



TOOL SUPPORT FOR PRODUCTION PLANNING MANAGEMENT- CASTING INDUSTRY CASE

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ISEP – School of Engineering
Mechanical Engineering Department



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KEYWORDS

Production Planning; Management Integrated System; Casting Industry; Classification Systems; Multi Criteria; Production Strategy

ABSTRACT

The present work, which took place within Sakthi Portugal, SA emerges with the need of defining the necessities of an Integrated System within the scope of the Enterprise Resource Planning (ERP) to deal with the requirements for making a Production Plan. During the internship, a description of the plan of action that needs to be followed to obtain the production plan was made.

In order to achieve this, a literature review regarding the subjects related to Integrated Systems, the Logistic functions and the various production scheduling approaches which are available related to the industry was made. In addition, a study was conducted on the classification systems available currently. Following this, the environment as well as the processes taking place has been described. A brief discussion regarding the functions of the Logistics department where the internship was carried out has been discussed. The current production planning strategy was studied and the difficulties which they face has been described.

Based on the understanding of the production planning process which is adopted, it was found that a considerable amount of time was spent on clerical tasks. It was also noted that there occurred a clash of objectives of the departments concerned with Production. In order to resolve these issues, the management required an Integrated System. Since there are a vast number of products, the need for a classification in order to improve the plan is discussed. A multi-criteria classification which incorporates the major activities related to production is made. The objective of the classification system was to integrate the various departments within the company.

The present work included the requirements analysis of the Integrated Management System on which the Production plan can be made. The system contains the necessary information as well as constraints to make the Production Plan. Another outcome resulted from the multi-criteria based classification system proposed with the focus in supporting the allotment of the products to the molding machines. This document also analyses propose improvements to the production plan with respect to the product classification criteria.

PALAVRAS CHAVE

Planeamento da Produção; Sistema Integrado de Gestão; Indústria de Fundição;
Sistemas de Classificação; Multicritério; Estratégia de Produção

RESUMO

O presente trabalho decorreu na Sakthi Portugal, SA, surgiu com a necessidade de definir os requisitos funcionais de um Sistema Integrado de Gestão no âmbito do Enterprise Resource Planning (ERP) com vista à elaboração de um Plano de Produção. Durante o estágio, foi feita uma descrição do plano de ação a ser seguido para a obtenção dos planos de produção.

O trabalho iniciou-se com a realização de uma revisão bibliográfica sobre os temas relacionados com a Gestão de Sistemas Integrados, a função Logística e as diversas abordagens do planeamento da produção disponíveis para a gestão de operações na indústria. Além disso, foi realizado um estudo sobre os sistemas de classificação de produtos atualmente disponíveis. De seguida, procedeu-se à caracterização do ambiente e dos processos produtivos. Simultaneamente discutiu-se as funções do departamento de logística onde o estágio foi realizado. A atual estratégia de planeamento da produção foi caracterizada e as dificuldades que esta enfrenta foram identificadas e analisadas.

Partindo da compreensão do processo de planeamento de produção seguida na empresa, constatou-se que um tempo considerável é consumido em tarefas administrativas e de introdução de dados nos sistemas de informação. Paralelamente foi observado que é comum ocorrerem conflitos entre os objetivos dos departamentos envolvidos na Produção. Para resolver esses problemas, a gestão pretende implementar um Sistema Integrado Gestão / ERP. Associado a este objetivo, devido a uma grande variedade de produtos, foi identificada a necessidade de um sistema de classificação para melhorar a construção do plano de necessidades. Assim, foi construído um sistema de classificação multicritério que incorpora as principais atividades relacionadas à produção.

O presente trabalho incluiu a análise de requisitos do Sistema de Integrado Gestão responsável pela criação do plano de produção. O sistema contém as informações necessárias e as restrições para a construção do plano de produção. Outro resultado resultante do presente trabalho é um sistema de classificação baseado em multicritério, com o foco no apoio à distribuição dos produtos pelas máquinas de moldagem. Este documento também inclui propostas de melhoria no plano de produção com relação aos critérios de classificação do produto.

LIST OF ABBREVIATIONS

List of Abbreviations

| | |
|-----|------------------------------|
| AHP | Analytical Hierarchy Process |
| ERP | Enterprise Resource Planning |
| LMP | Logistics Master Planning |
| MTO | Make-to-Order |
| MTS | Make-to-Stock |
| SCM | Supply Chain Management |

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INTRODUCTION

1.1 CONTEXT

1.2 OBJECTIVES

1.3 METHODOLOGY

1.4 DOCUMENT STRUCTURE

1 INTRODUCTION

This chapter introduces the work performed in the logistic department of Sakthi SA, a foundry company that produces metal parts for automotive industry.

1.1 CONTEXT

The work presented in this document was done as part of the curricular unit Dissertation/ Project/ Internship in Master in Mechanical Engineering- Industrial Management at Instituto Superior de Engenharia do Porto, Instituto Politécnico do Porto.

1.2 OBJECTIVES

The work was carried out at the Logistics department in Sakthi SA, a foundry located in Maia, Portugal. The company deals with producing brake housings, differentials and engines for various automobiles that need to be sent for international clients.

The main objective is to define the parameters that must be present in an Integrated Management System that would be required in the production planning of the parts along the molding line. The Integrated Management System has been developed as part of the Enterprise Resource Planning (ERP) so that it would be easier to control and facilitate the exchange of data from various source platforms.

Also, as part of the work, a proposition for a multi-criteria classification system is done considering the parameters that would be used for the production planning function. Since the company deals with many parts, it would be easier to understand and analyze under which scenarios the bottlenecks are arising and apply the adequate materials management policy. It is easier to examine a group rather than to focus attention on each individual component due to the sheer number of parts which would consume a lot of time and effort.

1.3 METHODOLOGY

Firstly, a literature review regarding the production planning strategies adopted by firms operating in the same field was done. On completion of this, attention was shifted towards the production planning strategy which is followed by the company.

A thorough understanding of all the factors and the flow of information to make a production plan was noted down. They were then defined under which category they would come under in the Integrated System.

The production plan is of twofold level. First being the weekly plan and then, the daily schedule which is carried out by another department. In the weekly, it is required to make plans separately, one for the molding line and the other for the core shop. It is a two-level process where primarily, the plan for the molding machines is done followed by the core

shop since the machines require core and the number of cores that need to be planned cannot be carried out without knowing the necessity in the molding line.

A set of criteria were chosen and defined which combines the major goals of the different departments involved in the company to make it as a common ground. Based on these criteria, the importance of one criteria with respect to the other was made and a classification system was formed.

1.4 DOCUMENT STRUCTURE

This document has the following structure:

- **Introduction:** The context, objective and methodology followed in the given work is briefly described to help the reader get an idea about the study which was conducted.
- **Literature Review:** A brief synopsis and major takeaway points from various research papers are presented which acts as a guide to understand the concepts which would be used in the case study.
- **Case Study:** An introduction about the company where the case study was made is presented along with a brief description regarding the production process. It is followed by a summary of the functions of the Logistics department where the study was done. The current method followed for making the production plan along with the information system requirements for the Integrated Management System is described. This is followed by an explanation stating the process which was adopted for making the multi criteria classification. The results and outcomes which were inferred from the classification is briefly discussed.
- **Conclusion:** This chapter presents the conclusions for the work done and add proposals for the future work.

LITERATURE REVIEW

2.1 LOGISTICS: A BRIEF HISTORY

2.2 PRODUCTION SCHEDULING

2.3 PRODUCT CLASSIFICATION APPROACHES

2 LITERATURE REVIEW

This chapter presents the literature review required to develop the intended project work.

2.1 LOGISTICS: A BRIEF HISTORY

Ballou (2006) states that the first use of logistics as a subject was thought of in 1950s and before, was mainly used in the military for the procurement, maintenance and transport of military materials, personnel and facilities.

It was only later in the mid-1950s and 1960s that importance was being given to logistics as it contributed to about 15% of gross national product in the US. It is during this period that physical distribution as a subject started gaining attention from researchers, financiers, industrialists alike.

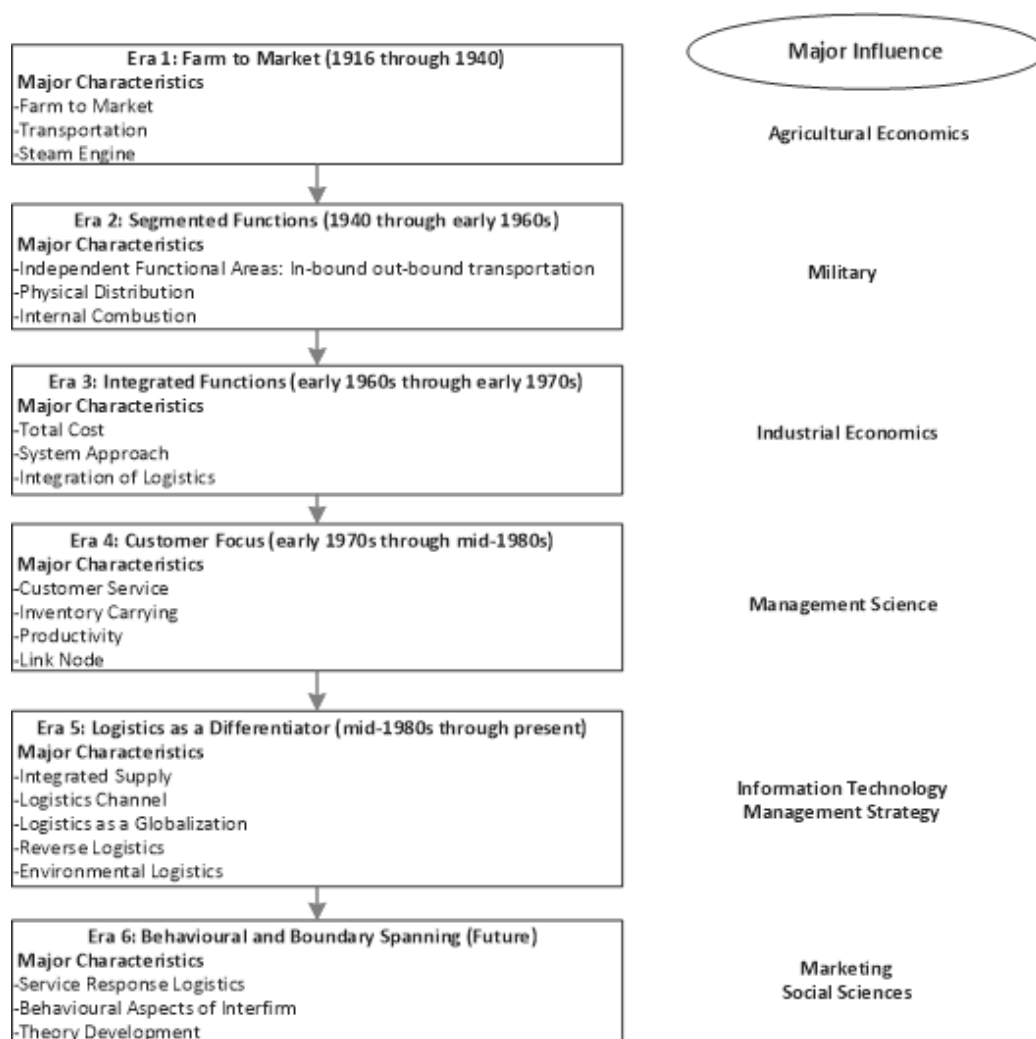


Figure 1: Development of Functions of Logistics (Kent Jr & Flint, 1997)

In reality, the definition offered by Smykay et al (1962) in 1962 for the term logistics is:

“Physical distribution can be broadly defined as that area of business management responsible for the movement of raw materials and finished products and the development of movement systems”

Physical distribution or logistics activities were associated with time and place utilities.

In the early years, the scholars debated over the title to be given to this field. Some of the familiar ones were:

- Distribution
- Physical distribution
- Logistics
- Business logistics
- Integrated logistics
- Materials management
- Value chains
- Rhocrematics, a Greek term referring to the management of material flows.

Besides the need to manage activities associated with the material flow from the acquisition of raw materials to the delivery of the finished goods to the customer, the total cost concept also served as a basis for managing certain activities collectively such as transportation and inventory control as they were in cost conflict. Also, physical distribution and logistics began to develop as an independent entity within the business even though it is closely linked to marketing and production.

The Council of Logistics Management, a trade organisation based in the United States, in 1991 defined logistics as “the process of planning, implementing, and controlling the efficient, effective flow and storage of goods, services, and related information from point of origin to point of consumption for the purpose of conforming to customer requirements.”

In easier terms, it can be defined as “Getting the right goods or services to the right place, at the right time, and in the desired condition (right condition) at the lowest cost and highest return on investment (right price). (The 5 Rights of E. Grosvenor Plowman).

In recent years, there is a new word called Supply Chain Management taking the logistics field by storm, which incorporates most of the logistics agenda.

According to the Council of Supply Chain Management Professionals (CSCMP), “Supply chain management encompasses the planning and management of all activities involved in sourcing and procurement, conversion, and all logistics management activities. Importantly, it also includes coordination and collaboration with channel partners, which can be suppliers, intermediaries, third party service providers, and customers. In essence, supply chain management integrates supply and demand management within and across companies.”

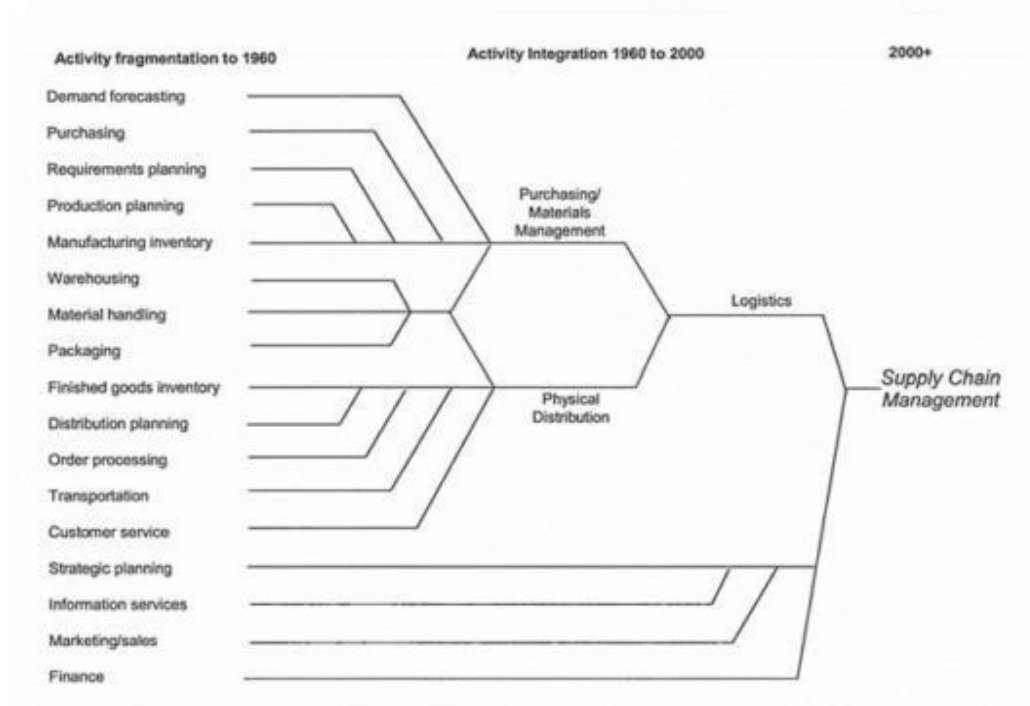


Figure 2: Evolution of Supply Chain Management (Ballou, 2006)

From the definition of Supply Chain Management, it can be concluded that:

- Logistics is essentially similar to SCM but has a wider range of vision as it focuses on aspects pertaining to not just the particular business but right from the acquisition of raw material in the supplier’s end to the delivery of the finished product to the end customer.

