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Continuous Improvement of Overall Equipment Effectiveness in Production unit of Automotive Industry

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CONTINUOUS IMPROVEMENT OF OVERALL EQUIPMENT EFFECTIVENESS IN PRODUCTION UNIT OF AUTOMOTIVE INDUSTRY

Vishad Viralbhai Vyas

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ISEP – School of Engineering
Department of Mechanical Engineering

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KEYWORDS

Overall Equipment Effectiveness, Unified Modelling Language, PDCA Cycle, Key Performance Indicators

ABSTRACT

With industrial revolution and growing competition in the production area specially in the automotive industry, focus shifted towards efficiency of the production area. The goal was to make the production area more efficient which includes the machine, work force etc. For the production unit to be efficient it is very important that machines work efficiently without stopping.

In order for the machine to work without stopping it needs to have a continuous supply of the raw material and the packaging material. But as it is automotive industry there is various kind of raw material and packaging material, so it is very important to understand, measure and plan the requirements accordingly.

The problem faced in improving the Overall equipment effectiveness was the machine has to stop multiple times because of the lack of raw material and packaging material which result into poor OEE of the production unit.

In this report, it is focused on increasing the overall equipment effectiveness of the plastic injection production unit of the automotive industry by first understanding the main activities and actors in the production unit by using Unified Modelling Language.

After understanding the main activities and the flow of activities the requirements of the machine is measured based on the production plan received from planning department. The logistic plan is been developed focused on the needs of the machine (Raw material and packaging material). The hours of work is been described so based on the cycle time the quantity to be produced, quantity and type of the raw material and packaging material is been calculated and forwarded to the production logistics so that based on that plan they can arrange the supply to the machine. Plan Do Check Act methodology is been used in implementing the logistics supply plan.

As a result of this plan it can be seen the drastic change in the increase of the Overall equipment effectiveness. The OEE is been measured without the supply plan which resulted into 70,27% after implementation of the supply plan there is a big increase in the OEE of the same production area of 82,34%, so there can be clearly seen the increase of 12,07% in OEE by just implementing the logistic plan. Thus, this report helps to understand the importance of logistic supply plan and UML in order to increase the Overall equipment effectiveness of the production area.

PALAVRAS CHAVE

Overall Equipment Effectiveness, Unified Modelling Language, PDCA Cycle, Key Performance Indicators

RESUMO

Com a revolução industrial e a crescente concorrência na área de produção, especialmente na indústria automotiva, o foco passou para a eficiência da área de produção. O objetivo era tornar a área de produção mais eficiente, incluindo máquina, força de trabalho etc. Para que a unidade de produção seja eficiente, é muito importante que as máquinas trabalhem eficientemente sem parar.

Para que a máquina funcione sem parar, ela precisa ter um fornecimento contínuo de matéria-prima e material de embalagem. Mas, como é a indústria automotiva, existem vários tipos de matérias-primas e materiais de embalagem, portanto é muito importante entender, medir e planejar os requisitos de acordo.

O problema enfrentado na melhoria da eficácia geral do equipamento foi o fato de a máquina ter que parar várias vezes, devido à falta de matéria-prima e material de embalagem, o que resulta em OEE insuficiente da unidade de produção.

Neste relatório, ele se concentra em aumentar a efetividade geral do equipamento da unidade de produção de injeção plástica da indústria automotiva, entendendo primeiro as principais atividades e atores da unidade de produção usando a Linguagem de Modelagem Unificada.

Depois de entender as principais atividades e o fluxo de atividades, os requisitos da máquina são medidos com base no plano de produção recebido do departamento de planejamento. O plano logístico é desenvolvido com foco nas necessidades da máquina (matéria-prima e material de embalagem). As horas de trabalho são descritas de modo que, com base no tempo de ciclo, a quantidade a ser produzida, a quantidade e o tipo de matéria-prima e material de embalagem sejam calculados e encaminhados para a logística de produção, para que, com base nesse plano, eles possam providenciar o fornecimento. a máquina. A metodologia Plan Do Check Act é usada na implementação do plano de fornecimento logístico.

Como resultado deste plano, pode-se observar uma mudança drástica no aumento da eficácia geral do equipamento. O OEE é medido sem o plano de suprimento, que resultou em 70,27%. Após a implementação do plano de suprimento, ocorre um grande aumento no OEE da mesma área de produção de 82,34%, de modo que se pode ver claramente o aumento de 12,07% no OEE, apenas implementando o plano logístico. Portanto, este relatório ajuda a entender a importância do plano de suprimento logístico e da UML para aumentar a eficácia geral do equipamento da área de produção.

LIST OF SYMBOLS AND ABBREVIATIONS

List of abbreviations

KPI	Key Performance Indicator
PDCA	Plan Develop Check Act
OEE	Overall Equipment Effectiveness
UML	Unified Modelling Language

List of units

Kg	Kilogram

GLOSSARY OF TERMS

Automotive Industry	Companies and organizations involved in the design, development, manufacturing, marketing, and selling of motor vehicles
Effectiveness	Effectiveness is the capability of producing a desired result or the ability to produce desired output.
Equipment	Refers to a set of tools or other objects commonly used to achieve a particular objective
Efficiency	Efficiency is the (often measurable) ability to avoid wasting materials, energy, efforts, money, and time in doing something or in producing a desired result

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INTRODUCTION

1 INTRODUCTION

1.1 Context

World is growing at a rapid pace and so is the manufacturing sector. Manufacturing sector now accounts for 16 percent of global GDP and 14 percent of employment. So with this rapid growth obviously we can see the competition that is been prevailing inside the manufacturing Sector. With rise in this competition, there was a race to offer Quality product in an affordable rate.

Post-World War II the manufacturing sectors including the Automotive industry started seeing the rapid changes with lot of new concepts pouring. Focus suddenly changed in increasing the efficiency of the manufacturing unit with different concepts, as it was quite clear by that time that working on overall efficiency could play a major role.

Preh GMBH, a German Automotive industry in which this work is been performed with a focus to increase the overall efficiency of the production unit

1.2 Objectives

The problem to be solved is to ensure the supply the required amount of raw material and packaging material. The production plan is been obtained from the planning department, following that production plan which has to be implemented the following day. The required amount of raw material and packaging material is been checked and supply plan is been prepared by the logistics team.

The main goal of this report is to provide inside of the approach with solutions of increasing the Overall equipment effectiveness of the production unit. There are different KPI´s affecting the overall efficiency, considering some we will be focusing to improve the overall equipment effectiveness of the production unit.

The aim of this report is to ensure that production plan doesn’t fail and the supply of required material is been ensured. At the start the overall equipment effectiveness was about 70,27%, after implementation the comparison will be done to check the change in the OEE.

1.3 Methodology

After receiving the production plan the calculations for the requirement is been made, the methodology used behind the solving the problem is PDCA and Use Business Modelling Methodology.

PDCA (Plan-Do-Check-Act):

Plan: To Establish objectives and processes required to deliver the desired results

Do: The do phase allows the plan from the previous step to be done. Small changes are usually tested, and data is gathered to see how effective the change is.

Check: During the check phase, the data and results gathered from the do phase are evaluated. Data is compared to the expected outcomes to see any similarities and differences. The testing process is also evaluated to see if there were any changes from the original test created during the planning phase. If the data is placed in a chart it can make it easier to see any trends if the PDCA cycle is conducted multiple times. This helps to see what changes work better than others, and if said changes can be improved as well.

Act: Also called "Adjust", this act phase is where a process is improved. Records from the "do" and "check" phases help identify issues with the process. These issues may include problems, non-conformities, opportunities for improvement, inefficiencies and other issues that result in outcomes that are evidently less-than-optimal. Root causes of such issues are investigated, found and eliminated by modifying the process. Risk is re-evaluated. At the end of the actions in this phase, the process has better instructions, standards or goals. Planning for the next cycle can proceed with a better base-line. Work in the next do phase should not create recurrence of the identified issues; if it does, then the action was not effective.

