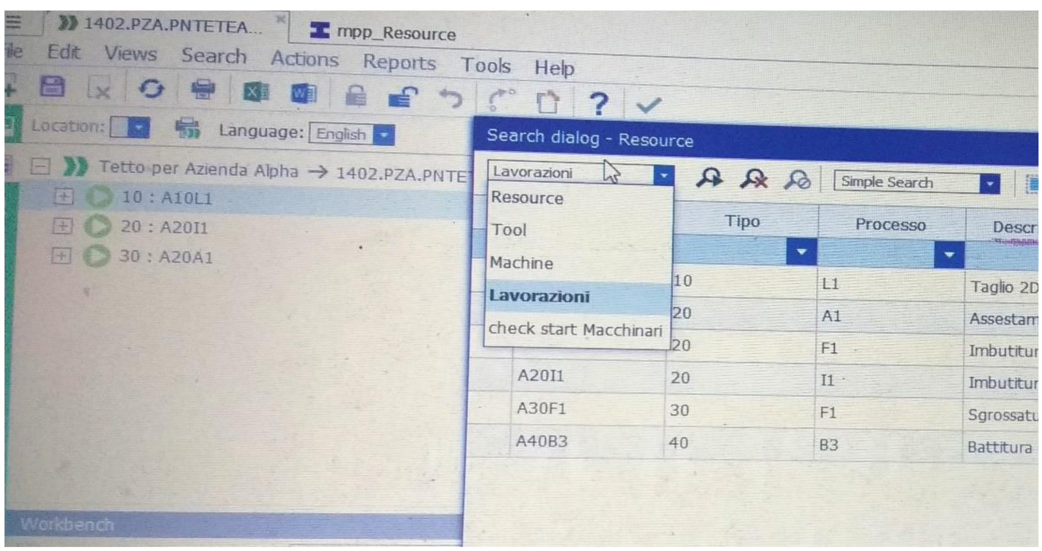


Figure 4.17 Insert Activity in an operation

- And Finally click on Save, Unlock and close .

4.3 Extraction of Data from ARAS Innovator

In any enterprise-wide PLM deployment, integration to legacy systems is likely to be an important topic. Whether we need to interface with an ERP suite, extend an old PDM system or plug into an EAI / ESB environment, we probably need to securely share data between systems across our company.

Integration is an area where our PLM platform has a significant advantage over legacy PLM systems.

As an open architecture, Aras offers open APIs, a published data dictionary, an openly available data model... and that's only half the story.

From a technological perspective we use a more modern approach -- a pure Web services approach that's designed from the ground up with technology agnostic interoperability in mind

Aras can be "connected to", "integrated with" and "wrapped around" anything we've got, whether it's based on IBM, Oracle, SAP, Linux, Unix, Microsoft, Progress... or all of the above. Aras even include a Web services wizard in their Solution Studio out-of-the-box.

Aras understand that global companies need to combine data from numerous existing systems in order to manage products across the lifecycle and they recognize that a highly robust, scalable and secure Federated approach is the right way to do this, both from a technical and a business perspective.

One of the approaches to extract data from Aras Innovator is to connect to the Aras database through SQL Server. We will look into how to extract data from SQL server, where Aras database is linked, to Excel.

Step 1. Open a Licensed version of Microsoft Excel and go to tabs called 'Data'. Go to 'Get Data' → 'From Database' → 'From SQL Server Database' as shown in Figure 4.18.