In simpler words, SCM is managing product flow across enterprises whereas logistics deals with the product flow within an enterprise.

The logistics consists of 5 interdependent activities: customer response, inventory planning & management, supply, transportation, warehousing (Frazelle, 2002).

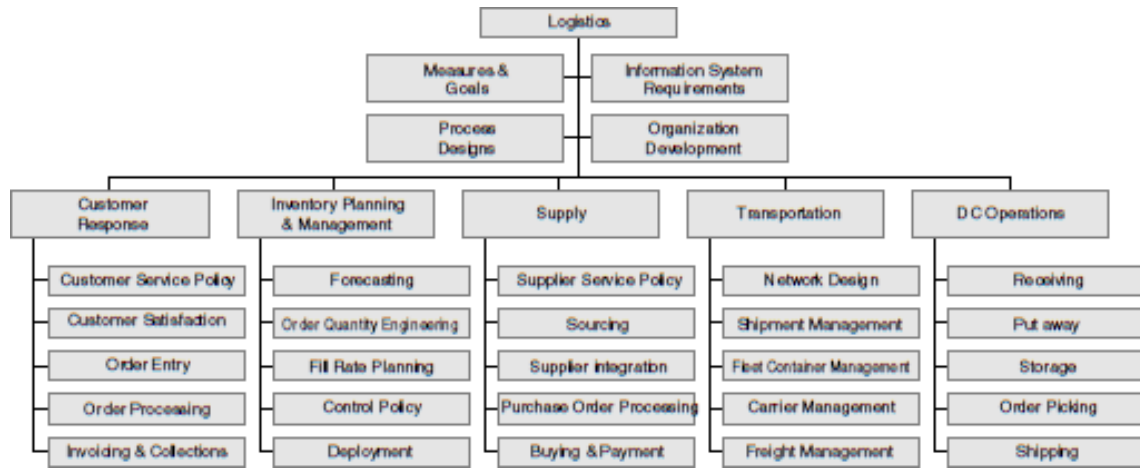


Figure 3: Logistics framework of activities (Frazelle, 2002)

The Figure 3 depicts the responsibilities involved in each of the Logistics activities.

2.1.1 INTEGRATED LOGISTICS MANAGEMENT

Kahn & Mentzer (1996) in their work discuss about the difference between interaction and collaboration.

Integration among departments can be described as one where there is communication between departments in the form of meetings and flow of information to unite the departments. In this type of interaction, the departments are considered to be independent identities competing for the resources. The departments may or may not need to share a common goal.

The philosophy of collaboration is to ensure and maintain a harmonious relationship with the various departments through shared visions, collective goals, and joint rewards. In a collaborative system, the departments are considered to be interdependent. This help in ensuring a higher customer service level as more focus is on co-operation and not competition.

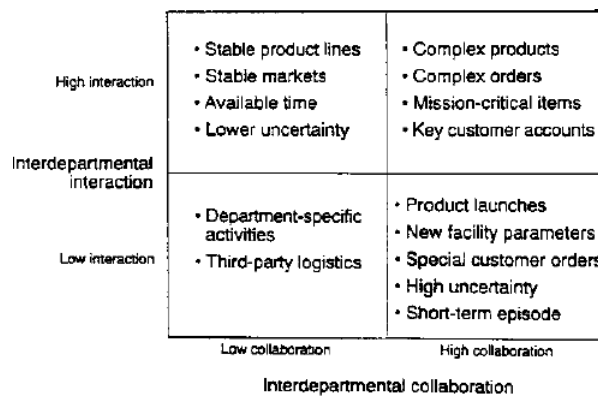


Figure 4: Logistics integration with other departments (Kahn & Mentzer, 1996)

Kahn & Mentzer (1996) in their paper conclude that it is required to ascertain to what extent the interaction and collaboration needs to be done in order to get fruitful results and also to not cause confusion among the departments.

Supply chain management deals with decision making in the strategic, tactical and operational levels (Fox et al., 1993).

The strategic decisions can be described as those which look at the overall goal and think of long term impact and addresses questions like where to allocate production and how much they would have to produce. The tactical can be described as those which deals with aspects related to scheduling, forecasting, ordering the materials. Lastly, operational deals with short-term goals and makes detailed daily production schedules, inventory deployment as well as steps to be taken in case of breakdown of machines.

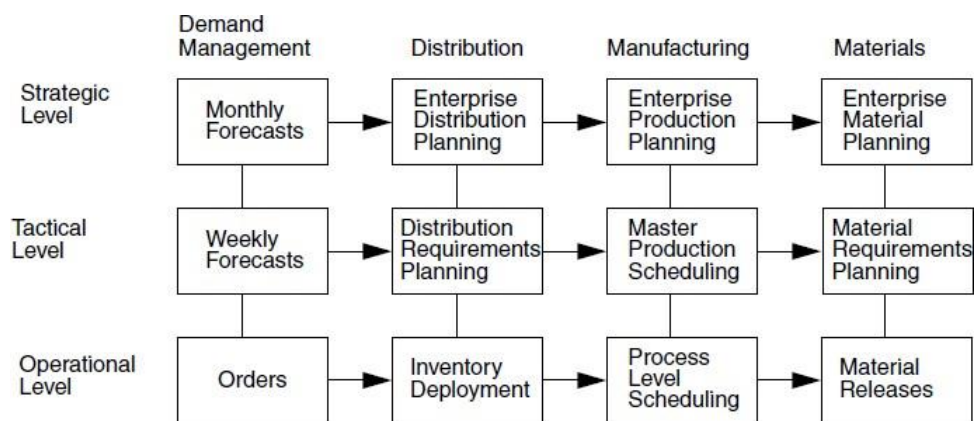


Figure 5: Supply chain management functions (Fox et al., 1993)

According to Frazelle (2002) a Logistics Master Planning (LMP) can be developed focuses on short and long term metrics, process definitions, information system requirements, and organizational requirements for logistics such as customer response, inventory management, supply, transportation, and warehousing. In order to achieve that, it is directed to follow through in stages of investigation, innovation and implementation.

In the investigation stage of LMP, it is necessary to create a Logistics Profiling to determine the standpoint of the department to analyse the gaps in comparison with world-class standards with regards to Warehousing, Transportation, Supply, Inventory Management and Customer Response. By doing so, the strengths, weaknesses and financial opportunities can be determined.

The Customer Activity Profile (CAP) demonstrates the customer activities in terms of sales, costs, the number of orders, the number of order lines, units, weight, cube, truckloads, pallets, and cases as not all customers have the same requirements.

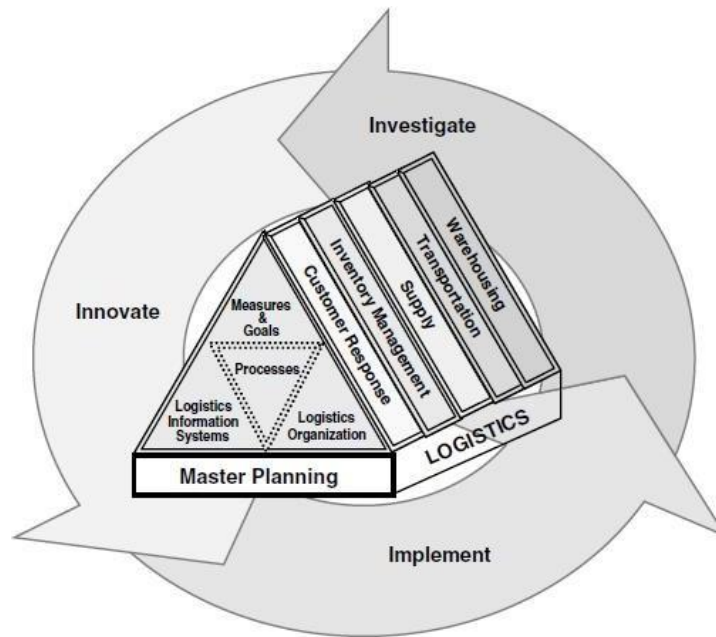


Figure 6: Logistics Master Planning Methodology (Frazelle, 2002)

Inventory Activity Profile (IAP) gives information regarding where the goods are gathered and by analysing this, suggestions can be made to reduce inventory and improve the customer service. The easiest technique is the ABC inventory synchronization profile. In this, the items are classified as A, B and C corresponding to the sales and management strategies and compare them to their positioning, i.e., whether the items are under-stocked or over-stocked.

Supply Activity Profile (SAP) serves as an indicator for suggesting purchasing improvements with respect to cost, volume, pallets, orders, etc keeping in mind the Stock Keeping Units (SKUs), SKU category, supplier, and supplier location.

Transportation Activity Profile (TAP) references the need to analyse the types of shipments done to the customer with regards to the route, the quantity being delivered, the cargo expenses and the necessary rules and regulations which need to be followed. Doing so helps in getting a better understanding on how the company is faring so that the improvements can be done in areas which face difficulties.

Warehouse Activity Profile (WAP) aims at understanding the pattern of order picking of the pallets and also how the cartons are filled in the pallet. It explains that by considering the picking pattern with the quantity, it would be possible to adopt different strategies for storing these so as to reduce costs, labour and also to maximise the utilisation of resources. It is essentially the profiling of the items as well as customer orders for management of warehouse.

Besides the activity profile analysis, it is also important to know the direction of flow of information and control between the various sectors. The Figure 7 shows the flow in a logistics information system.

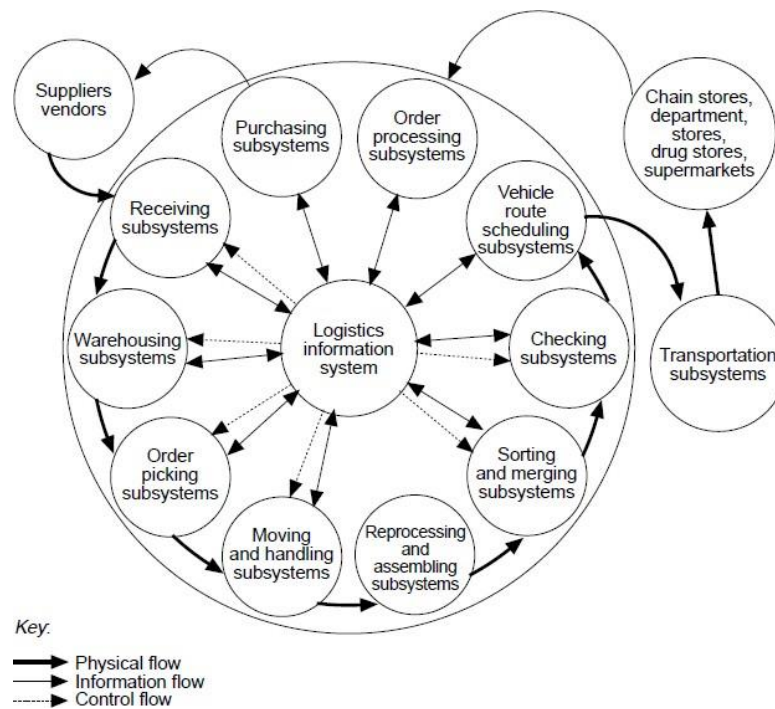


Figure 7: Subsystems and flows in a logistics information system (Neng Chiu, 1995)

Integrated system or System Integration is an IT or engineering process concerned with joining various subsystems or components as one system. It ensures that each integrated subsystem functions as required.

As per Fox, Chionglo and Barbuceanu (1993), In the Integrated Supply Chain System, all the sub-systems relay information to aid in the planning and execution process by means of an agent and each agent is responsible for a specific activity.

An integrated agent is one which is aware and can access the functional capabilities of other agents. In the ISCM, there are two types of agents- functional and information agents. While the functional agents are responsible for controlling the activities, the information agents transmit necessary information to support them.

The merging of the Logistics department activities makes it possible to create a planning and scheduling algorithms. The activities are divided into 6 functional agents, each representing the activities of the department, namely order acquisition, transportation management, resource management, scheduling, dispatch and logistics. Each of the agents have a specialized set of functions it is designated to do.

The Figure 8 represents the interaction among agents for transmitting information.

The supply chain agents exist within a broader framework called Enterprise Information Architecture (EIA). The EIA manages the information and ensures the flow is going the right way.

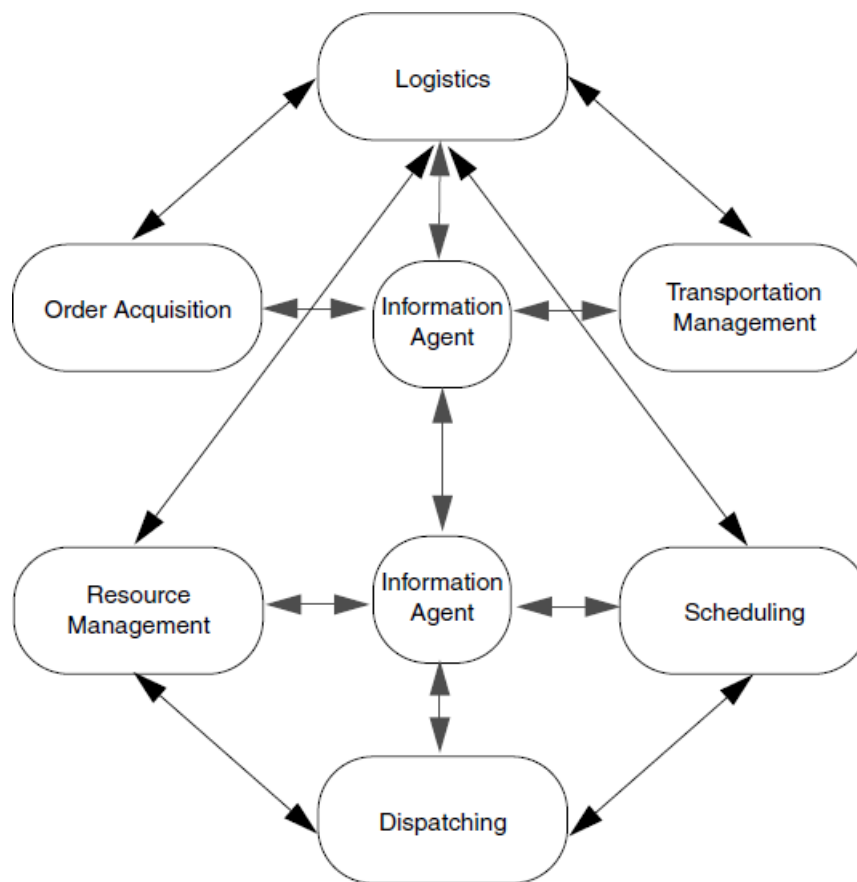


Figure 8: ISCM agents (Fox et al., 1993)

Order Acquisition Agent: It interacts directly with the customer regarding the customer's requirements, prices, due dates as well as customer support. The information received by the customer is communicated to the logistics agent. It also acts as a mediator with the customer when certain changes have been made in the order.