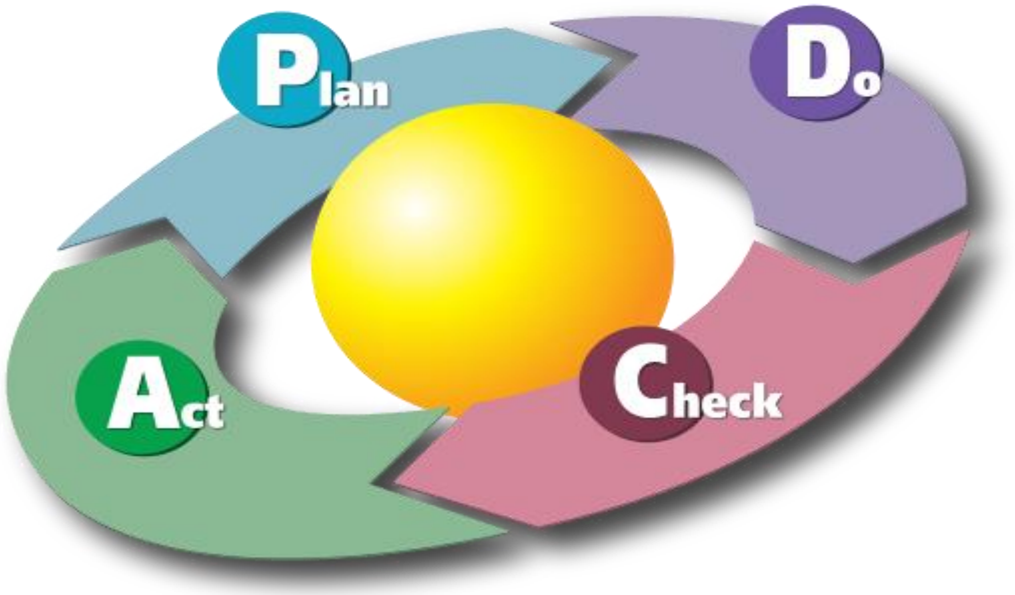

Figure 1 Plan Do Check Act (PDCA cycle)

Business Modelling Methodology: A use case is a methodology used in system analysis to identify, clarify, and organize system requirements. The use case is made up of a set of possible sequences of interactions between systems and users in a particular environment and related to a particular goal.

Unified Modelling Language (UML):

The Unified Modelling Language (UML) is a general-purpose, developmental, language in the field of software engineering that is intended to provide a standard way to visualize the design of a system.

The main purpose to use Unified Modelling language is to understand the activities that is been performed in our system of production unit. With the use of UML it can be identified the main actors that are acting in the production area. As there is presence of lot of machine in the production unit UML can be helpful to understand the requirement of each machine along with each part that is been produced as each part has their own requirement of raw material and packaging material.

The creation of UML was originally motivated by the desire to standardize the disparate notational systems and approaches to software design. It was developed by Grady Booch, Ivar Jacobson and James Rumbaugh at Rational Software in 1994–1995, with further development led by them through 1996.

In 1997 UML was adopted as a standard by the Object Management Group (OMG), and has been managed by this organization ever since. In 2005 UML was also published by the International Organization for Standardization (ISO) as an approved ISO standard. Since then the standard has been periodically revised to cover the latest revision of UML.

UML offers a way to visualize a system's architectural blueprints in a diagram, including elements such as:

- any activities (jobs);
- individual components of the system;
- and how they can interact with other software components;
- how the system will run;
- how entities interact with others (components and interfaces);
- external user interface.

Although originally intended for object-oriented design documentation, UML has been extended to a larger set of design documentation (as listed above), and been found useful in many contexts

UML is not a development method by itself; however, it was designed to be compatible with the leading object-oriented software development methods of its time, for example OMT, Booch method, Objector and especially RUP that it was originally intended to be used with when work began at Rational Software.

It is important to distinguish between the UML model and the set of diagrams of a system. A diagram is a partial graphic representation of a system's model. The set of diagrams need not completely cover the model and deleting a diagram does not change the model. The model may also contain documentation that drives the model elements and diagrams (such as written use cases).

UML Diagrams:

Use Case diagram- serves to identify the boundaries of the system and describe the services (use cases) that should be made available to each of the different users (actors).

Class Diagram -through which we describe the information structure (classes and their relations) that is used in the system.

Object Diagram- which can be used to illustrate a class diagram with a concrete example.

Sequence Diagram and Collaboration Diagram- serves to illustrate how system objects interact to provide the functionality of the use case. These diagrams are generally referred to as Interaction Diagrams

Activity Diagram- can be used to describe each of the use cases, highlighting the chaining of activities performed by each of the objects of the system, in a work-flow perspective.

State diagram- which is used to model the behaviour of objects i.e. describe changes in attribute values of objects as a result of the occurrence of certain events.

Component Diagram- used to describe the architecture of the software application in terms of software components.

Deployment Diagram- allows to describe the architecture of computer equipment used and distribution of the components of the application by the elements of the architecture

Use Cases:

The use cases, constitute the technique in UMI, to represent the survey of requirements of a system. The correct lifting of requirements in the development of information systems tries to ensure that the system will be useful to the end user, according to their needs.

The requirement in a system is a feature or characteristic considered relevant from the user's perspective. Usually, it represents the expected behaviour of the system, which in practice consists of a service that must be made available to a user.

Requirements are categorized in three types:

Functional requirements - describe what a system does or is expected to do. These are the requirements that will first be initially collected, covering the description of the processes to be performed by the system, inputs and outputs on paper or screen information that derive from interaction with people and other systems.

Non-functional requirements - related to the qualitative characteristics of the system, describing the quality with which the system should provide the functional requirements. It covers performance measures such as response times, data volume, or security considerations.

Usability - ensure that there is a good connection between the system developed, users of the system and also the tasks they perform using the system.

1.4 Work Summary

In Chapter 2, a literature review is made on the methodologies which include Lean Management. A study is made on the concept of production planning along with that KPI´S (Key performance indicator) including OEE (Overall equipment efficiency) is also been focused on.

In chapter 3, a elaborated problem is been explained starting with introduction to company where this problem has been solved, analysis has been done considering the UML (Unified modelling language) , strategy to solve the problem, improvement and results have been discussed.

In chapter 4, the conclusions and further work of this project is been discussed.

BIBLIOGRAPHIC WORK

2 BIBLIOGRAPHIC WORK

In this chapter literature review is been made starting with the same general information followed by the Lean methodology. After Lean methodology the focus is on Production Planning functions and then on Key Performance indicators which brings to the most important KPI that we want to improve i.e Overall Equipment Effectiveness.

2.1 General Information

With evolution of the production industry and its rapid growth, it resulted into the different concepts of improvement. Many concepts evolved in order to increase the productivity of the production unit. When there is a talk about increasing the productivity, it is either increasing the efficiency of the machines, man power or removing the unnecessary things (waste) which doesn’t add the value to the production. As there are different concepts and this report is focused on increasing the overall equipment efficiency below is some glance on the concepts that will be useful for the same.

2.2 Lean Management

Definition: Lean management refers to a technique developed with the aim of minimising the process waste and maximising the value of the product or service to the customer, without compromising the quality. It is coined by Toyota Production System, which is a part of lean thinking (John Krafcik, 1988)

Lean is possible through distinct techniques such as flow charts, just in time, total quality management, workplace redesigning, and total productive maintenance. It focuses on delivering value to customers. A number of tools are deployed by the lean management system to link customer value to the process and people.

It is a systematic method originating in the Japanese manufacturing industry for the minimization of waste (muda) within a manufacturing system without sacrificing productivity, which can cause problems. Lean also takes into account waste created through overburden (muri) and unevenness in workloads (mura). Working from the perspective of the client who consumes a product or service, “value” is any action or process that a customer would be willing to pay for.

Lean manufacturing attempts to make obvious what adds value, through reducing everything else (because it is not adding value). This management philosophy is derived mostly from the Toyota Production System (TPS) and identified as “lean” only in the

1990s.TPS is renowned for its focus on reduction of the original Toyota seven wastes to improve overall customer value, but there are varying perspectives on how this is best achieved. The steady growth of Toyota, from a small company to the world's largest automaker, has focused attention on how it has achieved this success.

There is a second approach to lean manufacturing, which is promoted by Toyota, called The Toyato Way, in which the focus is upon improving the "flow" or smoothness of work, thereby steadily eliminating mura ("unevenness") through the system and not upon 'waste reduction' . Techniques to improve flow include production levelling "pull" production (by means of kanban) and the Heijunka Box. This is a fundamentally different approach from most improvement methodologies, and requires considerably more persistence than basic application of the tools, which may partially account for its lack of popularity.

The difference between these two approaches is not the goal itself, but rather the prime approach to achieving it. The implementation of smooth flow exposes quality problems that already existed, and thus waste reduction naturally happens as a consequence. The advantage claimed for this approach is that it naturally takes a system-wide perspective, whereas a waste focus sometimes wrongly assumes this perspective.

Both lean and TPS can be seen as a loosely connected set of potentially competing principles whose goal is cost reduction by the elimination of waste. These principles include: pull processing, perfect first-time quality, waste minimization, continuous improvement, flexibility, building and maintaining a long-term relationship with suppliers, load levelling and production flow and visual control. The disconnected nature of some of these principles perhaps springs from the fact that the TPS has grown pragmatically since 1948 as it responded to the problems it saw within its own production facilities. Thus, what one sees today is the result of a 'need' driven learning to improve where each step has built on previous ideas and not something based upon a theoretical framework.

Lean implementation emphasizes the importance of optimizing work flow through strategic operational procedures while minimizing waste and being adaptable. Flexibility is required to allow production levelling (Heijunka) using tools such as SMED, but have their analogues in other processes such as research and development (R&D). However, adaptability is often constrained, and therefore may not require significant investment. More importantly, all of these concepts have to be acknowledged by employees who develop the products and initiate processes that deliver value. The cultural and managerial aspects of lean are arguably more important than the actual tools or methodologies of production itself. There are many examples of lean tool implementation without sustained benefit, and these are often blamed on weak understanding of lean throughout the whole organization.