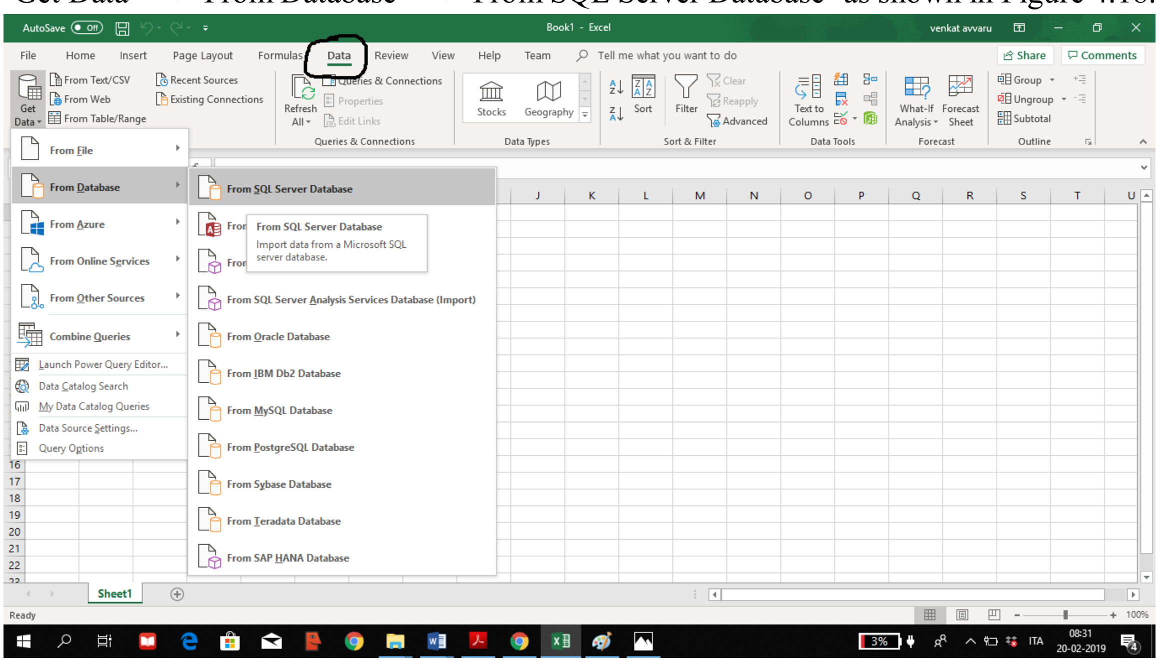


Figure 4.18 Connecting to database

Step 2. Give the Values of Server Name where Aras Database is connected and Database to which we want to connect as shown in Figure 4.19

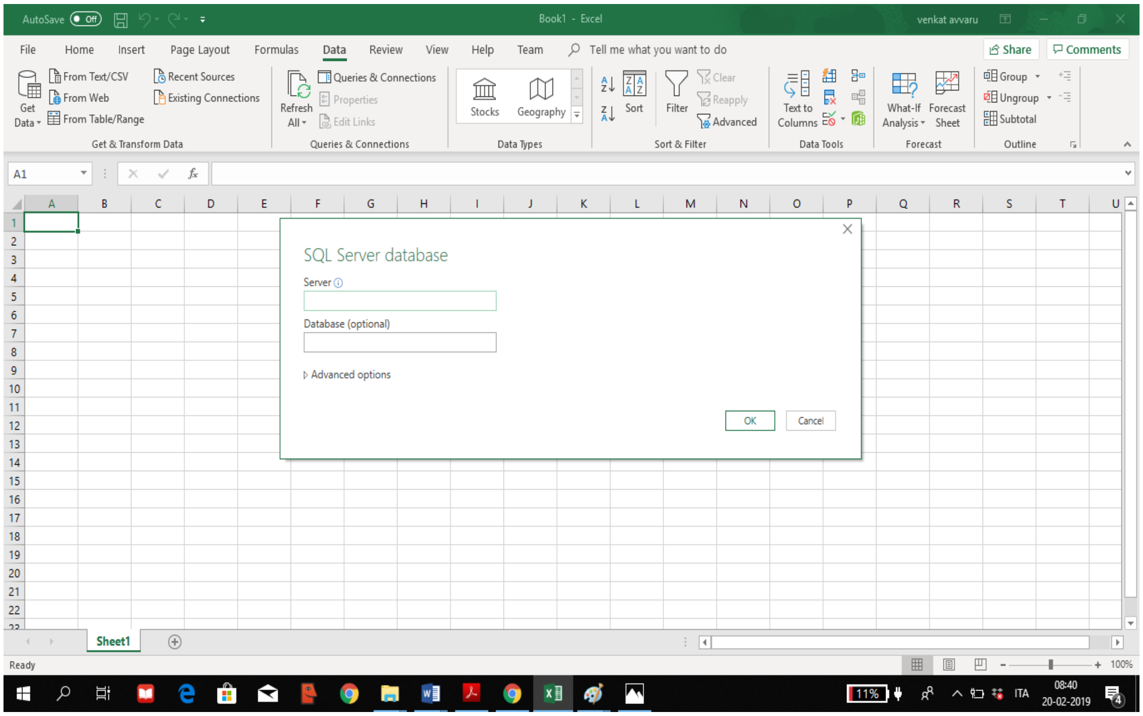


Figure 4.19 Connecting to SQL Server

Step 3: As shown in Figure 4.20, Figure 4.21 and Figure 4.22, Choose the items which you want to extract from database and delete rows and columns if needed. Then click ‘close and Load’.