Logistics Agent: It acts as a centre for all the logistics activities. It manages the flow of material from the raw material stage to the delivery of the finished product to the customer. It takes in info regarding the orders to be delivered and other changes in production which influence the transport schedules and requirements. It generates production and transportation requirements.

Transportation agent: It takes into account the goods, which are ready for delivery, and makes schedules and routes to be sent to the customer.

Scheduling agent: It takes the information regarding the production requests, the resources available, and deviation from the initial schedule to schedule and reschedule the activities in order to minimise the WIP. It also explores scenarios for the worst-case situation and possible solutions for those instances.

Resource agent: It stores information regarding the inventory level and the purchasing. It calculates the resources needed as per the production requirements by assessing the schedules and generates purchase orders.

Dispatching agent: It handles the floor operations and deviations from the schedule are recorded. It sends these deviations to the scheduling agent for the alternate solution and tries to maintain the errors to a minimum.

2.2 PRODUCTION SCHEDULING

The main objective in a supply chain or production distribution network is to produce and deliver finished products to end consumers in the most cost effective and timely manner.

The planning depends on the type of production system: make-to-stock, make-to-order, make-to-engineer, make-to-assemble being some of the most common ones.

According to Cheng & Gupta (1989), a scheduling problem comprises of J jobs to be performed on M machines each with their specific processing time, release time and due date. They critique that the due date is considered to be an information and considered to be an input in the scheduling problem but, it could also be considered to be a decision maker. The authors discuss that the due dates can be majorly classified as exogenous and endogenous. Exogenous meaning the dates are decided by an external body and endogenous, where the due date is decided by an internal scheduler.

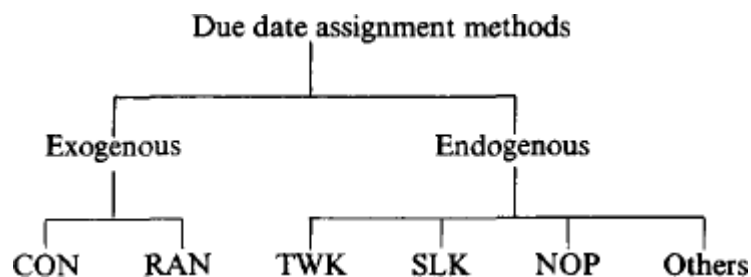


Figure 9: Due date classification (Cheng & Gupta, 1989)

The CON denotes when the all the jobs have the same flow and the RAN for the random flow. Meanwhile in the endogenous, the TWK represents the due dates allotted based on the total work done, SLK if there exists a slack time and NOP for the number of activities to be performed.

He proposes a model for the due date determination considering the total work done and number of operations performed. This was compared with a dynamic job shop and a conclusion was reached that the values agree closely with the results obtained and by further studying and applying it in actual production scenarios, it would be possible to minimise costs and reduce job tardiness.

As per Stevenson et al., (2005) Make-to-Order (MTO) cannot accurately forecast the demand and hence, it is not possible to predict the batch production methods. The production begins only on receiving the confirmed customer order. The industry can be classified into two types: Repeat Business Customizers (RBC) for whom a tailored product can be supplied continuously over a given contract period but can be repeated with minor predictability and the Versatile Manufacturing Companies (VMC) wherein a large variety of products are produced with low quantity with low repetition.

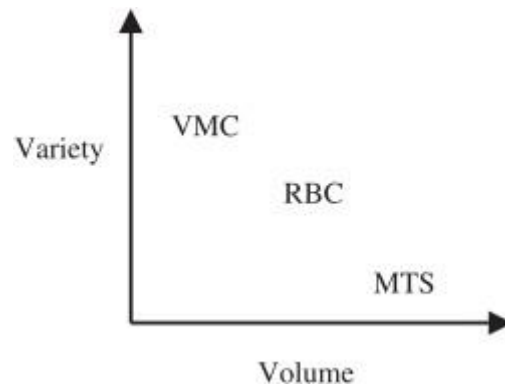


Figure 10: Classification based on Volume vs Variety (Stevenson et al., 2005)

The major issues faced by MTO companies is determining the capacity planning, the order acceptance and rejection rates and maintaining due dates. The assumption which are obtained from the Master Production Schedule of standard products with the Bill of Materials and from the forecasted data does not sit well with MTO due to highly variable environment they work with. This makes it difficult to implement a Material Resource Planning (MRP) with the key features which are more suited for repetitive manufacturing enterprise.

It would be possible to make changes in the MRP system to cater to the MTO companies, but it depends on the company size as it leads to an increase in expenditure. This would not to be a profitable decision for a small-scale industry. Hence, most of the small and medium scale companies stick to production only on receiving the confirmed customer order. It can be concluded that their main objective is maintaining and managing the delivery dates of the customer orders. Hence, their planning revolves around the delivery dates and are less focused on the capacity planning.

Meyr (2009) states that in a Make-to-Stock (MTS), the focus is on faster response to delivery dates, i.e., shorter lead times and the final goods are built on forecasts from which the customer requests are served. The MTS approach is mainly focused on those industries which produce low variety of products in high quantities. Gupta & Benjaafar (2010) in their paper explain that in a pure MTS environment, the finished products are stocked in the inventory from which the demand is satisfied until it reaches the buffer level. Once the buffer level is reached, the production is started to fill the inventory level again.

The major goal of both of these authors is to minimise the inventory costs. While Meyr (2009) focuses on the aspect of segregating the customers based on priority to maintain

the inventory so to achieve Available-to-Promise (ATP) against the clients with lesser priority for whom a minimum stock can be maintained. He suggests algorithms in order to achieve this differentiation.

Gupta & Benjaafar (2010) talks about how the final goods inventory can be maintained by having a single buffer of undifferentiated inventory against a dedicated inventory for each type of finished product. This is possible for those products which must undergo the common operations. They provide a formula for maintaining base stock level in such cases.

The MTS relies heavily on the forecasted data and in order to achieve good results, it is necessary to achieve a forecast which is close to the actual demand. Liao & Chiu (2017) critique that the key factors which influence the forecast are uncertainty, volatility, ambiguity and complexity. Volatility refers to quickly changing market with new products with shorter product lifecycles. Complexity can be described to the interaction of the key factors with each other which make it harder to predict the nature of the market.

Uncertainty are those forces which can suddenly change the demand pattern and ambiguity are those events which cannot be quantified but can influence the demand pattern. Graves (2011) talks about the production strategies that can be adopted in scenarios of uncertainties which can impact the capacity planning, the inventory level among the major. Liao & Chiu (2017) compares the forecasting techniques of linear regression, time series, exponential smoothing and autoregressive models by applying to a real-life scenario to obtain the accuracy of the models.

There has now emerged a new strategy which is a hybrid of the MTO and MTS strategies. Zaerpour et al. (2008) states this necessity arises in situations where there is a high variety of products with variable demands and focusing purely on either MTO or MTS makes the company incur huge expenses. A model is suggested to differentiate which products to be produced to stock and to order based on a combination Fuzzy Analytic Hierarchy Process to analyse the criteria and performing a SWOT (Strength Weakness Opportunities Threats) analysis.

Hemmati & Rabbani (2010) propose the differentiation of the products based on Analytic Network Process where the relationship among the products are identified and clusters are formed. From these clusters, the comparison is made to identify the products to be made to stock and to order.

Once the differentiation of the products is achieved, it is necessary to form a production planning structure. Rafiei et al. (2013) propose a bi-level production scheme that could be used for making the plan. This contains a plan which could be adopted for mid-term as well a plan for short-term goals.

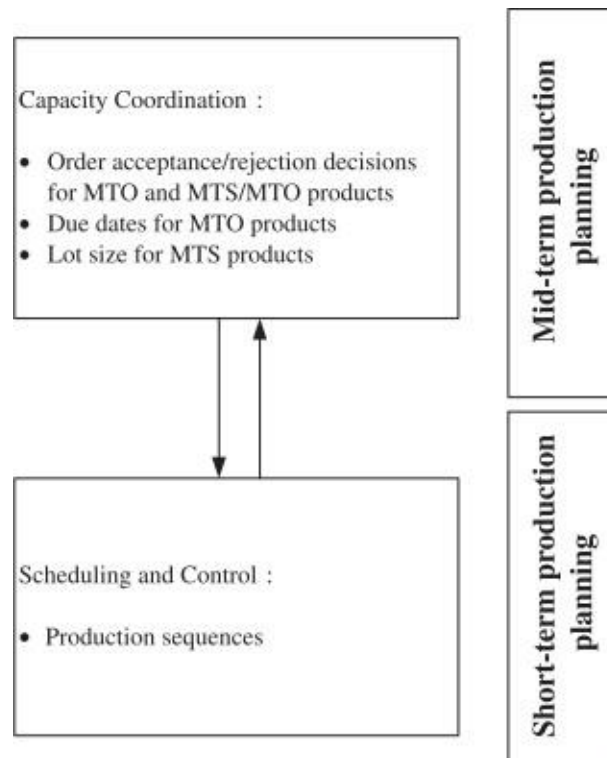


Figure 11: Bi-level production plan for MTO/MTS (Rafiei et al., 2013)

Tsubone et al. (2002) show a weekly production plan model for a combination of MTO and MTS where the factors which influence the total production capacity include the forecast demand of the MTS and the backlogs of the MTO with buffer capacity. This focuses majorly on short term aspect and the accuracy of the forecast data.

Tsubone & Kobayashi (2010) provide an interesting aspect to the production plan by booking the products to be scheduled for production much prior to getting the orders from customer. This is similar to how seats are blocked for travel in an airplane. The booking depends on the time available for producing the needed capacity.

| Types of planning | Purpose of planning |
|-------------------------|--|
| Master schedule | Determination of production capacity for week w |
| Setting production seat | Setting individual production seat for MTO and MTS products |
| Setting flexible seat | Setting flexible production seats for MTS product to be changeable seat for MTO products |
| Order assignment | Assigning MTS and MTO products to the production seats |
| Order releasing | Order release of MTS and MTO products received into the production process |

Figure 12: The production planning model for MTO/MTS based on booking system (Tsubone & Kobayashi, 2010)

2.2.1 METALLURGICAL INDUSTRY CONTEXT

Stawowy & Duda (2012) describe a general framework that is involved in the production planning and scheduling that arises in a foundry. The planning can be of a long term, mid-term and short term. The mid-term planning depends on the Master Production Schedule and Material Requirement Plan whereas the short term caters to the demand for the immediate requirements.

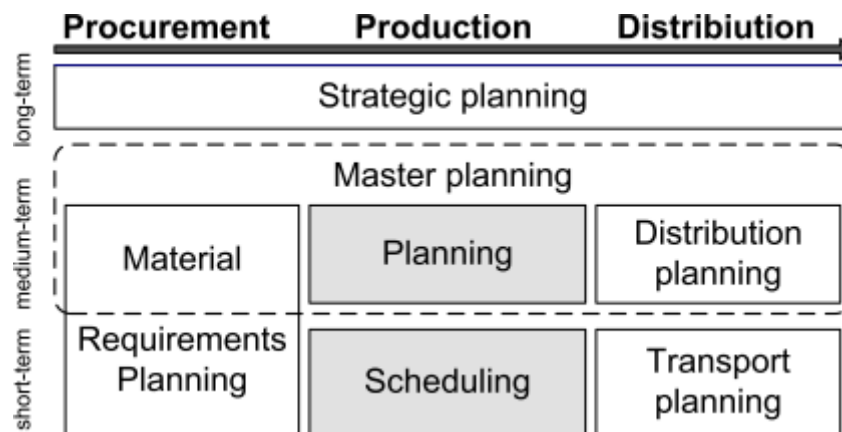


Figure 13: Decision areas in production planning (Ballestín et al., 2012)

The planning is straight forward with having to majorly deal with capacity constraints and minimising the costs. Since there is a constant demand for the products, the majority of the research papers with regarding to the planning in this field deal with adjusting the lot/ batch sizes in order to accommodate the capacity restraints.

Santos-meza & Oliveira (2002), Stawowy & Duda (2017), Araujo et al. (2008) provide some of the models that could be used for lot sizing the products. As most of the companies do not generally produce the final products, but more of products which act as raw materials in the production of higher end products, the research material available is limited and the available papers all cater to the problem of lot sizing as these types of companies generate products to be kept in stock. They majorly deal with problems arising in the inventory costs and ways to reduce them.

2.3 PRODUCT CLASSIFICATION APPROACHES

Kampen et al (2012) describes how the classification of Stock Keeping Units (SKUs) are generally used in the Production and Operations management in order to manage the production and inventory systems and by doing so, makes it easier to focus on the production strategy, inventory and customer service on the class as a whole rather on each SKU individually. The most commonly used classification is the ABC based on Pareto where the demand value or demand volume is used as the factor for making the classification.

While the classification is more popularly used for inventory management, it is not strictly necessary to use it solely for those purposes.

Keskin & Ozkan (2013) state that the classic ABC classification is dependent on the annual dollar value which might cause problems in the inventory with respect to the total costs and can cause financial losses. In these scenarios, it is better to use a classification based on multiple criteria rather than to focus only on the demand value.

Grosfeld-Nir et al. (2007) gives a basic summary on how the classic Pareto ABC classification. This was based on the observation made by the 20th century economist Vilfred Pareto that 80% of the wealth is owned by 20% of the population. This strategy is used in the inventory classifications wherein 80% of the revenue is generated by 20% of class A products, 10% by the next 30% and the remaining 50% contribute the rest of the income. But this classification becomes difficult in scenarios where the relative frequency is uniform. The classic classification is useful when the stark contrast between the items is clearly visible.