However, as Toyota veterans eventually wrote down the basic principles of TPS

Continuous Improvement breaks down into three basic principles:

Challenge: Having a long-term vision of the challenges one needs to face to realize one's ambition (what we need to learn rather than what we want to do and then having the spirit to face that challenge). To do so, we have to challenge ourselves every day to see if we are achieving our goals.

Kaizen: Good enough never is, no process can ever be thought perfect, so operations must be improved continuously, striving for innovation and evolution.

Genchi Genbutsu: Going to the source to see the facts for oneself and make the right decisions, create consensus, and make sure goals are attained at the best possible speed.

Principles of Lean:

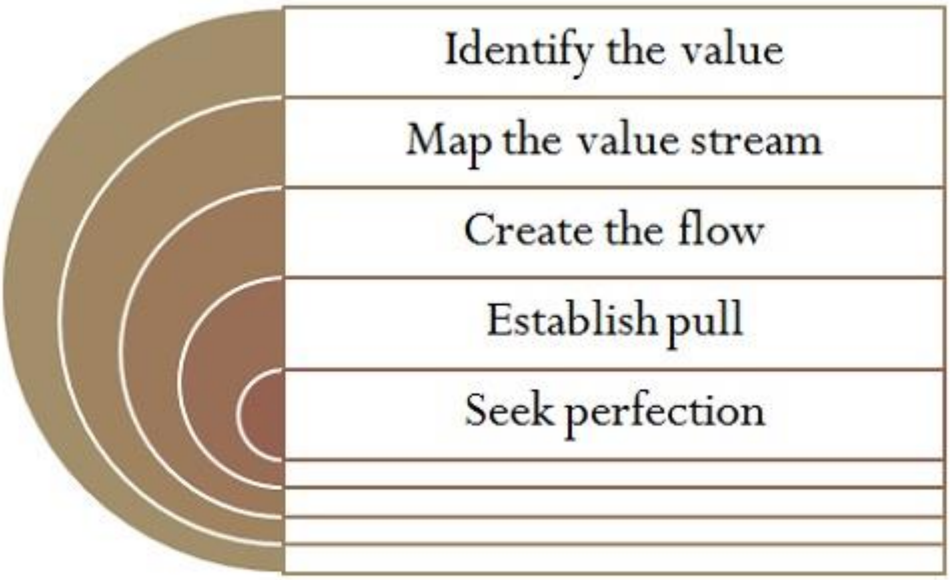

Figure 2 Principles of Lean Methodology

Accodring to (James Womack & Daniel Jones, 1997):
Identify value: The value must be ascertained from the point of view of the ultimate customer by product family.

Map the value stream: Ascertain all the steps involved in the value stream for each product family and then eliminating those steps that are not productive.

Create the flow: Ensure that the steps which create value take place in a perfect sequence, so the product reaches the customer smoothly.

Establish Pull: Once the flow is initiated, customers pull value from the next level activity.

Seek Perfection: When the value is specified, value streams are ascertained, non-productive steps are eliminated, and flow and pull are instigated. The process is started again and continue, till the perfection state is arrived, in which the perfect value is created with no waste.

Single Piece Flow is an ideal state of operation that replaces the batch sizes and lost production with working on one product at a time. Lean Manufacturing System aims at implementing one-piece flow in every operation possible. It can be achieved by eliminating the wastes such as overproduction, space, defects, unnecessary human motion, inventory, labour and so on.

Stakeholders of Lean Management:

Figure 3 Stakeholders of Lean Management

Customers: For a firm, nothing can give more satisfaction than seeing your customers delighted, which can be due to the satisfaction they derive from the product or the customer service. To achieve this the issues and concerns of the customers are addressed first.

Employees: Employees are the rank and file of the organisation, who are the most valuable asset of the organisation. When the employee is happy, he/she will also work for the organisation with great enthusiasm and efficiency that will help in making the organisation the best of its kind.

Organisation: Organisation includes board members, the Chief Executive Officer, and the business owners. Add to that; it covers the policies, programmes and procedures and another implementation. A well-managed and balanced organisation is capable of fulfilling customers' requirements.

Lean management is philosophy, which intends to continuously eliminate the waste, in all the processes, through small and incremental improvement. It improves quality and reduces defects, as well as enhances the overall manufacturing flexibility. However, at times, it encounters certain limitations such as low productivity, prolonged cycle time, costly organisation, etc.

2.3 Production Planning Functions

Production planning is the planning of production and manufacturing modules in a company or industry. It utilizes the resource allocation of activities of employees, materials and production capacity, in order to serve different customers.

Different types of production methods, such as single item manufacturing, batch production, mass production, continuous production etc. have their own type of production planning. Production planning can be combined with production control into production planning and control, or it can be combined with enterprise resource planning.

Production planning is the future of production. It can help in efficient manufacturing or setting up of a production site by facilitating required needs.

A production plan is made periodically for a specific time period, called the planning horizon. It can comprise the following activities (S Chand, 2006):

Determination of the required product mix and factory load to satisfy customer's needs.

Matching the required level of production to the existing resources.

Scheduling and choosing the actual work to be started in the manufacturing facility"
Setting up and delivering production orders to production facilities.

In order to develop production plans, the production planner or production planning department needs to work closely together with the marketing department and sales department. They can provide sales forecasts, or a listing of customer orders."

The "work is usually selected from a variety of product types which may require different resources and serve different customers. Therefore, the selection must optimize customer-independent performance measures such as cycle time and customer-dependent performance measures such as on-time delivery."

A critical factor in production planning is "the accurate estimation of the productive capacity of available resources, yet this is one of the most difficult tasks to perform well".

Production planning should always take "into account material availability, resource availability and knowledge of future demand".

2.4 Key Performance Indicators

Accodring to (Carol Taylor, 1990) A performance indicator or key performance indicator (KPI) is a type of performance measurement. KPIs evaluate the success of an organization or of a particular activity (such as projects, programs, products and other initiatives) in which it engages.

Often success is simply the repeated, periodic achievement of some levels of operational goal (e.g. zero defects, 10/10 customer satisfaction, etc.), and sometimes success is defined in terms of making progress toward strategic goals.

Accordingly, choosing the right KPIs relies upon a good understanding of what is important to the organization. What is deemed important often depends on the department measuring the performance – e.g. the KPIs useful to finance will differ from the KPIs assigned to sales.

Since there is a need to understand well what is important, various techniques to assess the present state of the business and its key activities are associated with the selection of performance indicators. These assessments often lead to the identification of potential improvements, so performance indicators are routinely associated with 'performance improvement' initiatives. A very common way to choose KPIs is to apply a management framework such as the balanced scorecard.

Categorization of Indicators:

Key performance indicators define a set of values against which to measure. These raw sets of values, which can be fed to systems that aggregate the data, are called indicators. There are two categories of measurements for KPIs.

Quantitative facts without distortion from personal feelings, prejudices, or interpretations presented with a specific value - objective- preferably numeric measured against a standard.

Qualitative values based on or influenced by personal feelings, tastes, or opinions and presented as any numeric or textual value that represents an interpretation of these elements.

An 'indicator' can only measure what 'has' happened, in the past tense, so the only type of measurement is descriptive or lagging. Any KPI that attempts to measure something in a future state as predictive, diagnostic or prescriptive is no longer an 'indicator' it is a 'prognosticator' - at this point its analytics (possibly based on a KPI).

Example of KPI:

The specific KPIs that you need to measure can differ greatly from industry to industry, but when it comes down to it, they are all tracked to aid in accomplishing the same goal: increasing your profit margin. Furthermore, most KPIs fall into one of the following four categories:

- Revenue improvement
- Cost reduction
- Process cycle-time improvement
- Increased customer satisfaction

To expand upon this, the following are KPI examples from real-life scenarios. Using these KPIs will benefit in reducing overheads, errors, delays and costs.