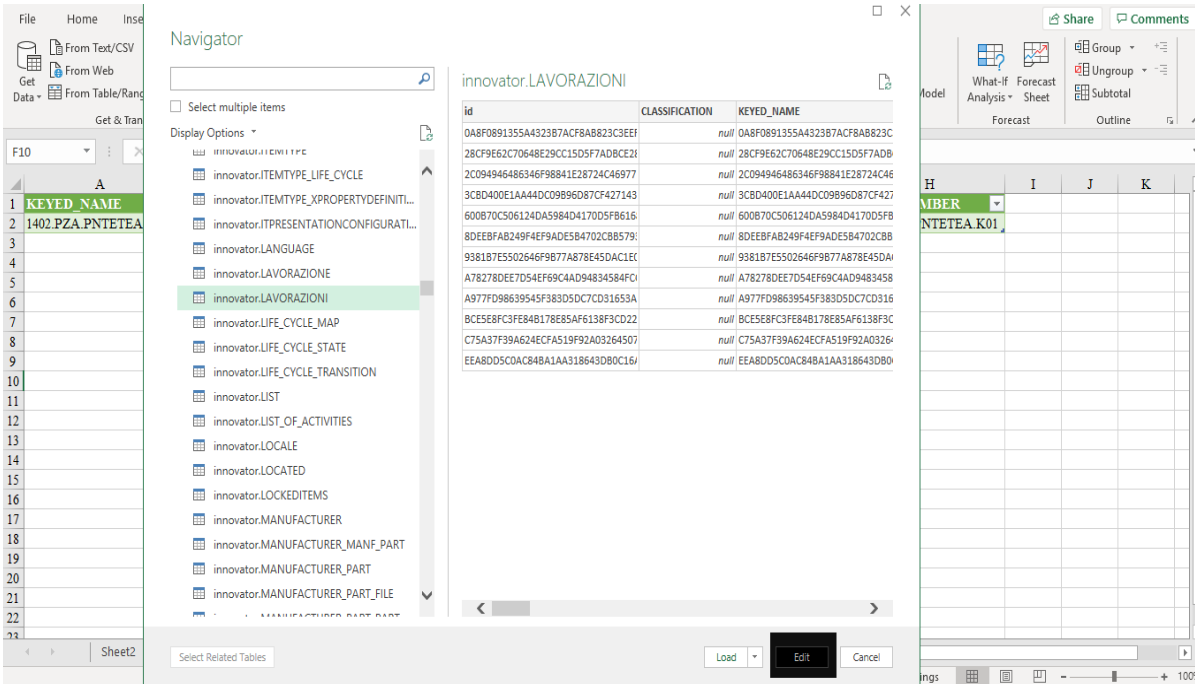


Figure 4.20 Selecting Data and Edit