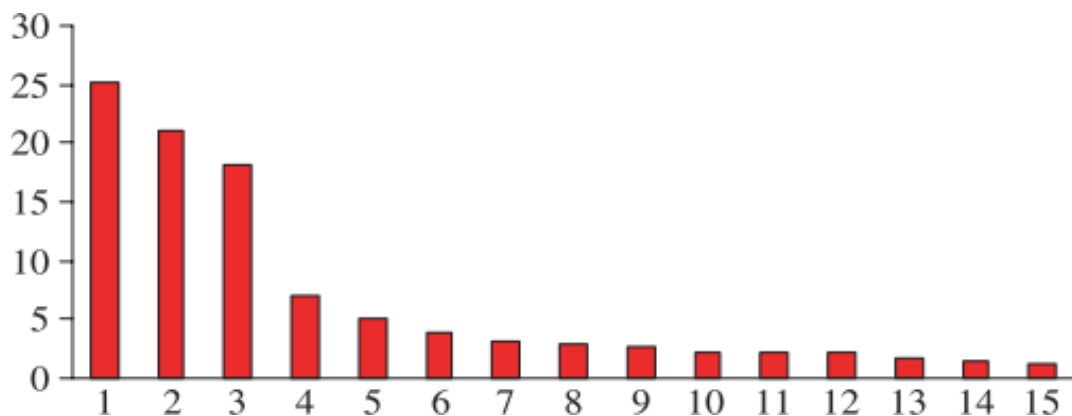


Figure 14: Differentiating Pareto chart (Grosfeld-Nir et al., 2007)

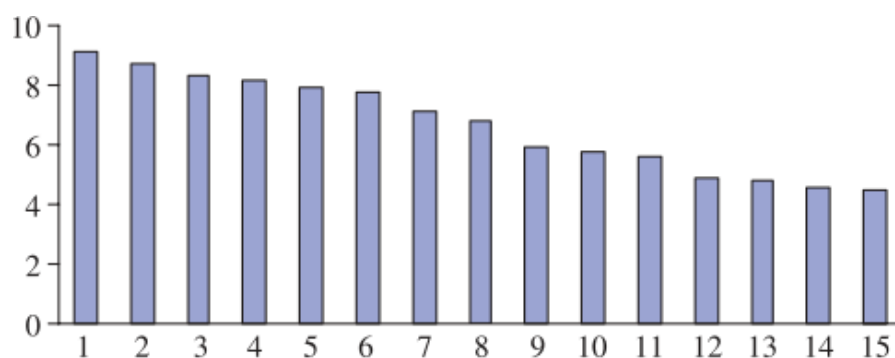


Figure 15: A uniform Pareto diagram (Grosfeld-Nir et al., 2007)

As the Pareto deals with taking only two criteria into consideration, the results obtained may not be accurate. In such cases where the distribution of the relative frequencies are uniform, considering more criteria would help in making a better analysis. Under these circumstances, more research is conducted towards the development of classification system based on multi criteria.

Over the years, a lot of multi criteria ABC classifications have been found. (Liu et al., 2016), (Ramanathan, 2006), (Saaty, 1980), (Ng, 2007) describe the models which can be used for the classification. There are a lot of classifications existing which has some amount of modification from the basic concepts which have been described in the above-mentioned classification systems. The other popular multi criteria classification system are those based on genetic algorithms and fuzzy logic. There has been several researches going on with respect to this classification and the nature of it depends on the field of applicability.

One of the more popular multi criteria based classification system is the Analytical Hierarchy Process (Saaty, 1980) since it can contain criteria which are both qualitative as well as quantitative. It is also easy to build. It is necessary to define the aim of the classification system in order to choose criteria that would be used for the development of the model.

CASE STUDY

3.1 DESCRIPTION OF THE COMPANY

3.2 PRODUCTION PROCESS

3.3 INTERNAL LOGISTICS

3.4 PRODUCTION PLAN ANALYSIS SUMMARY

**3.5 VISION FOR THE PRODUCTION PLANNING
MANAGEMENT**

**3.6 INFORMATION REQUIREMENTS TO SUPPORT THE
PRODUCTION SYSTEM**

3.7 PRODUCT CLASSIFICATION SYSTEM

3.8 CLASSIFICATION SYSTEM- APPLICATION CASE

3.9 CLASSIFICATION SYSTEM RESULTS

3.10 PROJECT OUTCOMES

3 CASE STUDY

In order to contextualize the problem and thus propose the solution within the scope of organization where the present project took place, an analysis of the project was made, starting with a description of the company.

3.1 DESCRIPTION OF THE COMPANY

The company was established in the year 1972 and later acquired by Sakthi Group which is an Indian Conglomerate dealing with the auto components, sugar, IT, education sectors and was established in Portugal in the year 2007 and came to be known by what it is today, i.e., Sakthi Portugal.

“Our Mission is to deliver to the next generation better than what we have received” is the motto they stand by. Their vision is to continuously maximize the client as well as the team satisfaction by constantly updating their knowledge and anticipating and offering solutions. The company believes in creating a work atmosphere with transparency in the various departments, constant engagement and proximity with the departments as well as clients so as to achieve perfection.



Figure 16: Sakthi Portugal SA

The company is based in Maia, Portugal about 10kms from the city of Porto, 12kms from the port Leixões and 8kms from the Aeroporto Francisco Sá Carneiro occupying 65,356 sq. meters of area.

The Sakthi SA group mainly deals with the manufacturing of automobile components, specifically brakes housings, suspensions control arms, differential cases and engines which are used in brands like Volkswagen, Ford, Peugeot and Daimler for which they

are the direct suppliers. They are also Tier 2 suppliers for other companies such as BMW, Fiat, Renault, Toyota among various others.

Their major customer base is in Europe constituting about 85 % of sales followed by USA. South America and South Africa constitute about 5% of overall sales. In Europe, Germany, Hungary, Slovenia, Spain, Portugal being the major players, and United Kingdom, France, Italy, Austria constituting the rest.



Figure 17: Castings produced

The annual production in Portugal is approximately 85,000 tons against the production plant in India which produces about 70,000 tons. In order to cater to the increasing production, the company has been expanding and has set-up another branch called SP21 which is based in Agueda, Portugal.

As of 2016, they had an annual production of 109,755 tons with about 80,500 tons from Sakthi SA and the remaining from SP21. In 2017, they reached 81,465 tons from both the branches, majority being from Sakthi SA producing 78,380.

The factory includes the foundry consisting of the 4 furnaces, molding machines with a dedicated cooling line, 2 separate sand areas to be sent for the molding, core shop, temporary storage for cores, quality check, storage of scrap, machining line, painting area, packaging as well as the warehouse for storing the finished products which are to be transported. It consists of an office area for miscellaneous activities.

The company works with Nodular Iron which has excellent ductility as well a good combination of strength, wear and fatigue when compared to grey iron which makes it the better choice for the production of automobile parts.

They have been certified for IATF 19649: 2016 issued by the International Automotive Task Force which is a mandatory requirement for companies manufacturing parts for the automotive industry. It provides the global technical specification and Quality Management Standards, which contains a collection of policies, processes,

documented procedures, and records which needs to be followed and implemented in the organization.

The company has been awarded the ISO 50001: 2011 which enables them to follow a systematic approach in achieving continual improvement of energy performance, including energy efficiency, energy use and consumption. They have also received the OHSAS 18001: 2007 relating to the occupational health and safety management in the work area. They have been certified for SA 8000 which refers to the fair treatment of workers across various industries and in any country.

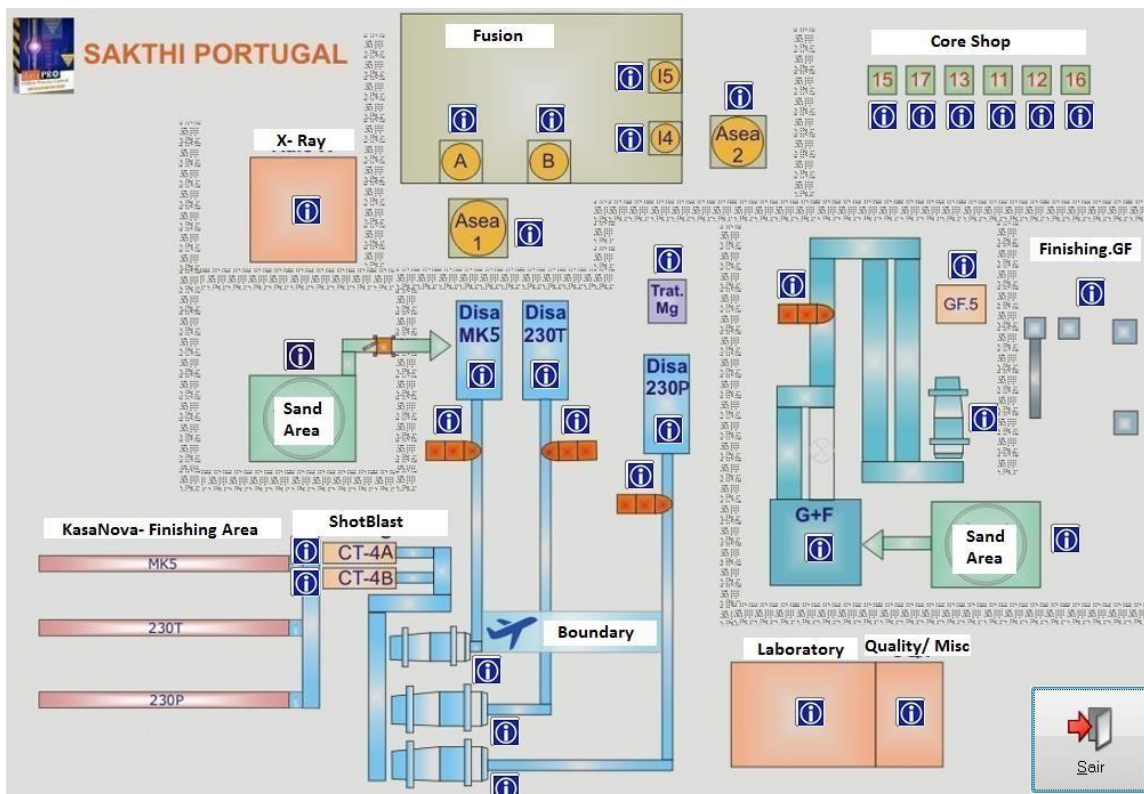


Figure 18: Factory Layout

The company currently owns 4 molding machines and 6 core making machines. Of the molding machines, 3 are of the vertical type with 2 of them being of the same model, all of them being Disas and 1 horizontal machine by George Fischer (GF). With regards to the core making machines, 4 are of the Loramendi and 2 of the Laempe.

3.2 PRODUCTION PROCESS

The production process follows the following steps:

- **Fusion:** The company has 4 furnaces, 2 large furnaces having a capacity of 12 tons and 2 smaller ones having a capacity of 5 tons. The iron is melted in this area so as to obtain the melt. The iron which is melted contains a mixture of the raw iron

obtained from the raw material supplier as well as the scrap from the finishing line. It takes about an hour to obtain the melt.

- **Holding Furnace:** There are 2 holding furnaces, ASEA 1 and ASEA 2. The melt from the larger furnaces A and B are stored in ASEA 1 which has a capacity of 42 tons with a buffer of 12 tons, whereas the melt from the smaller furnaces I4 and I5 are stored in ASEA 2 which has a lower holding capacity of 25 tons with a buffer of about 7 tons.



Figure 19: Process Chart

- **Treatment:** The melt stored in the holding furnace is to be sent to the molding machines. Prior to that, the chemicals are needed to be added and adjusted in order to obtain the Nodular Iron which is needed for making the cast parts. In each cycle of the melt being supplied for pouring, the noduliser, Cu, FeSi is added according to the desired chemical composition and properties requested by the customer.
- **Sand Area:** The addition of the binders, additives, water to the green sand which is used for making the mould is controlled in this area and the mixture is sent to the

moulding machines when required. There are 2 sand controls; one exclusively for the horizontal GF machine and the other which sends the sand to the Disas moulding machines. The sand which is left after getting the cast is reused after treating it. This sand goes to the sand area for storage and later for consumption in the process.

- **Core Shop:** The cores which are used in the molds to produce internal cavities are produced here. The cold-box process is followed in order to produce the cores. The cores are essentially made of sand with various additives/ resins added along with small amounts of water and compacted with air pressure. The curing gas is introduced in order to harden the cores so that it can maintain the shape even when the hot melt is poured. Certain parts of the cores are dipped in paint to cover the pores and also to ensure that the sand doesn't stick to the cast part as well as to prevent intrusions.

Moulding:

- **Vertical-** The vertical molding machines operate at a much faster pace compared to the horizontal molding machine. The Disas 230 can produce about 470 molds/ hour without cores and about 400 molds/ hour with cores. On the other hand, MK5 can produce about 350 molds/ hour without cores and 300 molds/ hour with cores. Even though the basic function of the vertical and horizontal machines are to prepare molds, the method of obtaining them differs. In the vertical molding line, each block of the compressed green sand has one side with the impression of one pattern plate and the opposite side with the impression from the remaining pattern plate. When two consecutive blocks are joined, the complete pattern can be obtained. The vertical molding machine has one pressure plate which is responsible for compacting the sand to make the block and has one of the pattern plates, and the other swing plate which holds the other plate and can swing upwards. The pressure plate is also responsible for moving the blocks forward. The cores are placed in molds automatically.
- **Horizontal-** The horizontal GF operates at a much slower pace producing about 90 molds/ hour and works with cores. The horizontal molding machine has the traditional approach where the cope (top half) and drag (bottom half) are made separately with the pattern plates and are assembled together further in the line. The other difference is that in this type of process, the cores are placed manually in the mold by the operators. After the cores are placed, the cope is rotated so that it is in the correct position and only then, it is assembled together with the drag.
- **Melting:** The hot melt after the treatment is poured into the basin. Fresh melt is provided to the basins of each of the molding lines at a time interval of 10 minutes in order to ensure that nodular iron is obtained. This time is calculated based on

the phasing out of Magnesium from the melt. The melt from the basin enters the sprue of the mold through the nozzle. At the exit of the nozzle, magnesium is sprayed in order to achieve the required microstructure and properties of the cast.

- **Product Control/ Boundary:** This area is specifically designed so that the poured melt has sufficient time to cool and harden before it goes further into the process. The speed of the blocks after the melt has been poured into the cavity is regulated by the Automated Mold Conveyor (AMC). This not only helps in the movement of the blocks but also, compresses it so there is no expansion of the metal during the cooling process. After the AMC comes the Synchronized Belt Conveyor (SBC), which further transports it along the line from the AMC and to the shot blast. The major difference between the AMC and SBC is that in the case of AMC, the movement is done with the help of a metal rod whereas in SBC, it is through an inflatable membrane.
- **Shot Blast:** The molds after getting sufficiently cooled are passed into a vibrating drum to break the blocks. During this, the majority of the sand mold is separated from the cast. The obtained cast still has sand clinging onto to it and needs to be cleaned before it enters the finishing line. This cleaning is done with the help of shot blast where tiny metal particles hit the cast at a high velocity, thereby getting rid of the small sand particles. This not only removes the sand but also helps to break the gating channels. The sand is filtered, and treatments are done to be re-purposed again.
- **Finishing:** The cast after exiting the shot blast enters the finishing line. Sometimes when the channels aren't broken in the shot blast, they are manually cut in this area. The obtained casts are sent for visual, x-ray and dimensional checks to ensure they are up to the required standards to be sent for the clients. Some minor machining operations are carried out to meet the standards. As per the customers' requests, the parts are sent for painting or are sent directly for packaging.
- **Painting:** The painting is done by the process of electroplating where the parts are made into the cathode and immersed in metal solution. On passing electricity, the cations (metal ions) deposit onto the metal surface.