Business Process – Key Performance Indicators:
The following are key metrics for gauging business process performance:
- Percentage of processes where completion falls within +/- 5% of the estimated completion
- Average process overdue time
- Percentage of overdue processes
- Average process age
- Percentage of processes where the actual number assigned resources is less than planned number of assigned resources
- Sum of costs of “killed” / stopped active processes
- Average time to complete task
- Sum of deviation of time (e.g. in days) against planned schedule of all active projects

Service Level Agreement (SLA) – Key Performance Indicators

The following are key metrics of SLA performance:
- Percentage of service requests resolved within an agreed-upon/acceptable period of time
- Cost of service delivery as defined in Service Level Agreement (SLA) based on a set period such as month or quarter
- Percentage of outage (unavailability) due to implementation of planned changes, relative to the service hours
- Average time (e.g. in hours) between the occurrence of an incident and its resolution
- Downtime – the percentage of the time service is available

- Availability – the total service time = the mean time between failure (MTBF) and the mean time to repair (MTTR)
- Number of outstanding actions against last SLA review
- The deviation of the planned budget (cost) is the difference in costs between the planned baseline against the actual budget of the Service Level Agreement (SLA)
- Percentage of correspondence replied to on time
- Percentage of incoming service requests of customers have to be completely answered within x amount of time
- Number of complaints received within the measurement period
- Percentage of customer issues that were solved by the first phone call
- Number of operator activities per call – maximum possible, minimum possible, and average. (E.g. take call, log call, attempt dispatch, retry dispatch, escalate dispatch, reassign dispatch, etc.)
- The number of answered phone call per hour
- Total Calling Time per Day or week.
- Average queue time of incoming phone calls
- Cost per minute of handle time
- Number of un-responded emails
- Average after call work time (work done after call has been concluded)
- Costs of operating a call centre / service desk, usually for a specific period such as month or quarter
- Average number of calls / service requests per employee of call center / service desk within measurement period
- Number of complaints received within the measurement period

Service Quality – Key Performance Indicators:

The following are KPI reporting examples for gauging Service Quality performance:
- Cycle time from request to delivery
- Call length – the time to answer a call
- Volume of calls handled – per call centre staff
- Number of escalations how many bad
- Number of reminders – how many at risk
- Number of alerts – overall summary
- Customer ratings of service – customer satisfaction
- Number of customer complaints – problems
- Number of late tasks – late

Efficiency – Key Performance Indicators:

The following are KPI reporting examples indicating Efficiency performance:
- Cycle time from request to delivery
- Average cycle time from request to delivery
- Call length
- Volume of tasks per staff

- Number of staff involved
- Number of reminders
- Number of alerts
- Customer ratings of service
- Number of customer complaints
- Number of process errors
- Number of human errors
- Time allocated for administration, management, training

Compliance – Key Performance Indicators:

The following are KPI examples for Compliance performance:
- Average time lag between identification of external compliance issues and resolution
- Frequency (in days) of compliance reviews

Budget – Key Performance Indicators:

- Sum of deviation in money of planned budget of projects

Index used in Key Performance Indicators:

The following indices are used in KPI as indicators:
Tolerating: The user notices performance lagging within responses greater than T, but continues the process.
Frustrated: Performance with a response time greater than F seconds is unacceptable, and users may abandon the process.
Satisfied: The user is fully productive. This represents the time value (T seconds) below which users are not impeded by application response time.

2.5 Overall equipment effectiveness (OEE)

Seiichi Nicky Jamima in 1982 defined Overall equipment effectiveness (OEE) as measure of how well a manufacturing operation is utilized (facilities, time and material) compared to its full potential, during the periods when it is scheduled to run. An OEE of 100% means that only good parts are produced (100% quality), at the maximum speed (100% performance), and without interruption (100% availability)

The term OEE was coined by Seiichi Nicky Jamima. It is based on the Harrington Emerson way of thinking regarding labor efficiency. The generic form of OEE allows comparison between manufacturing units in differing industries.

Calculation Of OEE:

The simplest way to calculate OEE is as the ratio of Fully Productive Time to Planned Production Time. Fully Productive Time is just another way of saying manufacturing only Good Parts as fast as possible (Ideal Cycle Time) with no Stop Time. Hence the calculation is:

OEE= (Good Count x Ideal Cycle time)/Planned production Time

Although this is an entirely valid calculation of OEE, it does not provide information about the three loss-related factors: Availability, Performance, and Quality. For that – we use the preferred calculation.

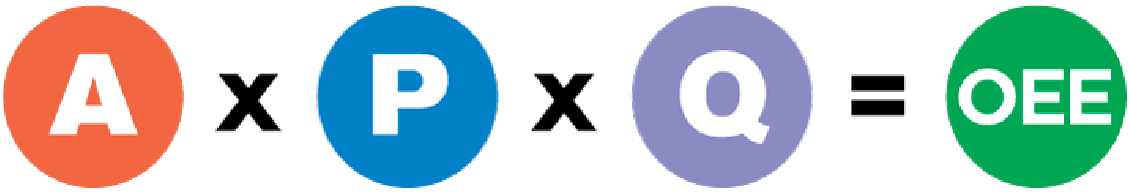

Figure 4 Overall Equipment Effectiveness Formula

Availability:

Availability takes into account all events that stop planned production long enough where it makes sense to track a reason for being down (typically several minutes).

Availability is calculated as the ratio of Run Time to Planned Production Time:

Availability = Run Time / Planned Production Time

Run Time is simply Planned Production Time less Stop Time, where Stop Time is defined as all time where the manufacturing process was intended to be running but was not due to Unplanned Stops (e.g., Breakdowns) or Planned Stops (e.g. changeovers)

Run Time = Planned Production Time – Stop Time

Performance:

Performance takes into account anything that causes the manufacturing process to run at less than the maximum possible speed when it is running (including both Slow cycle and Small Stops).

Performance is the ratio of Net Run Time to Run Time. It is calculated as:

Performance = (Ideal Cycle Time x Total Count) / Run time

Ideal Cycle Time is the fastest cycle time that your process can achieve in optimal circumstances. Therefore, when it is multiplied by Total Count the result is Net Run Time (the fastest possible time to manufacture the parts)

Since rate is the reciprocal of time, Performance can also be calculated as:

Performance = (Total Count / Run time) / ideal Run RATE

Performance should never be greater than 100%. If it is, that usually indicates that Ideal Cycle Time is set incorrectly (it is too high).

Quality:

Quality takes into account manufactured parts that do not meet quality standards, including parts that need rework. Remember, OEE Quality is similar to First Pass Yield, in that it defines Good Parts as parts that successfully pass through the manufacturing process the first time without needing any rework.

Quality is calculated as:

Quality = Good Count / Total Count

This is the same as taking the ratio of Fully Productive Time (only Good Parts manufactured as fast as possible with no Stop Time) to Net Run Time (all parts manufactured as fast as possible with no stop time).

OEE takes into account all losses, resulting in a measure of truly productive manufacturing time. It is calculated as:

OEE = Availability x Performance x Quality

If the equations for Availability, Performance, and Quality are substituted in the above and reduced to their simplest terms the result is:

OEE = (Good Count × Ideal Cycle Time) / Planned Production Time

This is the “simplest” OEE calculation described earlier. And, as described earlier, multiplying good count by Ideal Cycle Time results in Fully Productive time (manufacturing only Good Parts, as fast as possible, with no Stop Time).

CASE DEVELOPMENT

3.1 COMPANY PRESENTATION:

3.2 AS-IS ANALYSIS

3.3 VISION

3.4 TO BE PHASE

3.4 IMPLEMENTATION CASE RESULT

3 Case Development:

In this Chapter firstly there will be discussions on the Company its introduction, followed by the analysis, strategy and implementation.

3.1 Company Presentation:

The host to accomplish this project was `Preh Lda` which located in Trofa, Portugal. Preh Lda is a German based automotive industry and headquarter in Bad Neustadt, Germany. Started in 1919, Preh is celebrating the year of century this year.

Preh got its presence in many countries around the world including Portugal, Germany, Poland, Mexico, USA, Romania, Sweden and China. Focusing towards the main customers of Preh it includes automobile giants like BMW, Audi, AMG, Ford and many more.

Focusing on the products offered by Preh it includes Car Connect, Climate Control, Central Control, Switches, Center Stacks.

Figure 5 Component manufactured in preh

Process Description of Company:

Plastic Injection moulding:

Injection moulding is a manufacturing process for producing parts by injecting molten material into a mould. Injection moulding can be performed with a host of materials mainly including metals, glasses, elastomers, confections, and most commonly thermoplastic and thermosetting polymers.

Material for the part is fed into a heated barrel, mixed (using a helical shaped screw), and injected (Forced) into a mould cavity, where it cools and hardens to the configuration of the cavity.

Figure 6 Plastic Injection Machine

Injection moulding is widely used for manufacturing a variety of parts, from the smallest components to entire body panels of cars. Advances in 3D printing technology, using photopolymers which do not melt during the injection moulding of some lower temperature thermoplastics, can be used for some simple injection moulds.

Application of Plastic Injection moulding is used to create many things such as wire spools, packaging, bottle caps, automotive parts and components, toys, pocket combs, some musical instruments (and parts of them), one-piece chairs and small tables, storage containers, mechanical parts (including gears), and most other plastic products available today. Injection moulding is the most common modern method of manufacturing plastic parts; it is ideal for producing high volumes of the same object.

Figure 7 Injection Machine in Preh

Equipment used in Plastic Injection:

Injection moulding machines consist of a material hopper, an injection ram or screw-type plunger, and a heating unit. Also known as platens, they hold the moulds in which the components are shaped. Presses are rated by tonnage, which expresses the amount of clamping force that the machine can exert. This force keeps the mould closed during the injection process.