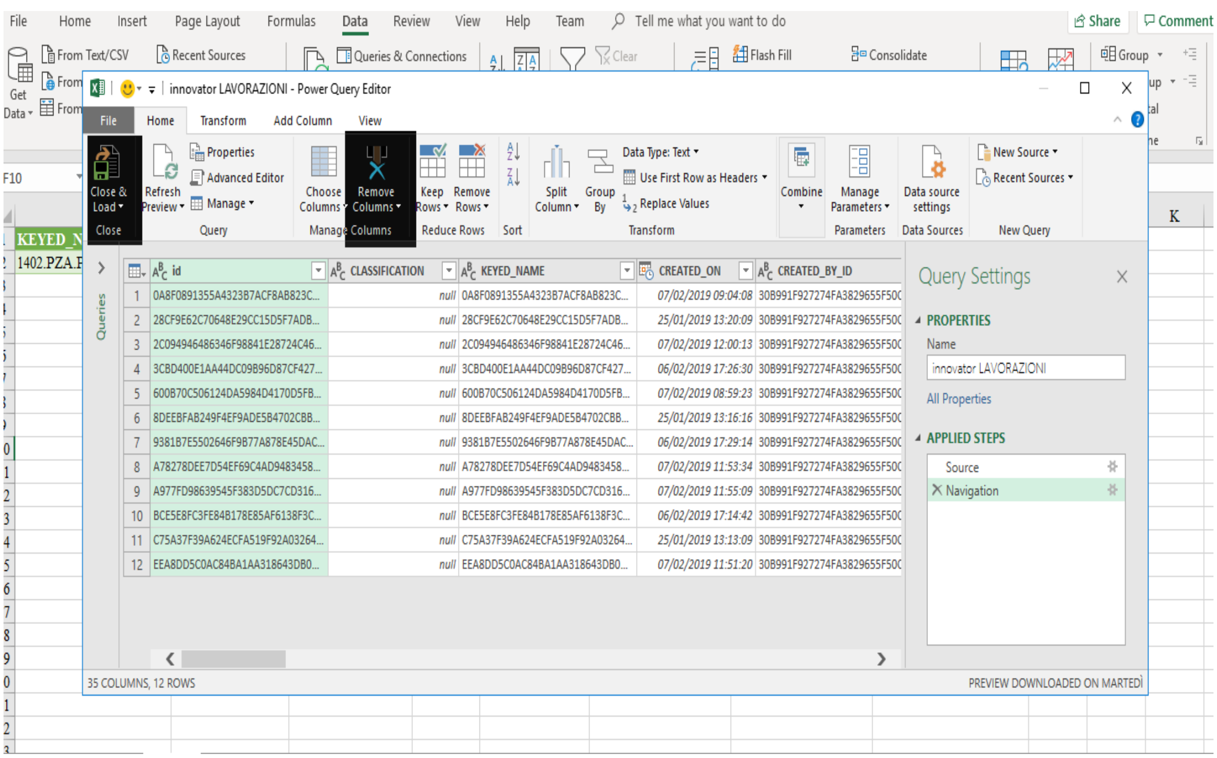
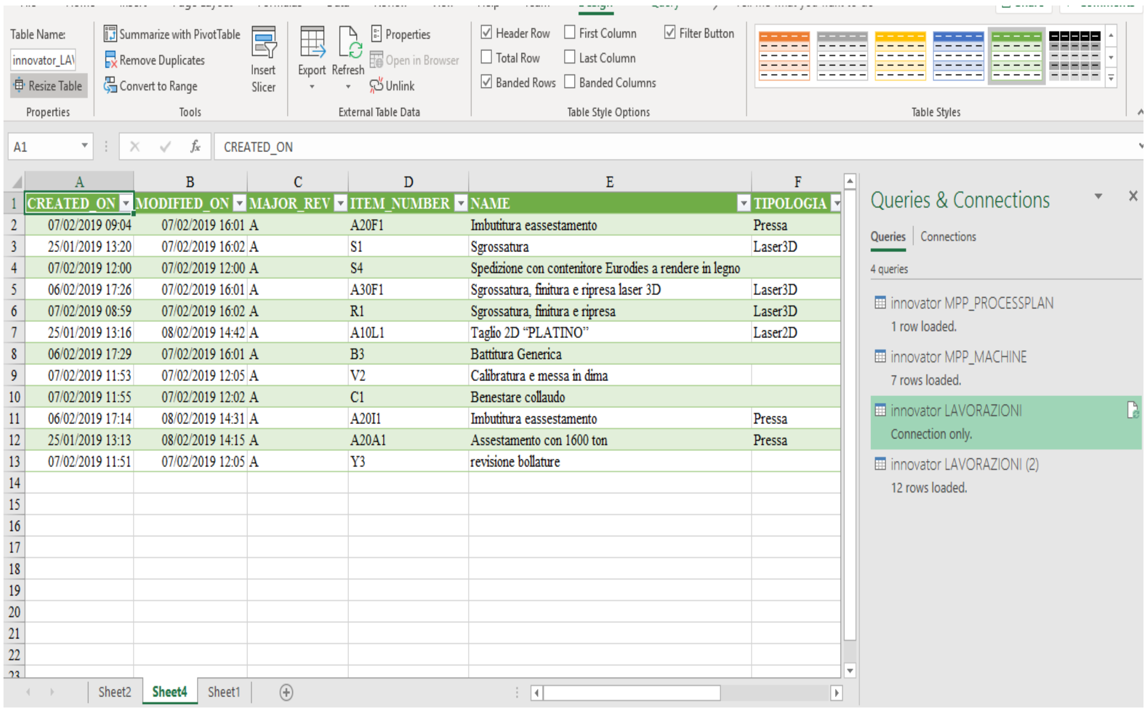