After all the processes are completed, the parts are packaged as per the customer request and are stored in the warehouse before they are to be dispatched.

3.3 INTERNAL LOGISTICS

The logistics department in the company mainly handles the customer response, production planning, transportation, requirement planning and order for sand cores.

The warehouse management of the company is handled by a third party logistics company.

3.3.1 INTRODUCTION TO THE FUNCTIONS:

In this section it is described the main functions of the Logistic Department.

Customer Service - The department receives the demand order as well as the delivery dates from the customers directly. Each client has their own ID which is referred to in the company. Most of the customers have multiple parts which the company acts as a supplier to. The order and the delivery sheet contain the part information which needs to be converted into the company reference. They interact with the customer regarding the delivery notes, change in schedules, any grievances regarding the delivery, problem with some of the parts so that they can interact with other departments inside the company to come up with a solution. They also coordinate with the I&D (Engineering and Development) team regarding the new parts which needs to be approved as well as for improvement.

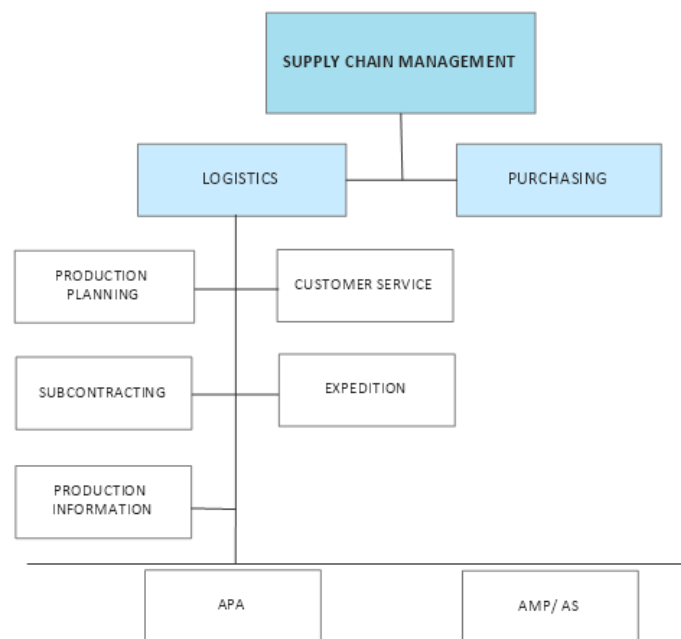


Figure 20: Functions of Logistics Department at Sakthi

Production Planning - The department also does the weekly production planning to be sent for the production. The complete detail of the planning will be discussed in the next section. It also handles the sub-contracting of cores which should be done in advance for the supplier to deliver it on time for the production.

Transportation - The trucks required for transporting the goods to the customers are calculated and time-windows frame for the pick-up is arranged. They also prepare the customs declaration form for transporting the boxes containing the parts to overseas customers. They also make the delivery slip containing information regarding the

number of parts and boxes being transported along with the bar code so that the boxes can be tracked in case the customer requests information regarding the location of the package. They currently deal with three types of transportation activities: EXW, DDP and FOB.

EXW (Ex Works): The customer is responsible for the transportation of the goods from the company to their base. The company does not bear any responsibility for any problems or accidents that may occur during the transit and their function ends with the loading of the trucks.

DDP (Delivered Duty Paid): In this type, the seller holds the complete responsibility from the receiving of the orders till the arrival of the goods at the destination defined by the customer. The seller endures the costs and risks as well as the import clearance, duties and taxes.

FOB (Free On Board): The seller holds complete custody of the risks which includes the transportation and the insurance. The charge of the seller ends once the products are delivered on board the ship. (Virginia, 2012)

Production information - The department is also tasked with maintaining a data base and continuously reviewing the production orders to keep a track of the actual production amount and the amount at the completion of the product to view the usage and the wastage of materials. This also acts as a secondary verification of data so that it would help to identify areas where the possible mistakes might have occurred.

Packaging and Supply requests - The department has to keep an account of the packaging materials such as the cartons, wooden boxes, fundamentally to manage the packages which has been defined by the I&D departments and the customers. The packages can be of 2 kinds; one where the quantity, material and packaging has been defined and set by the I&D department on consultation with the client, and the other where the client themselves are responsible for the packaging and send the boxes for the goods to be packed in.

Supplier requests and demands - They are also tasked with dealing with the outside suppliers for the machining operations. The company currently has 3 external suppliers based in Spain for the machining operation and 1 machining centre which is a part of Sakthi and is located in Trofa. Most of the machining activities being carried out at Trofa due to the close proximity as well as being a part of the company, ensures the lesser costs and the profit is higher.

The logistics also handles the storage of raw materials(AMP) as well as the spare parts(AS) along with the warehouse of finished products(APA).

3.3.2 MANUAL PRODUCTION PLANNING DESCRIPTION

The company follows a make-to-stock approach, so they can deal with the fluctuating behaviour of the automotive market and to provide and maintain a better customer service. The inventory level was previously decided by the Board which includes the CEO as well as the CFO that the stock level could accommodate the goods that could be produced in a 7 days period. This value has increased in recent times.

Usually, the production is done to meet the delivery requirements. This is due to the reason that mass production and storage for a very long period requires additional processes like painting or oil dipping in order to prevent rusting of parts. They also get orders for “off market” parts which makes it hard to produce the parts in advance as the requirement cannot be determined. It can be concluded that the company does not completely follow a Pull system nor a Push system, it is at the intersection of both. So, it can be said that it follows a mix of make-to-order and make-to-stock.

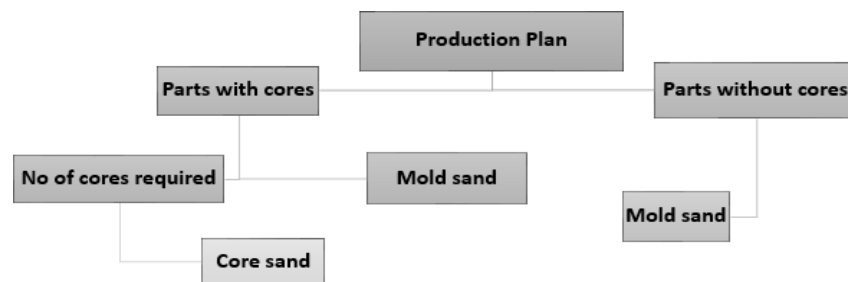


Figure 21: Requirements for making a production plan

The weekly production plan is done every Wednesday/ Thursday. After the production plan is done, it is sent to the Production Control who oversee the daily production. The Logistics, Back Office and the I&D departments often consult each other regarding the customer needs as well as availability of pattern plates for production.

The Logistics is not only in charge of the mold production planning, but also the core production planning as the cores are required to make inner cavity of the casts. They also generate the order for the sub-contracted parts to be sent to the supplier a week in advance.

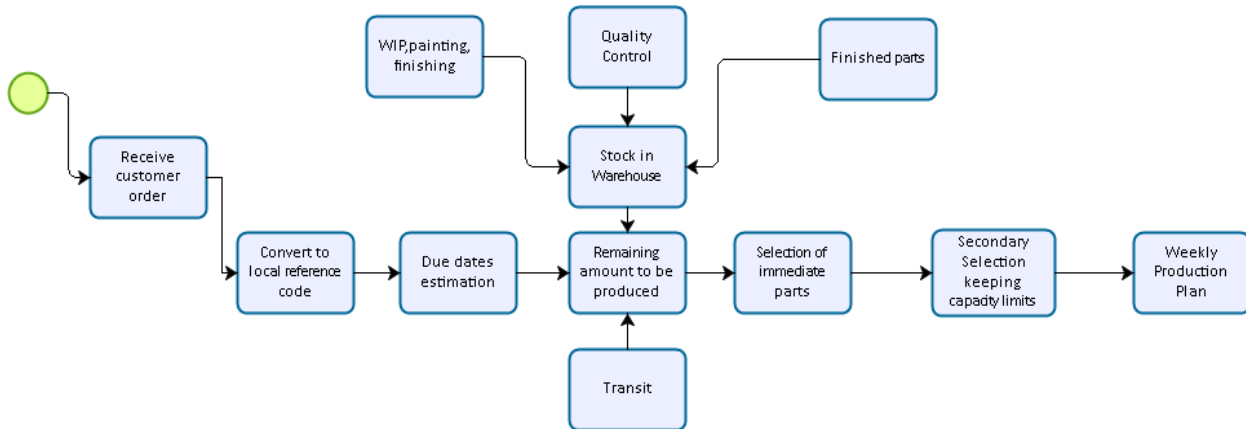


Figure 22: BPMN diagram - General overview of production planning

The Logistics department receives the customer orders through the EDI (Electronic Data Interchange), E-mails, Customer portals, and Fax which contains the customer reference code, purchase order number, quantity and the delivery date. The company reference code for the parts are different from the customer reference code and hence, it needs to be converted to the internal references for calculation. The customer orders are analysed to a period of 4 months which majorly consists of the total monthly production in order to have a general view about the production feasibility and requirement.

Purchase Order

SHIP TO:
[Redacted]
UNITED KINGDOM
Cliente 100026

Purchase Order No. 4500061695
Date 02.08.2018
Buyer [Redacted]
Buyer's e-mail [Redacted]

THIS ORDER COVERS SUPPLY OF THE FOLLOWING:
No deviation from the specification, price or quantity will be accepted unless confirmed in writing by us. Failure to do so will result in the return of your invoice, causing late or none payment of your invoice. Dana Standard Terms and Conditions, in conjunction with any applicable Supplemental Terms and Conditions, apply to this order. Copies of which are available on request or at <http://supplier.dana.com>

PLEASE QUOTE THIS PURCHASE ORDER NUMBER AND OUR PART NUMBER ON ALL PAPERWORK

Seller Address
SAKTHI PORTUGAL S.A.
APARTADO 1090
000-4471 MAIA CODEX
PORTUGAL

Your Seller No. With us: **101416**
Customer id

E-MAIL INVOICE TO
Indirect Product & Services [Redacted]
Direct Materials [Redacted]

| PAYMENT TERMS | | INCOTERMS | | TERM | | |
|--------------------|---|------------------------------------|----|------------|------------|----------|
| Net due in 90 days | | FCA(Free Carrier)/Sellers Premises | | | | |
| Item | Material/Description | Quantity | UM | Price Unit | Net Amount | Currency |
| 10 | 10066086 ADAPTOR - CASTING (SUSI) Delivery of first off parts from WK4 2018 Delivery date: 10.09.2018 | 2,496.00 | EA | 11.92 EA | 29,752.32 | EUR |
| | Customer part no [Redacted] Company part no [Redacted] | | | | | |

Figure 23: Purchase order

A detailed order analysis is made for a period of 2 months. In this analysis, it contains information regarding the number of parts which needs to be produced and ready for shipment each week which is calculated using backward calculation from the time the

parts are supposed to reach the customer and the transit time. This ensures that the production is done well beforehand, so it reaches the customer on time (see Table 1).

| Country(s) | Transit (days) |
|-----------------------------|----------------|
| Germany | 4 |
| Slovakia, Sweden, UK | 5 |
| Spain | 1 |
| Mexico | 20 |

Table 1 - Transit Duration

$$\text{Customer order shipment} = \text{Delivery Date} - \text{Transit Time}$$

Equation 1

It is to be noted that the demand orders received can be the forecasted demand of the customer so there can be a variation of the delivery date as well as the demand. They have fixed orders which are in continuous production.

The changes in the delivery date is mandatory to be notified 2 weeks in advance owing to the restrictions of the stock and the transit.

The next phase is updating the data bases with the number of parts in the warehouse, work-in-progress from the finishing line and quality check, pieces in transit and the weekly requirement.

$$\text{Remaining Order} = \text{Total Customer Order} - (\text{Stock} + \text{WIP}) - \text{Transit}$$

Equation 2

Even though the above formula holds true for calculating the remaining order, it is done in two phases: primarily deducting the pieces in transit, followed by the stock and WIP. The major reason being the constraint of the software. The information regarding the transit being stored in ERP management software called PHC and the warehouse information in the Excel files. This causes a delay in transferring of data from one software to the other.

The pieces in transit essentially contains the information about the last delivery which was made. The delivery information projects the information of the product code, the pieces, and the date on which the delivery was made. This information is stored in the ERP management software PHC.

| Dados Diversos | | | | | | | | | | | |
|--------------------|---------------|-------------|----------------|------------|---------------|--------------|----------------|----------------|-----------------|------------|--------------|
| Tipo de Documento | | | | | | | | | | | |
| Guia de Remessa PA | | Da Entidade | 100281 | Do Artigo | | | | | | | |
| Desde a data | | 09.07.2018 | À Entidade | 100281 | Ao Artigo | | | | | | |
| Cliente | Nome do Clien | Artigo | Descrição | Nº da Guia | Data de Envio | Qtd. Enviada | Qtd. Env. Acum | Qtd. Facturada | Qtd. Fact. Acur | Nº Factura | Data Factura |
| 100281 | | F74473474 | R 463 353 0101 | 2189 | 31.07.2018 | 288,000 | 288,000 | 288,000 | 288,000 | 1753 | 31.07.2018 |
| 100281 | | F77123486 | R 463 331 06 0 | 1993 | 11.07.2018 | 756,000 | 756,000 | 756,000 | 756,000 | 1601 | 12.07.2018 |
| 100281 | | F77123486 | R 463 331 06 0 | 2114 | 23.07.2018 | 504,000 | 1.260,000 | 504,000 | 1.260,000 | 1702 | 24.07.2018 |
| 100281 | | F77123486 | R 463 331 06 0 | 2190 | 31.07.2018 | 504,000 | 1.764,000 | 504,000 | 1.764,000 | 1753 | 31.07.2018 |
| 100281 | | F77423475 | R 463 335 02 0 | 2188 | 31.07.2018 | 440,000 | 440,000 | 440,000 | 440,000 | 1753 | 31.07.2018 |

Figure 24: Transit information

When the customer places an order, it contains the information regarding the reference that is required in a certain quantity on a certain date, as well as a number that identifies the last delivery that they have received (Nº da Guia). Upon the arrival of the order, a verification is carried out to check if the last delivery received by the customer matches with the company's last delivery with the help of a number that is identified as "Nº da Guia" in Figure 17. If the numbers match, it means that there are no pieces in transit. If there are pieces in transit, the quantity of pieces that has been sent to the customer will be deducted from the first order request from the customer for the current period and the remaining quantity is marked for the delivery dates keeping in mind the transit time.

The production requirements is calculated for a period of 2 months. This includes the weekly requirement for a period of 8 weeks. From this, it is necessary to determine the mold openings required in order to meet the requirement as for each reference, the number of parts obtained from each moulding differs. Generally, the production is done to satisfy the demand for a period of 2 weeks. On more availability, the production demand could be considered for a longer period.