Tonnage can vary from less than 5 tons to over 9,000 tons, with the higher figures used in comparatively few manufacturing operations. The total clamp force needed is determined by the projected area of the part being moulded. This projected area is multiplied by a clamp force of from 1.8 to 7.2 tons for each square centimetre of the projected areas.

As a rule of thumb, 4 or 5 tons/in2 can be used for most products. If the plastic material is very stiff, it will require more injection pressure to fill the mould, and thus more clamp tonnage to hold the mould closed. The required force can also be determined by the material used and the size of the part. Larger parts require higher clamping force.

Mold:

Mold or die are the common terms used to describe the tool used to produce plastic parts in moulding. Since moulds have been expensive to manufacture, they were usually only used in mass production where thousands of parts were being produced.

Typical moulds are constructed from hardened steel, pre-hardened steel, aluminium, and/or copper alloy. The choice of material to build a mould from is primarily one of economics; in general, steel moulds cost more to construct, but their longer lifespan will offset the higher initial cost over a higher number of parts made before wearing out.

Pre-hardened steel moulds are less wear-resistant and are used for lower volume requirements or larger components; their typical steel hardness is 38–45 on the Rockwell-C scale. Hardened steel moulds are heat treated after machining; these are by far superior in terms of wear resistance and lifespan. Typical hardness ranges between 50 and 60 Rockwell-C (HRC). Aluminium moulds can cost substantially less, and when designed and machined with modern computerised equipment can be economical for moulding tens or even hundreds of thousands of parts.

Beryllium copper is used in areas of the mould that require fast heat removal or areas that see the most shear heat generated. The moulds can be manufactured either by CNC machining or by using electrical discharge machining processes.

Mould Design:

The mould consists of two primary components, the injection mould (A plate) and the ejector mould (B plate). These components are also referred as moulder and mouldmaker. Plastic resin enters the mould through a sprue or gate in the injection mould; the sprue bushing is to seal tightly against the nozzle of the injection barrel of the moulding machine and to allow molten plastic to flow from the barrel into the mould, also known as the cavity. The sprue bushing directs the molten plastic to the cavity images through channels that are machined into the faces of the A and B plates. These channels allow plastic to run along them, so they are referred to as runners. The molten plastic flows through the runner and enters one or more specialised gates and into the cavity geometry to form the desired part.

Figure 8 Mold of Injection Machine

The amount of resin required to fill the sprue, runner and cavities of a mould comprises a “shot”. Trapped air in the mould can escape through air vents that are ground into the parting line of the mould, or around ejector pins and slides that are slightly smaller than the holes retaining them. If the trapped air is not allowed to escape, it is compressed by the pressure of the incoming material and squeezed into the corners of the cavity, where it prevents filling and can also cause other defects. The air can even become so compressed that it ignites and burns the surrounding plastic material.

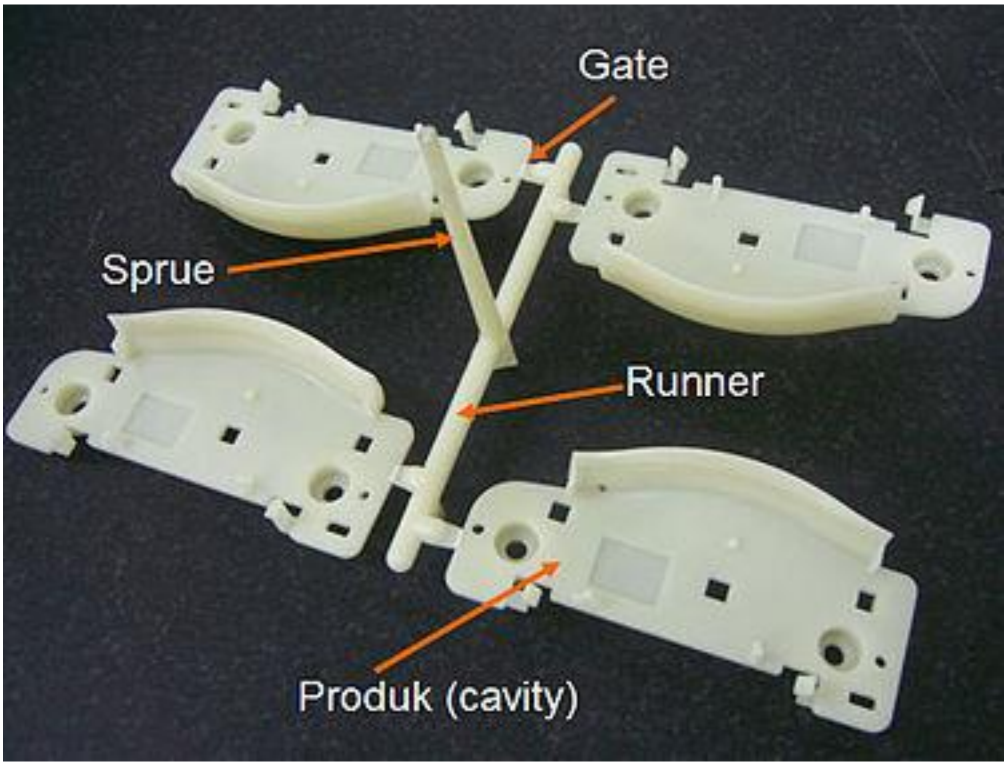

Figure 9 Components of Mold

To allow for removal of the moulded part from the mould, the mould features must not overhang one another in the direction that the mould opens, unless parts of the mould are designed to move from between such overhangs when the mould opens (using components called Lifters).

Sides of the part that appear parallel with the direction of draw (the axis of the cored position (hole) or insert is parallel to the up and down movement of the mould as it opens and closes) are typically angled slightly, called draft, to ease release of the part from the mould. Insufficient draft can cause deformation or damage. The draft required for mould release is primarily dependent on the depth of the cavity; the deeper the cavity, the more draft necessary. Shrinkage must also be taken into account when determining the draft required. If the skin is too thin, then the moulded part will tend to shrink onto the cores that form while cooling and cling to those cores, or the part may warp, twist, blister or crack when the cavity is pulled away.

A mould is usually designed so that the moulded part reliably remains on the ejector (B) side of the mould when it opens and draws the runner and the sprue out of the (A) side along with the parts. The part then falls freely when ejected from the (B) side. Tunnel gates, also known as submarine or mould gates, are located below the parting line or mould surface. An opening is machined into the surface of the mould on the parting line. The moulded part is cut (by the mould) from the runner system on ejection from the mould.

Ejector pins, also known as knockout pins, are circular pins placed in either half of the mould (usually the ejector half), which push the finished moulded product, or runner system out of a mould. The ejection of the article using pins, sleeves, strippers, etc., may cause undesirable impressions or distortion, so care must be taken when designing the mould.

The standard method of cooling is passing a coolant (usually water) through a series of holes drilled through the mould plates and connected by hoses to form a continuous pathway. The coolant absorbs heat from the mould (which has absorbed heat from the hot plastic) and keeps the mould at a proper temperature to solidify the plastic at the most efficient rate.

To ease maintenance and venting, cavities and cores are divided into pieces, called inserts, and sub-assemblies, also called inserts, blocks, or chase blocks. By substituting interchangeable inserts, one mould may make several variations of the same part.

More complex parts are formed using more complex moulds. These may have sections called slides, that move into a cavity perpendicular to the draw direction, to form overhanging part features. When the mould is opened, the slides are pulled away from the plastic part by using stationary “angle pins” on the stationary mould half.

These pins enter a slot in the slides and cause the slides to move backward when the moving half of the mould opens. The part is then ejected and the mould closes. The closing action of the mould causes the slides to move forward along the angle pins.

Some moulds allow previously moulded parts to be reinserted to allow a new plastic layer to form around the first part. This is often referred to as overmoulding. This system can allow for production of one-piece tires and wheels.

Two-shot or multi-shot moulds are designed to "overmould" within a single moulding cycle and must be processed on specialised injection moulding machines with two or more injection units. This process is actually an injection moulding process performed twice and therefore has a much smaller margin of error.

In the first step, the base colour material is moulded into a basic shape, which contains spaces for the second shot. Then the second material, a different colour, is injection-moulded into those spaces. Pushbuttons and keys, for instance, made by this process have markings that cannot wear off, and remain legible with heavy use.

A mould can produce several copies of the same parts in a single "shot". The number of "impressions" in the mould of that part is often incorrectly referred to as cavitation. A tool with one impression will often be called a single impression (cavity) mould. A mould with 2 or more cavities of the same parts will likely be referred to as multiple impression (cavity) mould. Some extremely high production volume moulds (like those for bottle caps) can have over 128 cavities.

In some cases, multiple cavity tooling will mould a series of different parts in the same tool. Some toolmakers call these moulds family moulds as all the parts are related. Some examples include plastic model kits.

Defects in Plastic Injection:

Blister: Tool or material is too hot, often caused by a lack of cooling around the tool or a faulty heater

Burn marks: Tool lacks venting, injection speed is too high

Colour streaks: Masterbatch isn't mixing properly, or the material has run out and it's starting to come through as natural only. Previous coloured material "dragging" in nozzle or check valve.