Figure 4.21 Delete Columns and Save



CREATED_ON	MODIFIED_ON	MAJOR_REV	ITEM_NUMBER	NAME	TIPOLOGIA
07/02/2019 09:04	07/02/2019 16:01	A	A20F1	Imbutitura eassestamento	Pressa
25/01/2019 13:20	07/02/2019 16:02	A	S1	Sgrossatura	Laser3D
07/02/2019 12:00	07/02/2019 12:00	A	S4	Spedizione con contenitore Eurodies a rendere in legno	
06/02/2019 17:26	07/02/2019 16:01	A	A30F1	Sgrossatura, finitura e ripresa laser 3D	Laser3D
07/02/2019 08:59	07/02/2019 16:02	A	R1	Sgrossatura, finitura e ripresa	Laser3D
25/01/2019 13:16	08/02/2019 14:42	A	A10L1	Taglio 2D “PLATINO”	Laser2D
06/02/2019 17:29	07/02/2019 16:01	A	B3	Battitura Generica	
07/02/2019 11:53	07/02/2019 12:05	A	V2	Calibratura e messa in dima	
07/02/2019 11:55	07/02/2019 12:02	A	C1	Benestare collaudo	
06/02/2019 17:14	08/02/2019 14:31	A	A20I1	Imbutitura eassestamento	Pressa
25/01/2019 13:13	08/02/2019 14:15	A	A20A1	Assestamento con 1600 ton	Pressa
07/02/2019 11:51	07/02/2019 12:05	A	Y3	revisione bollature	

Figure 4.22 Data in Excel

BIBLIOGRAPHY

- (Saaksvuori, A. and Immonen, A. , 2004) ‘Product lifecycle Management’ , Springer - VerlagBerlin, Heidelberg.
- (Grieves, 2005).: Product Lifecycle Management: Driving the Next Generation of Lean Thinking. McGraw Hill Professional, New York
- (Mourtzis, 2013).: The role of simulation in digital manufacturing: applications and outlook. Int. J. Comput. Integr. Manufact. 28(1), 3–24
- (Messaadia, 2013), AEK (2005) ‘Systems Engineering Processes Deployment for PLM’. International Conference on Product Lifecycle Management (PLM'05), 11-13 July, pp.282-291.Lyon
- (Meyer, 2009)Manufacturing Execution Systems (MES): Optimal Design, Planning, and Deployment. McGraw-Hill Professional, New York
- (Gerhard Greeff, 2004),: Practical E-Manufacturing and Supply Chain Management.

- (Addo-Tenkorang, 2011). Enterprise Resource Planning (ERP): A Review Literature Report. Proceedings of the World Congress on Engineering and Computer Science (WCECS 2011). 10.13140/2.1.3254.7844.
- (Heike Schumacher, 2004), (2004) ‘Communication through B2MML – is that possible’, The World Batch Forum North American Conference Chicago, IL May 16-19, 2004.
- (Siemens, 2010), A CIMdata Report, May 2010.
- (X. G. Ming, 2005): Technology Solutions for Collaborative PLM - Status Review and Future Trend, Journal Concurrent Engineering, Vol.13, No.4, 2005, pp.311-321.
- (Gecevska, Cus, Lombardi, & Chiampo, 2015); (2015) Product lifecycle management competitive technology solution, University of Maribor, Faculty of Mechanical Engineering.
- (Xue), Ph.D., P.Eng., Professor in Department of Mechanical and Manufacturing Engineering, University of Calgary, One-of-a-kind Product Design and Manufacture.
- (Tu), A framework for production planning and control in a virtual OKP company, Technical Papers of North American Manufacturing Research Institution of SME 1996, SME, pp.121–126.
- (Link) CAPP-CAM-I Automated Process Planning System, Proceedings of the 1976 NC conference.
- (T.C. Chang, 1985) An Introduction to Computer-Aided Process Planning Systems, Prentice Hall, NJ, 1985.
- (Rolstadas, 1994)Beyond year 2000—production management in the virtual company, production management methods.
- (Calza, 2018) Thesis work on Eurodies company Italia S.r.l under the supervision of Prof. Franco Lombardi
- (automotive-prototype-uses from concept to creation, 2016)
- (Aras, s.d.)