The weekly planning for the number of moldings is done initially and is followed by core requirement planning.

$$\text{Number of molds} = \frac{\text{Number of parts to produce}}{\text{Number of parts per pattern plate}} + 10\% \text{ error}$$

Equation 3

The error percentage includes the 5% error which occurs as losses due to the parts which might have accidentally gone to scrap during the cleaning of sand stage in the Shot blast and the other 5% due to some mistake which might have occurred during the pouring of the melt (defect). As a rule of thumb, this is established for the safety of the Logistics department.

The next step involves adjusting the moldings of various parts so as to achieve the maximum utilisation of the molding machines which is 9000 moldings/day for the Disas 230 (P+T), 6000 molds/day for MK5 and 2000 molds/day for the horizontal GF. This is also done so that the individual departments can meet their daily goal criteria.

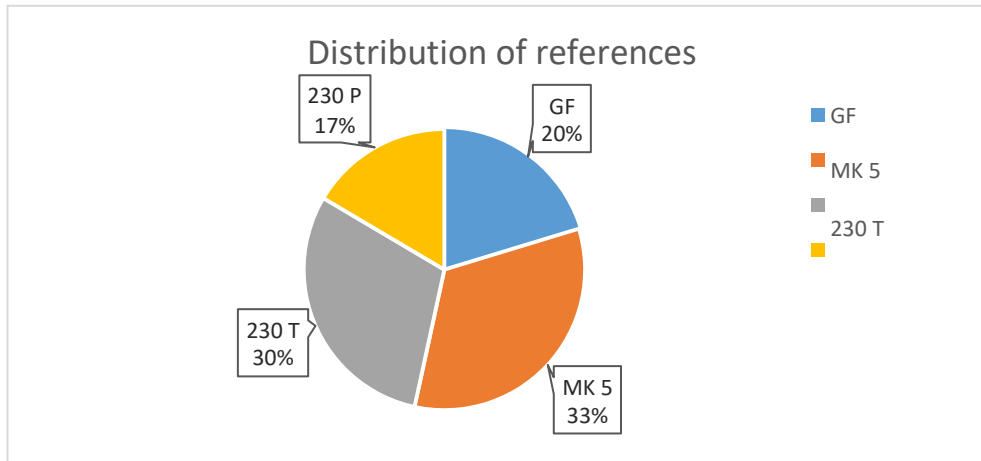


Figure 25: Distribution of references

The number of moldings are always considered to be a value which is a multiple of 500 with the exception of the horizontal GF line which generally has a value in multiples of 50.

One of the other main factors in deciding the production plan is adjusting the number of moldings of parts working with or without sand cores. The ideal distribution of parts is that approx. 30% work is done without cores and the rest with cores. By increasing the number of moldings with cores, the requirement of cores vs the availability of them is not proportional as it takes a much longer duration to produce them.

It is also required to check the previous core plan and if the plan contains references which were not used in the previous plan, it is necessary to include those references for production in the molding plan and adjust the no of opening accordingly.

Besides the usual parts, there are also a few parts which need to be outsourced for machining. It is required for these parts to be made much prior to the due date in order to give enough buffer time for the machining to be finished so that the confidence of the delivery can be maintained.

The weekly mold production plan is then forwarded to the Production control and all the other departments within the company. The Production control are responsible for the daily production schedules. They decide the order in which the references are to be produced and are responsible for taking quick decisions in case of failure/ problem with a particular reference. The main agenda of the production department is to ensure that a daily 360 tonnage of useful melt is being utilised to produce the parts. They take into account the details of the products like the chemical composition

similarity, core availability, etc. to decide on the daily schedule consulting with the Logistics department regarding the urgency of any particular product.

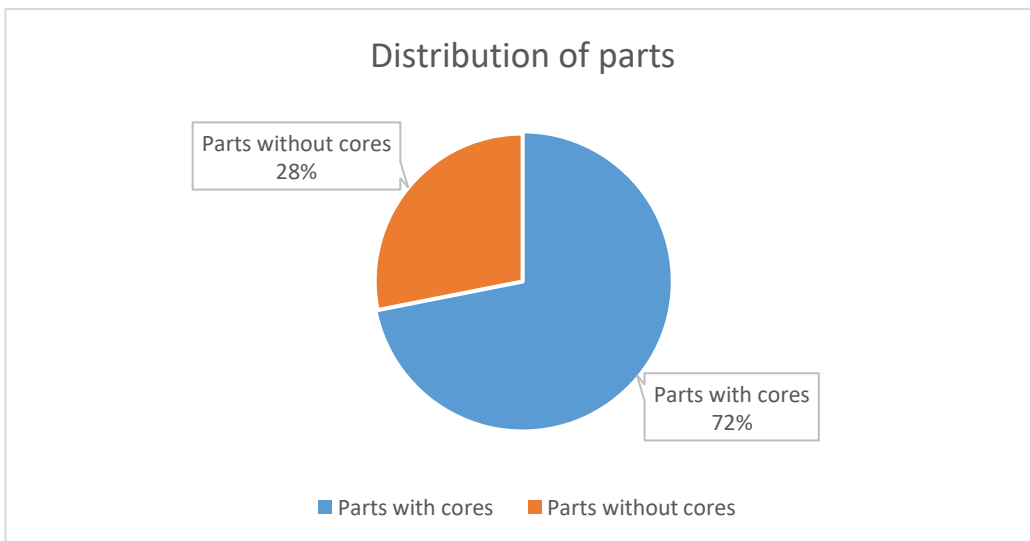


Figure 26: Percentage distribution of parts with & without cores

The mold planning is followed by the core planning. The Logistics department is exclusively responsible for the core planning.

Among the 121 references, 87 references need cores in order to get the required part. It is essential for the cores to be prepared well in hand in order for it to be used for making the mold. Each core opening can produce multiple cores. The planning is done for the number of core openings necessary in order to meet the molding requirements.

$$\text{Number of Core Openings} = \frac{\text{Number of Moldings} * \text{Number of parts per pattern plate}}{\text{Number of Cores per Opening}}$$

Equation 4

It is possible for 2 or more references to be working with the same core. In that case, the total number of parts which would be obtained is taken as the numerator in the above formula.

One of the important factors which affect the mold plan is the number of cores which is required in the molding line as the core shop has a capacity limit for the number of cores it can produce during the week. This value varies between 4500-6000 core openings per week for each of the 6 core making machines.

There are certain conditions and restrictions which need to be taken into account while making the plan for the cores as some references can be produced only with the

machines assigned to it while with others, there is a flexibility to produce them among a selection of machines.

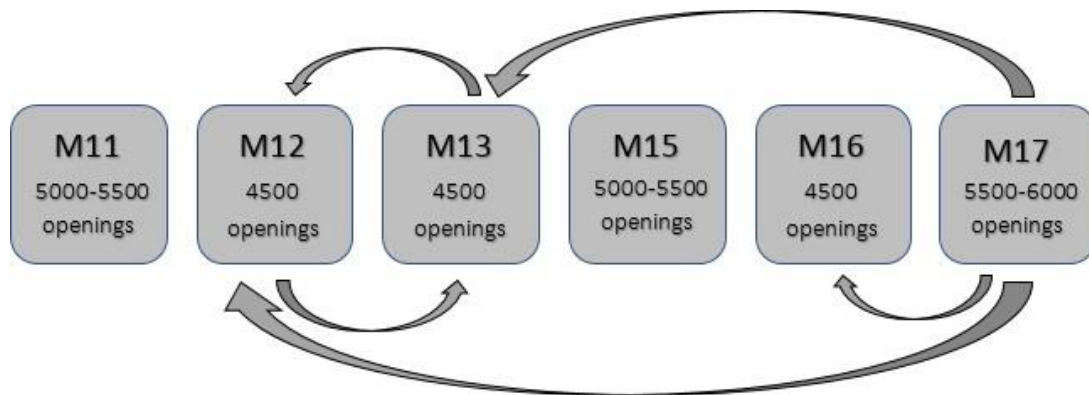


Figure 27: Core machine with the capacity and flexibility

A few things have to be taken into consideration while planning cores for the parts which work in GF. One major factor is that some references need multiple cores to be used to produce a single part. It needs to be ensured that all the required cores are planned and in sufficient quantities as the number of cores obtained per opening differs even with the same part. Generally, the bigger cores has a limit of 1 or 2 per opening and the smaller cores can produce between 4-8 cores per opening both having the same reference number but differentiated with the lettering 'a' for the former and 'b' for the latter. They do not have the full capacity to produce all the cores and hence, as the need arises, it is subcontracted from an external supplier. But, the majority of the core production is being done in-house.

The cores to be sub-contracted are ordered a week in prior so that there's availability during production. The order is generally placed through an email.

3.4 PRODUCTION PLAN ANALYSIS SUMMARY

The current production plan involves catering to the immediate customer requirements. The plans are made for the short term goals rather than for the long term aspect. There is no definite way or value for maintaining the inventory level. The plans are made and inventory is maintained based on the expertise of the planner.

The current planning strategies focus on a continuous production making the maximum possible utilisation of the machines. There is a two stage planning process where at the first level, the Logistics department decides which products and how much of it needs to be produced. Their goal is to mainly satisfy the customers. The plan also ensures the machines are employed to the maximum extent by deciding on the number of mold openings. Upon completion, the core requirements are calculated and the order is dispatched to the core shop for them to start the production.

The next level of planning is done by the Production control which makes the daily production plan and their criteria is to make sure that a specified amount of good metal/useful melt (the actual consumption of metal in making the part disregarding the wastages) is being produced so that the machines are being completely utilised and the idle time is less.

In simpler terms, the primary plan complies with the market demand while the secondary plan with the melt consumption. This sometimes leads to a conflict of objectives between the two departments.

3.5 VISION FOR THE PRODUCTION PLANNING MANAGEMENT

The objective is to define a set of requirements which needs to be included in the development of a software whose purpose is to integrate all the necessary data into a single platform for ease of access and suggest possible products that could be added for generating a weekly production plan before it is forwarded over to the next phase of the production. The system will not be completely automatic. The majority of the decisions to be taken will still be with the handler.

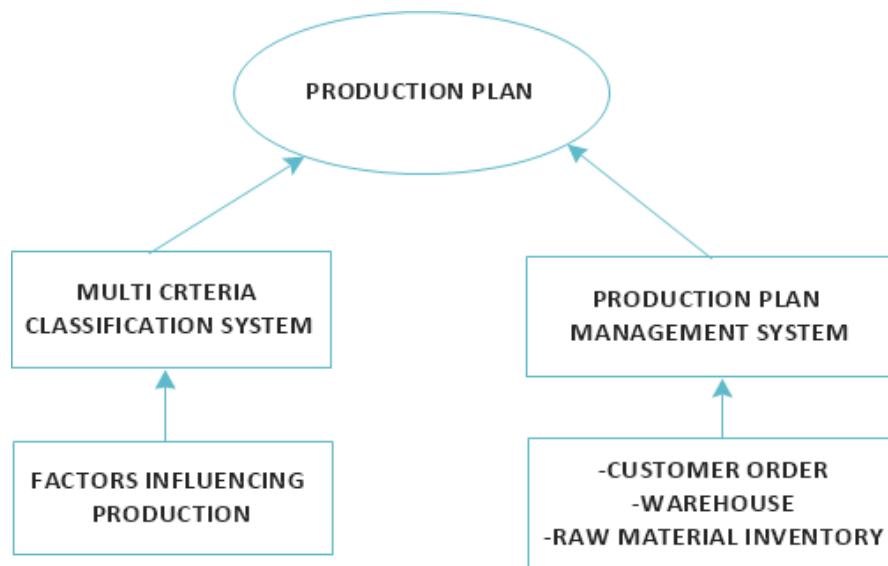


Figure 28: Vision for Production Planning

It also includes a proposal for the classification of products based on multi criteria considering the factors which affect production. This could help in understanding the distribution of parts and help in maintaining the inventory level, and also possibly help in identifying the ways the bottleneck could be avoided or the impact kept to a minimum.

3.6 INFORMATION REQUIREMENTS TO SUPPORT THE PRODUCTION SYSTEM

The major objective is to combine all the information sources onto a single platform to aid in the general production planning. The centralised approach is considered as it is a management decision. It acts as a bridge connecting the information from the different data sources which are present within the scope of the company. This reduces the time consumed in seeking out the information required.

The ERP system acts as a guide and is not an independent thinking system. Most of the decisions to be taken are handled by the operator and the system is only capable of giving a few basic suggestions.

The following provides an aspect regarding the general requirements that needs can be included in a customised Enterprise Resource Planning (ERP) system which is mainly focused on the interactive data acquisition, Inventory control, Production planning and execution as well as the quality control.

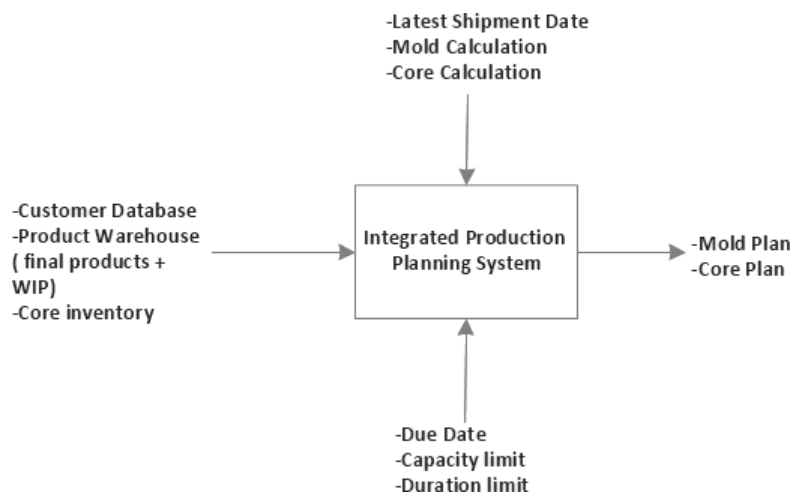


Figure 29: Model of the Integrated Production Management System

3.6.1 INFORMATION INPUTS

The inputs act as an information agent and gathers the needed data from the various sources and provides it to the personnel for easy access. The system developed is mainly developed for integrating the various departments in the company and foremost, act as the information gatherer reducing the hassles of acquiring the necessary data.