Contamination: Poor material introduced by bad recycling or regrind policy; may include floor sweepings, dust and debris

Flow Marks: Injection speeds too slow (the plastic has cooled down too much during injection, injection speeds should be set as fast as is appropriate for the process and material used)

Polymer Degradation: Excess water in the granules, excessive temperatures in barrel, excessive screw speeds causing high shear heat, material being allowed to sit in the barrel for too long, too much regrind being used.

Cracks: Threadline gap in between part due to improper gate location in complex design parts including excess of holes (multipoint gates to be provided), process optimization, proper air venting.

Assemby lines:

An assembly line is a manufacturing process (often called a progressive assembly) in which parts (usually interchangeable parts) are added as the semi-finished assembly moves from workstation to workstation where the parts are added in sequence until the final assembly is produced.

By mechanically moving the parts to the assembly work and moving the semi-finished assembly from work station to work station, a finished product can be assembled faster and with less labour than by having workers carry parts to a stationary piece for assembly.

Assembly lines are common methods of assembling complex items such as automobiles and other transportation equipment, household appliances and electronic goods.

Assembly lines are designed for the sequential organization of workers, tools or machines, and parts. The motion of workers is minimized to the extent possible. All parts or assemblies are handled either by conveyors or motorized vehicles such as fork lifts, or gravity, with no manual trucking. Heavy lifting is done by machines such as overhead cranes or fork lifts. Each worker typically performs one simple operation.

Figure 10 Assembly Line in Preh

Types of Assembly lines:

Modular Assembly: This is an advanced assembly line method that is designed to improve throughput by increasing the efficiency of parallel subassembly lines feeding into the final assembly line. As applied to automobile manufacturing, modular assembly would involve assembling separate modules chassis, interior, body on their own assembly lines, then joining them together on a final assembly line.

Cell Manufacturing: This production method has evolved out of increased ability of machines to perform multiple tasks. Cell operators can handle three or four tasks, and robots are used for such operations as materials handling and welding. Cells of machines can be run by one operator or a multi-person work cell. In these machine cells it is possible to link older machines with newer ones, thus reducing the amount of investment required for new machinery.

Team Production: Team-oriented production is another development in assembly line methods. Where workers used to work at one- or two-person work stations and perform repetitive tasks, now teams of workers can follow a job down the assembly line through its final quality checks. The team production approach has been hailed by supporters as one that creates greater worker involvement in the manufacturing process and knowledge of the system.

U-shaped assembly "line": A line may not be the most efficient shape in which to organize an assembly line. On a U-shaped line, or curve, workers are collected on the inside of the curve and communication is easier than along the length of a straight line. Assemblers can see each process; what is coming and how fast; and one person can perform multiple operations. Also, workstations along the "line" are able to produce multiple product designs simultaneously, making the facility as a whole more flexible. Changeovers are easier in a U-shaped line as well and, with better communication between workers, cross-training is also simplified. The benefits of the U-shaped line have served to increase their use widely.

3.2 AS-IS Analysis

In Plastic injection production area of Preh it consist of 20 injection machines which produces around 153 different types of products which will be further supplied to the assembly line for the assembly of the final product.

In order to make this parts in injection it uses variety of different raw material. In total around 109 different types of granules of raw material is been used. As some parts require the mixture of the granules while some need separate supply but more than 2 types of raw material.

Figure 11 Raw Material used in Injection Machine

Along with the raw material, Packaging material is also required in order to pack the parts after the production. The parts are been packed based on the future use and supply. But the packaging material and separators also has variety depending on the product such as:

1.Caixa ESD Big

2.Caixa ESD Small

3.Cardboard Box

4.Tray

5.White Sponge

6.Yellow Sponge

7.Cardboard Seperator

8.Paper Seperator

Figure 12 Cardboard Box

Figure 13 Yellow Sponge Seperator

As it is but obvious that all the parts has their own characteristics requirement and time to produce. The planning of the production is been done by the production planning department and is been given to the production department. The problem that persist is that the production plan is been given to the production department but the planning of the supply is not been done.

Because of the uncertainty of the supply of the required raw material and packaging material there is often stoppage of the machine because of the lack of the raw material or packaging material. As the machine stops the productivity of the production unit goes done which affects the OEE of the production area.

Due to failure in the proper supply of the raw material and packaging material the machine often stops that result into low OEE of the production unit. The OEE before the planning of the supply to the production area was around 70,27%

As it can be seen in the below mentioned table all the criteria of the OEE which include Availability, performance and Quality. It can be clearly seen that the availability of the production area is very low. The main reason for this situation was failure of supply of raw material and packaging material. Along with that other steps will be taken intoed to increase the capacity of milkrun and improve the quality of product which can directly help in increasing the OEE of our production system.

Table 1 OEE of all Machine

Machine Num	Performace	Availability	Quality	OEE
3	99.9	80.3	99.8	80
4	99.7	57.4	99.7	57.1
11	99.6	60.1	84.8	50.8
14	100	94.6	99.9	94.5
18	98.7	93.1	99.3	91.3
21	99.4	87.4	98.1	85.3
22	100	86.4	90.8	78.4
23	99.2	23.2	89.1	20.5
24	100	95.3	98.8	94.2
25	99.8	21.3	83.4	21.3
26	99.7	74.7	97.6	72.7
27	97.9	101.7	99.9	99.5
28	100	96.6	99.9	96.5
29	99.8	74	99	73.1
30	99.8	67.8	93.1	63
31	99.9	102.8	99.2	101.9
32	99.9	44.9	86.6	38.8
33	98.8	110	98.1	106.6
34	100	86.7	83	71.9
35	98.9	46.4	76.5	35.1
Average:	99.55	75.235	93.83	70.27

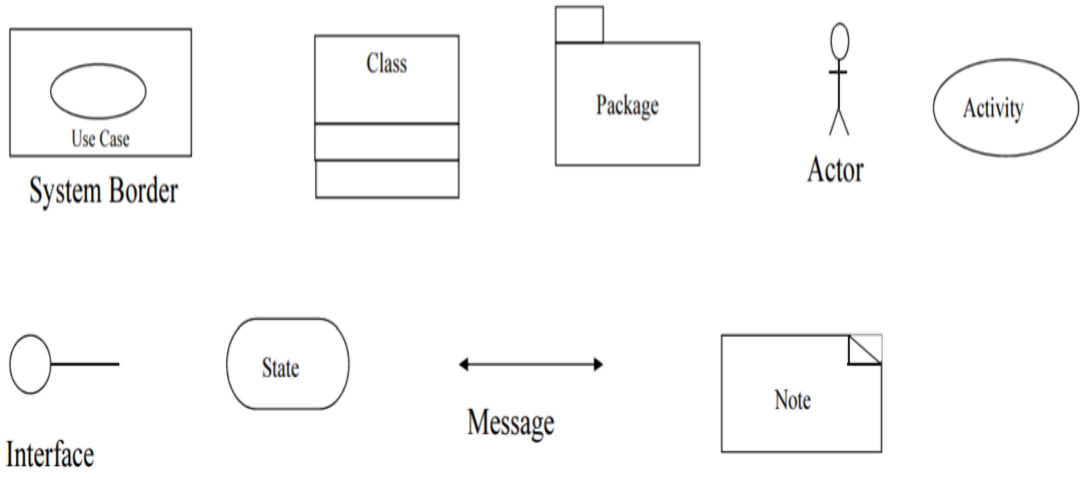

Figure 14 Symbols used in UML

In fig 14 different symbols are shown which is used in UML. The first symbol is of the system border which indicates the things which is inside our system. In this case our system is Production area, the human symbol is the symbol of actor who performs the activity inside the system and activities that is been performed by the actors and showcased by oval shape. The two way symbol is the message/interaction between the actors or between the activities.