- **Customer Database Agent** - The foremost thing is to convert the customer code to the company reference code. Primarily, the system should be able to match the customer id accurately and since there are various products that is requested from the customer, it is necessary to match the customer's unique reference for the part with the 8 digit reference which is assigned by the company. The planner generally uses the last 4 digits of the code as it is unique for each type of part with the exception of few products. The system should transfer the demand orders obtained from the customers through the various incoming portals like EDI, email to the single platform where essentially, the user can avoid the hassles of transferring the data from one medium to the other. It should update the database with each incoming order to the final order sent in by the customer. It needs to include the details such as the order number, order quantity, delivery date. All the departments will have access to the system but cannot modify the data besides the concerned personnel. It needs to display the last delivery information that includes the details of the expedition date, the quantity and the packaging the goods were delivered in. This helps to determine the pieces in transit.
- **Storage Agent** - The other necessary function is that the warehouse data be updated taking in the information from the Data Pro (the inbuilt data execution system). The warehouse data can be classified into two kinds: Work-In-Progress (WIP) which may include parts undergoing operations such as machining, primary quality checks, painting, packaging, and the final stock which have been packaged and are in storage having cleared all the previous steps, waiting to be dispatched to the customers. The WIP can include a subdivision with an additional quality control for those parts withheld due to some issues which were detected by the Quality, Production, or by the Customers themselves till it is resolved.
- **Resource Agent** - It can also include a third warehouse information regarding the amount of cores which has been produced and also to include information regarding the space utilisation. This agent analyses and modify the plan so as to avoid overcrowding and/or understocking of cores as well as to keep an account of the cores which were produced as they form one of the main materials to get the final product since about 72% work with cores as per the year 2018.

3.6.2 INFORMATION OUTPUT

The following provides a basis of information which would be obtained on feeding the inputs.

- The system should display the amount of moldings required to fulfil the customer orders for the week and signal the personnel in case of over-

scheduling with regards to the amount being produced with and without cores, as well as the machine limits.

- It should automatically create a backorder for the core shop using the planned weekly production schedule. The amount of cores that needs to be produced should be calculated by the system by gathering the information from the mold planning and by incorporating the formula to calculate the cores within the program itself.
- It would also be useful if the system can develop a list of the external requirements to be sent for the supplier.

The weekly planning done by the Logistics is then handed over to the production control who are in charge of making the daily production plan and confirm that the production demands are satisfied as well as to all the other concerned departments in the company.

3.6.3 TOOLS

The tools with respect to our context are the formulas which are used for calculating the shipment date (Equation 1) by which the customer order needs to be satisfied, number of mold openings (Equation 3) and number of core openings (Equation 4) which is needed to meet the demand.

3.6.4 CONSTRAINTS

The following lists the constraints which need to be respected in order to meet the customer expectations as well as to keep the OEE of the machines above 85%.

- Primarily, the system should display the delivery date information with the amount remaining to be produced which is calculated by the system by subtracting the stock from the total order quantity, which is basically the Projected Required Balance to satisfy the demand.
- The total production hours planned cannot exceed 23h/day, i.e., 115h/ week for the molding line. The exception would be when a particular machine isn't operating full time due to low demand/ seasonality issues/over time.
- The Disas molding machines should meet the criteria of having at least 9000 mold/day with respect to 230 series and 6000 mold/day for MK5. The horizontal however, needs to have about 2000 mold/day due to the complexity of the operation. This can be achieved by suggesting the no of mold openings to be planned for the selected time period by the planner.

- The planned core shop production cannot exceed the machine limitations which has been described before.(Figure 27: Core machine with the capacity and flexibility)
- There should be some flexibility in changing the references from one machine to another in the core shop planning. Firstly, a default machine is allotted for the reference and in that, can include the complementary machines. According to the availability of the machine, the reference parts should be allotted.
- On the molding line however, the references are regularly made to operate on a particular machine until and unless there is an urgency that it cannot be produced on the particular machine with the exception being GF.

3.7 PRODUCT CLASSIFICATION SYSTEM

There is a lack of an active LMP which aides in working out the short and long term goals of the company. The primary step to achieve that is to classify and analyse the customers as well as the products to ascertain each reference position with respect to the machine utilization, standpoint of the department and its functions.

The company follows a policy of Make-to-Stock with advanced order information. This helps the plan maker in seeing an overall position to help determine possible future scenarios where there could be chances of stock out. Generally, there is no specified quantity which is maintained to prevent stock out. Since the customers are in a long term agreement, the company produces stock for a period of up to 2 months in case of low demand items and majorly follows a Make-to-Order scenario for High demand items. In reality, the company managers feel that it is not feasible to maintain a proper quantity in stock due to the fast movement of the product and the fluctuating nature of the market they are working in.

Currently the company has 329/386 items to be active from the time period of 2015 to the present. Among the 329, about 143 are being produced in Maia in the year 2018 and 149 in 2017.

Around 140 products are being produced almost monthly. The production planning is usually done in the value of multiples of 500 with the exception of the horizontal line as they have to produce very heavy products.

The current dispatching of products is being done from the on-hand inventory. While conducting the analysis of the warehouse whose information is used in production planning, it was found that some products being produced regularly have very low stock in the warehouse whereas some other products having an average demand, the stock levels are either high or non-existent and wait for production only when the

delivery schedule is released. In other words, the distribution of amount of products in the warehouse is random and completely depends upon the demand of products.

Currently, there exists no working criteria used for the classification of products according to importance. The allocation of parts on the molding line is decided by the category the part belongs to. But on the core machine, the parts can be interchangeable and is initially allotted a default machine with the possibility to produce it in other machines.

The classification could also help analyse the distribution of parts in the molding and core machines. It would make it easier to find which machine is being over burdened with a particular variety or type of product and distribute the parts evenly to ensure that all the machines are being used to the utmost capacity.

By establishing the connection, and analysing the previous production plans, it would be possible to create future plans keeping in account which are the orders which need to be continuously produced and those which can be stocked up. A safety stock level could be calculated for the higher priority items and maybe a weekly production plan where the division of items being produced satisfy the classification.

The first step in order to achieve that would be to establish a classification system that takes into account the various factors which affect the production plan and to form a connection between the weekly master plan and the daily production plan.

3.7.1 MULTI CRITERIA PRODUCT CLASSIFICATION PROPOSAL

There exists an ABC classification done by the Logistics department which consider the demand of the product with the number of working days to form the 80-20 rule. It was found that the ABC criteria was previously tried to control the production and the warehouse but failed.

Based on this information and studying the production planning process, a multi-criteria product classification system is suggested in order to work as a meeting point for the Logistics and the Production Planning departments with the objective to better coordinate the production process.

The classification will be done based on a 2 Step approach. Primarily, the AHP (Analytic Hierarchy Process) is done to calculate the weightage that needs to be given to a criteria and later, Ng model is applied to convert the values of the various criteria into a linear scale. AHP is chosen due to the flexibility it provides and helps take into consideration the qualitative and quantitative properties. It also gives the decision maker in having a say at what they think would be important given their experience and knowledge about the products. The literature review also suggests that it provides a better accuracy compared to the traditional ABC approach.

For the ease of classification, 4 factors are being considered for assigning the ranking. Considering more criteria would lead to a much bigger matrix and with the 4 criteria, (320×4) 1280 values are to be allotted to the products.

The factors being considered are: Demand, Core consumption, Weight and Added Value.

The Ng model is used since the values of the criteria chosen do not follow the same scale and some of them do not have any unit. In order to achieve this, a formula from the model is used so that all the criteria have a value in the same range and when used with the weightage obtained from the AHP model, it would be possible to get a better assessment.

3.7.2 DEMAND

The foremost concern is to make certain that all of the customer demands are satisfied by their standards. The whims of the customer are to be given top priority because without the customers, there would be no revenue being generated. Also by making sure that the customers are kept happy, it would help to develop better customer relationship.

By understanding the pattern of how the demand varies, it would be possible to create a safety stock and maintain a base inventory for the major customers and possibly in the future, an ATP could be registered for customers who sometimes request for the items to be delivered earlier than schedule. The major reason for this being that the orders received by the company depend on the forecast of the customer. If there is a change in forecast, i.e., if they predict a surge during a particular period and the company cannot cater to the demand, it leads to a loss of sales which has a negative impact throughout the departments.

Since the type of demands varies, it would be easier to segregate the orders and establish a rule defining the parts which could be categorized as make-to-stock and the rest make-to-order.

The demand plays the most important criteria compared to the other factors while computing the weights to be assigned for the classification of products.

3.7.3 CORE CONSUMPTION

As previously discussed above, nearly 70% of the parts being produced work with cores which are being produced in-house with approx. 5% being sub-contracted from an outside supplier. The sub-contracted cores all being used for producing parts in the GF line since they are very large and hard to produce.

This number has been increasing year by year with the addition of new products as was found out during the stay at the company. During the starting years of the

company, about 40% or even lesser number of parts were being produced with the requirement of cores. This is a huge increase compared to the present production.

The core shop constitutes the bottleneck in the production as its production time of cores is comparatively slow compared to the molding line due to its constraints of having to pressurise and compact the sand which generally takes a longer duration compared to the molding line. Also, it requires a resting period for it to harden before it can be used in the molding line as the brittleness can lead to crumbling inside the mold on pouring the hot melt which can cause defects in the parts.

It was also noticed that the core shop often worked for 6 days per week to meet the production schedule of the molds. By understanding the core consumption with respect to the demand, it would be possible to analyse the production vs consumption of the parts with respect to time so as to make better plans and/or relocate the parts to the core machines so as to ensure that all the machines work with almost the same utilisation and reduce the over-burden of any particular machine if found.

A calculation is carried out to understand how the cores are being consumed. The major factors taken into consideration include the cycle of the molding line as well as the core shop with the no of pieces obtained as output. Essentially, everything is converted w.r.t core cycle time as it is much longer. The number of parts which would be obtained in the molding line with the core cycle time is compared and a ratio of cores consumed with the cores obtained is done (see Equation 5 and Equation 6).

$$\text{Core consumption} = \frac{\text{Core Cycle Time}}{\text{Mold Cycle Time}} * \text{No. pieces obtained per mold}$$

Equation 5

By understanding how the different references are consuming the cores, the plans can be improved by regulating as well as choosing the parts which need to be produced at a certain time and avoid having the situation where all the parts with high core consumption are being produced at the same time frame.

$$\text{Ratio of core consumption} = \frac{\text{Core Consumed}}{\text{TimeCore produced}}$$

Equation 6

Hence, this takes the next higher priority while assigning values for AHP calculation.

3.7.4 WEIGHT

One of the goals of the classification system is to establish a common ground between the Logistics and the Production control. The above two factors define the goals of the Logistics department.

The main goal of the Production control is to make a daily production plan taking the weekly plan into account and to produce parts which would totally yield about 360 tons of useful melt per day.

While the Logistics department is concerned with keeping the customers happy, the Production control ensures the maximum utilisation of the machines and especially the furnaces.

The furnaces yield about 760 tons per day of melt, in this about 50% goes to the scrap due to the runners and gates which are included in the design of the mold pattern. Some of the metal may also go to the scrap if it does not comply with the chemical property requirements. They make the daily plan so as to reduce the quantity of melt going to scrap and also to keep the furnace in working condition. It is to be noted that the scrap iron is repurposed for the production again, but it leads to a loss of energy and time.

Despite the percentage of error already being included in the weekly production plan, there arises a few situations where a particular product is being produced in a much larger amount compared to the others in order to meet the daily goal. The vice versa is also true where some parts are usually pushed to the last possible minute since it clashes with their objective. This sometimes leads to a friction with the two departments.

This takes the next level of priority among the factors.

3.7.5 ADDED VALUE

The added value activities include the machining and the painting operations. These activities being done in-house increases the value of the product. By conducting these operations within the same facility, the customer has the option of cutting down the excess cost by reducing the necessity of going to a separate vendor for these operations which in turn gets the company more profit.

The painting operation started being carried out in the year 2014 and the machining since 2017. Since these operations need an additional time, it is required for them to be produced well in advance. Also, due to the painting operation, they can be stored for a longer duration without the problem of having rusty parts.

This takes the least priority as not many products are currently working with these operations.

3.8 CLASSIFICATION SYSTEM- APPLICATION CASE

There are two phases of operations that need to be carried out for assigning the category to which the system belongs. The primary phase is to calculate the criteria weights using AHP after which is the secondary phase where the values of each criteria associated with each reference is converted into a linear scale using the Ng model. The scores are multiplied with the corresponding criteria weights and summed to get the overall weighted sum. This is then arranged in descending order with the 20% of total working products to be assigned 'A', the bottom 50% being the 'C' and the remaining to be 'B'.

3.8.1 PHASE 1 - ANALYTICAL HIERARCHY PROCESS (AHP)

The priority of factors is Demand > Core Consumption > Weight > Added Values. Keeping this priority in mind, a pairwise square matrix A $m \times m$ is formed where m denotes the number of criteria considered with the values in the matrix a_{jk} . The values are assigned on the basis of the importance of criteria j against criteria k and the values ranging from 1 – 9 where 1 denoting that both the criteria are equally important to a 9 where j is absolutely more important than k . Also,

$$a_{jk} * a_{kj} = 1$$

Equation 7 (Saaty, 1980)

The normalised pairwise matrix A_{norm} is formed so that the sum of each column tallies to a value of 1. This is done by obtaining the values \bar{a}_{jk} of A_{norm} using the formula present in Equation 8.

$$\bar{a}_{jk} = \frac{a_{jk}}{\sum_{j=1}^m a_{jk}}$$

Equation 8(Saaty, 1980)

On obtaining the A_{norm} , the criteria weight vector w is computed by averaging the values of the row ,i.e.,(see Equation 9)

$$w_j = \frac{\sum_{j=1}^m \bar{a}_{jk}}{m}$$

Equation 9 (Saaty, 1980)

The criteria weights that was obtained for the factors considered with the relative importance is shown in Table 2:

Table 2 - Score of Criteria Weights in percentage

| Criteria | Criteria Weight (%) |
|------------------|---------------------|
| Demand | 52.96 |
| Weight | 12.65 |
| Core consumption | 29.13 |
| Added Value | 5.26 |

It is necessary to check for consistency in the pairwise comparison matrix as there may arise some inconsistencies while assigning the values. The Consistency Index (CI) for the obtained matrix is computed and compared with the Random Index (RI). It is considered to be consistent if the ratio of the values falls below 10% error. The RI value is taken from a readily available Table 3 (Saaty, 1980).

Table 3 - Values of Random Index (RI) for small problems

| | | | | | | | | | |
|-----------|---|------|------|------|------|------|------|------|------|
| <i>m</i> | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| <i>RI</i> | 0 | 0.58 | 0.90 | 1.12 | 1.24 | 1.32 | 1.41 | 1.45 | 1.51 |

The CI value obtained from the resulting pairwise matrix is 0.04719. Since 4 criteria are taken into consideration, the *m* is taken to be 4 and the RI is 0.9 (See Equation 10)

$$\text{Consistency} = \frac{CI}{mRI} = \frac{0,04719}{0,9} = 0,0524$$

Equation 10

Since the value is less than 0.1, the matrix is said to be consistent.

The next part is the tabulation of the score. In the AHP method, a score matrix is formed which is a pairwise comparison matrix allotting scores to each of the criteria selected with the relative importance of one factor against the other for the references individually and the similar calculations are carried out to find the total score.

Due to large number of references, which are present in the current study, it would consume a lot of time in forming and tabulating the score matrix. Also, the accuracy of the formed matrix depends on the expertise with which the importance are marked for each of the reference. Hence, a different model is adopted for the computation of the score.