Relationships:

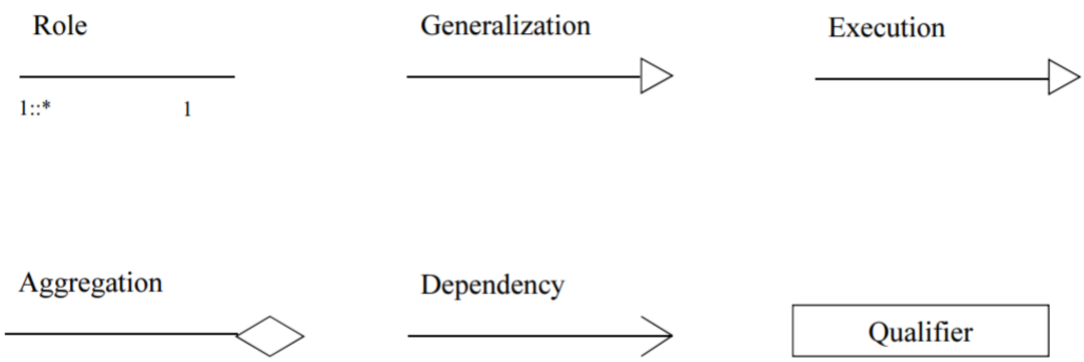

Figure 15 Relationship symbols used in UML

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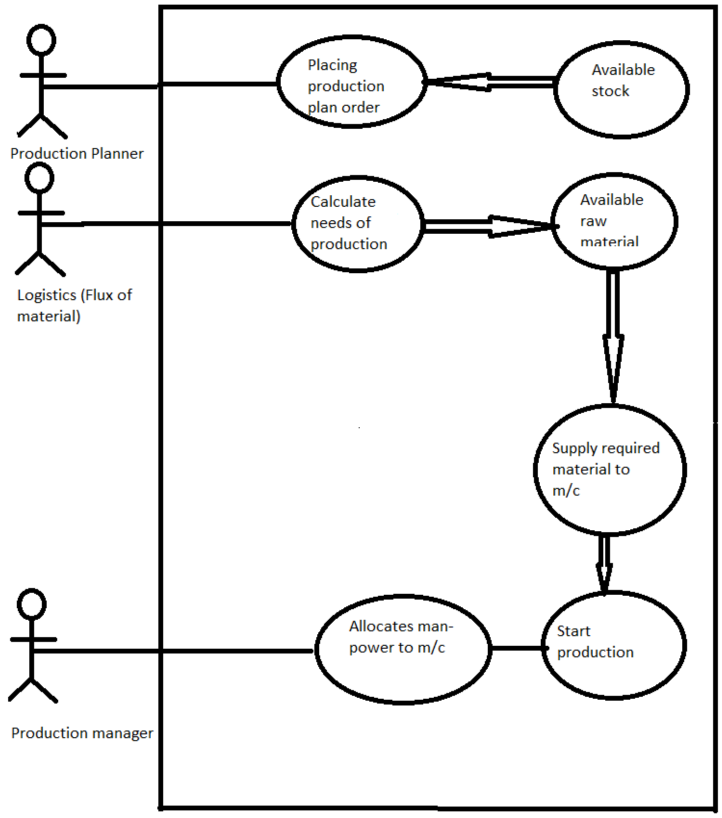

Figure 16 UML Use Case Diagram

In the figure 16 which describes the use case diagram from Preh, it will help to understand different activities performed by different actors in the industry.

As it can be seen that there are three main actors in the given system they are:

- Production Planner
- Production Manager
- Logistics Specialist

Production Planner releases the production plan with number of hours with the information of part to be produced, tool to be used, machine to be utilised, quantity is indirectly been mentioned based on the number of hours of work.

Role of Logistics specialist is to ensure the supply of raw material and packaging material to the machine. Once the production plan is received it is necessary to calculate the requirements for each machine and each part to be produced and plan the supply of the requirements considering the available stock, capacity to transport per cycle, lead time, storage capacity near the machine.

Meanwhile, Production manager/head already received the plan of the production so the allocation of the manpower, tool change, maintenance starts to begin in order to ensure that production starts at the time based on the production plan.

Summarising the analysis, the insight is been obtained based on the different types of raw material and the packaging material that has to be supplied to the machines. Also with the use of UML use case diagram the actors and the activities done by them are also been identified.

3.3 Vision

Table 2 Vision

Problem	Action	Result
Contamination of raw material	Usage of air tight drums	Less Contamination, Better quality product
Failure of Supply of raw material and Packaging	Preparation of logistic plan	No breakdown of machines because of failure to supply
Capacity to Transport per cycle	Designed carriage to transport	More materials can be transported per cycle
Long cycle time to transport	Preparation of transport route	More efficient transport

3.4 To Be Phase

Once the production plan is been implemented, it is very much necessary that the machine has to be continuously supplied with raw material and packaging material. If the supply stops then machine stops also which affects the OEE of the production area. This is one of the biggest factor due to which the OEE is around 70,27%. This OEE was measured for a month (19th Nov to 19th Dec) of continuous production (considering the stoppage for maintenance, breakdowns) but biggest reason for the low OEE was the failure in the supply of raw material and packaging material.

This made it clear that a logistic plan needs to be developed to plan the supply of raw material and packaging material. Data collection is been done to understand the perfect needs of each and every parts that has to be produced. Data collection is been done based on the cycle time of the part. Number of parts that can be produced in a hour and what are the hourly needs for that part in that particular machine.

Next step is just to check the number of hours mentioned in the production plan for that part in that machine, which makes it easy to calculate the exact requirement of that machine as well as the part which is been produced. Doing the same for each and every machine and part mentioned in the production plan helps to ensure the supply of the raw material and packaging material without failure. As the biggest problem of stopping of the machine was the failure of the supply by this strategy of implementing the logistic supply plan may help us to achieve our plan of increasing the OEE of the production unit.

In Table 3 a production plan is been given which gives the information about the machine which will work, part that machine will produce, time at which machine should be ready to start the production after mounting the molds and number of hours the machine will keep on producing the untill the planned time.

In table 4 logistics supply plan is been given in which it describes about the needs of all the machine along with the quantity that will be produced and need of quantities of raw material and packaging material with specifications.

Table 3 Production Plan

Maquina	Reference	Start (Hrs)	Num of Hours
3	13065-264	6:00 AM	11
4	13056-459	8:00 AM	61
11	13065-479	7:00 AM	139
18	12788-134	6:00 AM	132
21	12788-113	2:00 PM	73
22	10451-050	11:00 AM	133
23	13039-710	1:00 PM	6
24	12788-468	10:00 AM	166
25	12788-001	9:00 AM	62
26	12788-117	3:00 PM	53
27	13056-467	8:00 PM	27
28	12789-024	11:00 PM	53
29	13056-214	2:00 AM	29
30	13566-485	4:00 PM	20
31	12788-517	8:00 PM	147
32	12001-004	7:00 PM	75
34	12788-512	8:00 AM	18
35	12788-220	9:00 AM	42

Table 4 Logistic Supply Plan

Machine Num	Reference Num	Quantity Produced	Raw Material	Quantity (Kg)	Packaging	Quantity
3	13065-264	12000	00698-263	21	Tray 13099-615	172
4	13056-459	20000	00698-263	80	Tray 13099-435	2500
			00698-216	277	White Sep	2620
			00698-198	91	Brown cardboard	1572
11	13065-479	11000	00701-028	47	Box	262
18	12788-134	70000	00701-290	202	Tray 13099-364	2500
21	12788-113	5000	00698-281	465	White Tray	500
22	10451-050	15000	00698-281	787	Tray 03523-430	1500
23	13039-710	2000	00701-012	19	ESD Box	5
24	12788-468	15000	00698-281	1128	Tray 03523-695	3750
25	12788-001	5760	00698-216	276	Cardboard Box	35
26	12788-117	3600	00698-295	466	Box ESD	300
27	13056-467	12960	00698-295	97	Tray 13099-450	90
					Caixa ESD	42
28	12789-024	8000	00698-007	156	Paper Seperator	714
			00698-007	45		
			00701-332	25		
29	13056-214	3600	00698-295	12	Tray 13099-287	60
30	13565-485	4000	00701-189	19	Plastic Bag	8
31	12788-517	15000	00698-281	918	Tray 03523-695	3750
32	12001-004	6630	00701-028	192	Tray 03523-477	663
			00698-281	56		
34	12788-512	2600	00698-290	55	Tray 13099-591	520
35	12788-220	3600	00698-281	29	Tray 13099-623	1200

Moving towards the improvement project, the methodology to be followed is Plan, Do, Check, Act (PDCA Cycle). After receiving the required information from the production plan we follow the following steps:

Plan: Based on the parts which has to be produced the requirements is to be measured as all the parts has their own requirement of raw material and packaging material. For example: Machine 34 produces the part 12788-512 which is used to assemble in BMW BZM project.

This part based on the production plan will be produced for 18 hours continuously in which around 2600 parts which will be produced so it necessary to measure and plan the supply based on its requirement.

It needs two raw material to manufacture this part they are 00698-281, 00698-290 and the quantities required for each is 56 Kg and 55 kg respectively. For the packaging material this part needs a special kind of tray which is 13099-591. In each tray 5 pieces of this part can be accomdated so as we are planning to manufacture 2600 parts we will need 520 trays to fulfill the packaging requirement. So this kind of planning is needed inorder for the supply to the machine so machine works without stoppage because of the failure of the supply.

Do: After measuring the requirement for each machine and each part the logistic plan is been developed considering the quantity of the raw material to be supplied. In Preh in order to supply the raw material to the machine and avoid the contamination of the raw material Stainless steel drums are been used which has the capacity to supply 75 kgs of the raw material at the same time. So the machine which is running for long time and needs more than 75 kgs of the raw material the supply of the raw material is been made in the different shifts based on the needs. So this kind of logistic plan has to be developed for each machine which varies for each part to be manufactured.