3.8.2 PHASE 2 - RANKING SYSTEM

The step entails calculating the scores for each of the criteria. The demand values for a period of 8 months is obtained from the rolling forecast for the present year, as well as the weight of each part, the core consumption and the added value activities like painting and machining were collected and computed.

Since the values of the criteria are in different ranges, i.e., the demand is in a multiple of 1000s while the weight is a unit of kgs. Since they don't follow a uniform scale pattern, it is necessary to convert them into one and for this, the linear transformation from the Ng model (Ng, 2007) is used.

The percentage contribution of each of the criteria is calculated for each reference that is actively working and have a demand in the current working year. Taking the individual contribution and using the transformation formula for scaling from the Ng model, the score/ scale factor is calculated, i.e.;

$$\text{scale factor} = \frac{y_{ij} - \min(y_{ij})}{\max(y_{ij}) - \min(y_{ij})}$$

Equation 11

Where y-percentage contribution of reference:

- i-reference number (i=1,2,3,.....,n)
- j-criteria(j=1,2,3,4)

The value of the scale factor is in the range from 0-1. The obtained scale factor is multiplied with the matching criteria weight and these values are summed for the particular reference to get the weighted sum.

$$\text{weighted sum} = \sum (\text{scale factor} * w_j)$$

Equation 12

Where i- reference number (i=1,2,3,.....,n)

- w- criteria weight
- j- criteria (j=1,2,3,4)

In the Ng model, the weights are not calculated. It differs from AHP model in the sense that while AHP is exogenous since the weights are computed externally and the value of the weights remain the same for all the parts. In the Ng model, the weights are computed endogenously while forming the normalised linear score.

The weighted sum is then arranged in descending order and the top 20% of the total working references are allotted 'A', the bottom 50% constitute 'C' and the remaining as 'B'.

| Reference | % demand distribution | Scale factor 1 | % weight distribution | Scale factor 2 | % Added value | Scale factor 3 | % core consumption | Scale factor 4 | Weighted Sum (%) | Classification |
|-----------|-----------------------|----------------|-----------------------|----------------|---------------|----------------|--------------------|----------------|------------------|----------------|
| 3281 | 15.19 | 1.00 | 0.13 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 53.32 | A |
| 4355 | 4.21 | 0.28 | 0.16 | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 | 15.12 | A |
| 4353 | 3.93 | 0.26 | 0.28 | 0.06 | 0.00 | 0.00 | 0.61 | 0.22 | 20.93 | A |
| 4354 | 3.92 | 0.26 | 0.28 | 0.06 | 0.00 | 0.00 | 0.61 | 0.22 | 20.91 | A |
| 3282 | 3.57 | 0.24 | 0.13 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 12.81 | B |
| 4295 | 3.29 | 0.22 | 0.27 | 0.06 | 0.00 | 0.00 | 0.31 | 0.11 | 15.50 | A |
| 4296 | 3.28 | 0.22 | 0.27 | 0.06 | 0.00 | 0.00 | 0.31 | 0.11 | 15.48 | A |
| 3481 | 2.54 | 0.17 | 0.21 | 0.05 | 0.00 | 0.00 | 1.08 | 0.39 | 20.88 | A |
| 3491 | 2.32 | 0.15 | 0.45 | 0.10 | 2.94 | 1.00 | 0.77 | 0.28 | 22.73 | A |
| 4290 | 2.19 | 0.14 | 0.30 | 0.07 | 0.00 | 0.00 | 0.46 | 0.17 | 13.31 | B |
| 4289 | 2.18 | 0.14 | 0.30 | 0.07 | 0.00 | 0.00 | 0.46 | 0.17 | 13.28 | B |
| 4240 | 2.06 | 0.14 | 0.25 | 0.06 | 0.00 | 0.00 | 0.00 | 0.00 | 7.90 | C |
| 4303 | 1.91 | 0.13 | 0.13 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 7.00 | C |
| 4368 | 1.42 | 0.09 | 0.30 | 0.07 | 0.00 | 0.00 | 0.36 | 0.13 | 9.62 | B |
| 4367 | 1.41 | 0.09 | 0.30 | 0.07 | 0.00 | 0.00 | 0.38 | 0.14 | 9.80 | B |

Figure 30: Application example of the ranking system

3.9 CLASSIFICATION SYSTEM RESULTS

The new classification system obtained shows a very large variation when compared to the previously adopted system of using primarily only demand as a factor.

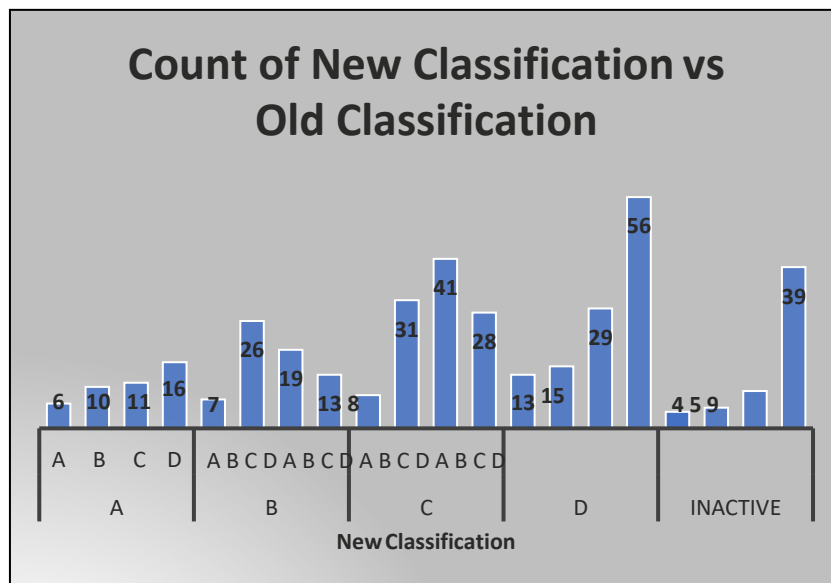


Figure 31: Change of classes of references when compared to the old classification system

From the classification system results, it was observed that some references despite having higher demand was not placed in “A” since they ranked lower in other factors which also contribute to the classification system. Also, it was noticed that a majority of the components working without cores were placed in the “C” category due to the relative ease of production. A 4th class “D” was formed for the components which are not active but can still come into production albeit in small quantities as “after market” sales. The category “A” consists of all the references with the highest scaling factor with respect to the criteria.

3.10 PROJECT OUTCOMES

From the new classification system, the distribution of the classes among the machines is shown in Figure 32.

From the Figure 32 chart, it can be noticed that MK5 has the majority of the references allotted to it. The “A” class references are divided almost equally among the machines working at Sakthi SA with the exception of 230P. Also, it is to be noticed that MK5 has the largest number of working references whereas 230P has the least. The machine 230P works almost exclusively with “B” and “C” products. The machine MK5 has the highest number of “C” class which majorly deal with a mix of components with small quantities as well as “after sales” products.

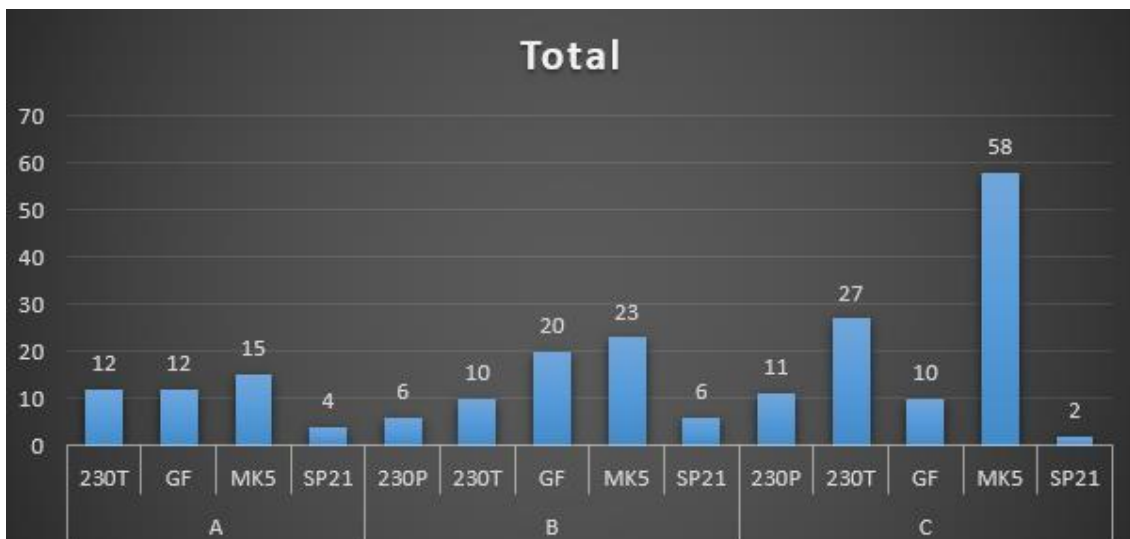


Figure 32: Distribution of references among the references

The planned production distribution of the parts with respect to the classification for the time period from Jan 2018 to July 2018 was done to analyse the pattern. The Figure 33 shows the distribution pattern.

From Figure 33, it is to be noted that a cyclical pattern can be noticed in the production plan. The problem arises when there is an increase in the “B” and “C” classes. This is due to the factor of uneven production time between the molding

machines and the core machines for the quantity of products to be produced. This can be noticed in the time period between 8- 12 weeks. An increase in the number of certain references can cause a downtime in the molding machines due to the unavailability of cores which is needed for production in the molding line.

One way to manage this would be fix the number of moldings per week of class “A” products, i.e., to follow a Make-to-Stock approach for “A” components. This way, even if there is an increase in all types of products, there is already an amount of “A” products available beforehand and with this, even if more “A” products are needed, it can be dealt with due to the fact that more of these products were produced in the period that their demand was low. This opens the option of focusing more on “B” and “C” products. It would be wise to follow a Make-to-Order approach for the “C” class products since the demand is low and it is harder to predict when they would come into production again. Producing a large amount of “C” products than the demand would take up space in the inventory without knowing the quantity that would be needed in the future. Also, in order to store these products, special care needs to be taken so that the products do not degrade over time. The “A” class products are fairly easier to predict since they are in constant production and also, the number of references which belong to this is lesser.

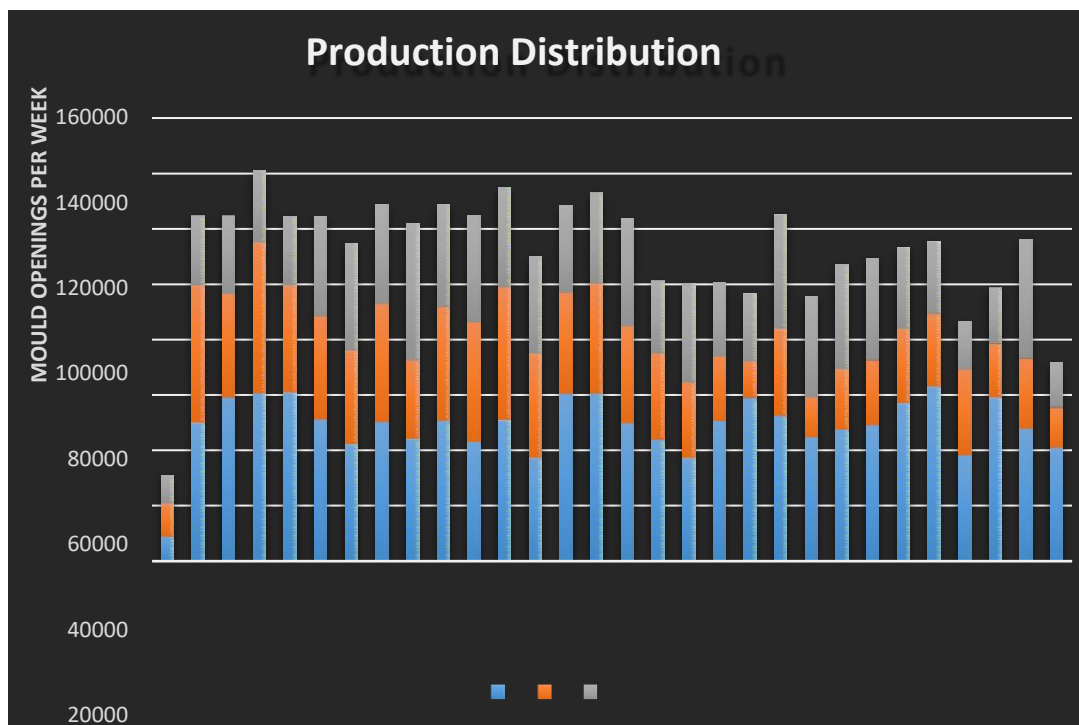


Figure 33: Production Distribution

CONCLUSIONS AND FUTURE WORK

4.1 CONCLUSIONS

4.2 PROPOSALS OF FUTURE WORKS

4 CONCLUSION AND FUTURE WORK

The present chapter presents the final comments and conclusions regarding the work project. Also includes future works proposals.

4.1 CONCLUSIONS

The work presented describes the framework of production planning within the company Sakthi SA. The study was done to understand the factors that come into play while making a weekly production. This was carried out to describe the inputs and constraints that need to be included in the development of an Integrated System.

A lot of time and labour is employed in manually entering and fact checking the data. The data has been spread over multiple files, due to this, an Integrated System is required. This helps in reducing the time spent on copying data and gives more time to focus on the other functions of the Logistics department as well as the Production plan. It can also help to reduce the human error that could happen while shifting the data from one platform to the other. The main purpose of the Integrated System is to have a relative ease of access in gathering data from various sources and also, to monitor the activities within the facility.

Also, during the course of the work, it was noticed that there was a lack of an active product classification. A classification system is proposed with regards to factors that are considered in the production. The classification is done to understand how the factors that come into play are spread over the allocation of molding machines. It also aides in understanding how the different classes are being produced through the course of the period. The classification system can help to organise the products in a simpler manner and it could enable the operator to focus on improving each category rather than to direct the entire attention towards one particular product which would consume a lot of time and effort due to the vast number of products.

4.2 PROPOSALS OF FUTURE WORKS

There has not been enough attention given to how to varying amounts of production affect the core production. The amount of time that is taken for producing the cores that is required for the molding production could also be considered as a factor for the production and an analysis regarding the feasibility and improvements that could be performed can be made.

The Integrated System could also include an alert for the personnel regarding the most urgent requirement and/or suggest products which are a bit hard to produce/ face difficulties from either a list of parts that is made after discussion with the various concerned departments or from the number of incidences that a particular part was held back because of problems in the part that might have occurred along the production line due to some complications. This ensures that there is enough buffer time to respond in case a problem arises.

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ANNEXES

ANNEXES

ANNEX A

| Demand Consumption | | Weight | Core | Added Value |
|--------------------|-----|--------|------|-------------|
| Demand | 1 | 4 | 3 | 7 |
| Weight | 1/4 | 1 | 1/3 | 3 |
| Core consumption | 1/3 | 3 | 1 | 7 |
| Added Value | 1/7 | 1/3 | 1/7 | 1 |

Pairwise comparison matrix following AHP model