Figure 17 Raw material Storage drum

Check: After planning and measuring the supply of required raw material and packaging material, it is time to check the available stock, capacity of the border line , cycle time of the milkrun, safety stock in the border line.

Act: if any of the factors mentioned doesn’t fall in the line then we need to change the plan. For example if the available stock for some raw material or packaging material is not to the level which can satisfy the demand of the production supply plan then it is necessary to change the production plan. So it is very much necessary to keep acting based on the current situation and try to maintain and stick to the production plan so that it can help in achieving the goal of increasing the Overall equipment effectiveness of our production unit.

Also as discussed in the vision the special multi purpose carriage has been developed which helps in increasing the capacity of the raw material and packaging material to be transported to the border line of the machine

Figure 18 Milkrun

Also in order to decrease the cycle time of the milkrun the transport route has been developed so that the stops that has to be done by the milkrun decreases hence increase the number of possible cycles to be performed which can result into sufficient supply of raw material and packaging material to the border line.

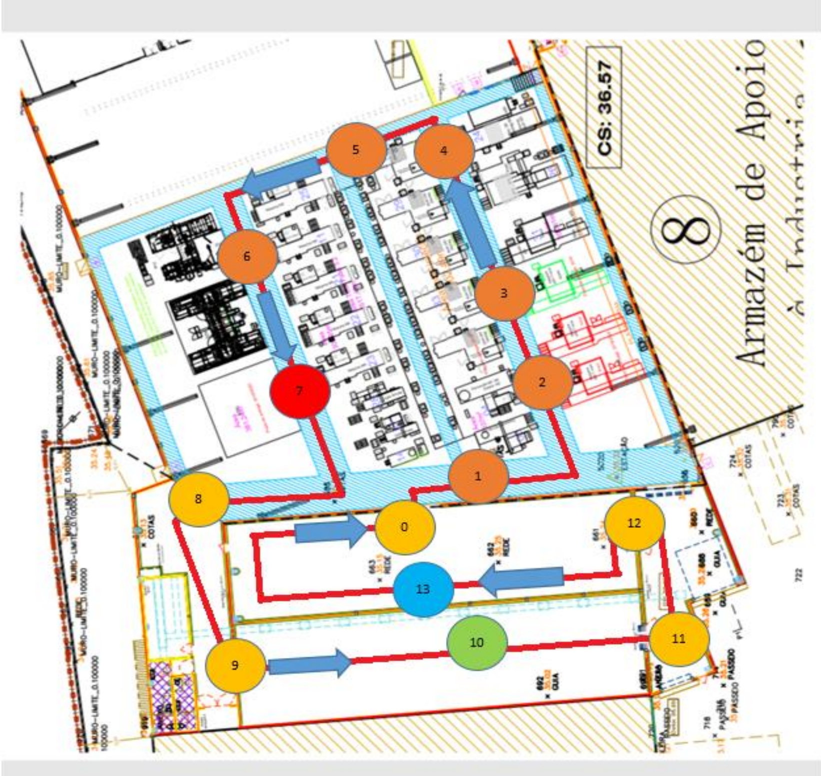

Figure 19 Transport route for milkrun

3.4 Implementation Case Result

Here in this report two scenarios is been considered first scenario was the case in which there was no planning of logistics supply of required to the raw material and packaging material and second case is the situation in which after receiving the production plan the requirements of each machine and parts is been calculated and logistic supply plan is been made so that the machine don't stop due to the failure of the supply of raw material or packaging material.

The Overall equipment efficiency in the first case was 70,27% (measured from 19th Nov to 19th Dec) as it can be seen the OEE is very less because there was no proper planning in the supply of the requirements of the machine which result into the stoppage of the machine.

On the contrary, after implementation of the measurement and logistics supply plan there is drastic change in the performance which result in the big increase in the overall equipment effectiveness of the plastic injection production unit. The criteria was as follow between (31st Jan to 1st Mar):

Performace: 98,65%

Availability: 87,125%

Quality: 95,805%

Table 5 OEE after implementation

Machine Num	Performance	Availability	Quality	OEE
3	99.8	90.9	99.6	90.4
4	99.4	88.2	99.5	87.2
11	99.9	77.2	96.6	74.5
14	78.9	70.6	99.5	55.5
18	99.8	80.1	99.8	79.7
21	100	81.7	99.3	81.2
22	99.9	93.6	90.3	84.4
23	99.9	44.8	79.4	35.6
24	99.9	107.4	99.8	107.1
25	98.7	60.7	88.3	52.9
26	99.6	94.5	98.5	92.7
27	100	92.4	99.6	92
28	99.8	92.6	99.7	92.2
29	99.8	92.3	99.7	91.9
30	99.9	87	93.7	81.4
31	98	116.5	99.6	113.8
32	99.8	77.4	95.5	73.7
33	99.9	110.7	98.7	109.2
34	100	99.6	91.4	91
35	100	84.3	87.6	73.8
Average:	98.65	87.125	95.805	82.34

Therefore, OEE= Availability x Performance x Quality

= 0,9865 x 0,87125 x 0,95805

OEE = 82,34%

Increase in OEE (After planning – Before Planning) = 12,07%

With Increase in OEE it has good benefits on whole production area like:

- Stability of the production system increase
- Profitability increase
- Extra work hours due to low OEE can be reduced
- Process quality increases

CONCLUSIONS

4 CONCLUSIONS AND PROPOSALS OF FUTURE WORKS

4.1 CONCLUSIONS

As per the results obtained and considering the increase in the overall equipment efficiency, we can firmly conclude that logistics planning of the requirement of the machines are very much important as it ensures that machine works efficiently without stopping.

Also, by implementing Unified modelling language it makes really very easy to understand the flow and the actions that are been carried by each and every actor in the system which is production planner, logistics specialist and production manager in our case.

With higher OEE the profitability of the industry increases as the production area is more efficient. Sometimes workers have to work extra hours in order to cover up the losses incurred in the low OEE cases, but then with this implementation the extra hours of work can be reduced.

4.2 PROPOSALS OF FUTURE WORKS

By calculating and planning the supply of requirements of machines in the production area it helped to increase the OEE by 12,07%, thus the OEE achieved was 82,34% but the world standard of OEE is as follow:

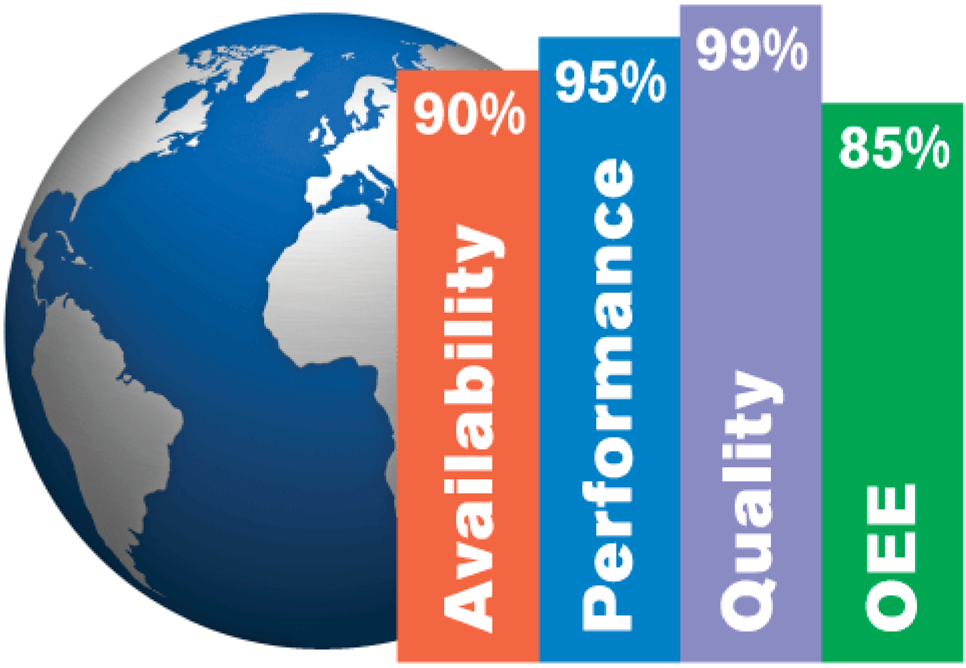

Figure 20 World OEE Standard

Availability: 90%

Performance: 95%

Quality: 99%

Therefore, OEE (World standard- Practitioner point of view) = 85%

In our case, the availability is been achieved as per world standard, but it needs to focus on the performance and the quality in order to achieve the world class OEE standard of 85%. Hence future work can be to achieve world standard OEE level.

By this logistic plan the machine won't stop because of the lack of raw material or packaging material but there can be more improvements which can be implemented in order to achieve our future goal to reach OEE of 85% are as follow:

- Avoid contamination of raw material to have good quality parts
- Maintenance of machine which avoids frequent breakdown of machines
- Planning to avail raw material and packaging material in stock

Also performance can be improved by avoiding the machine breakdown by analysing preventive maintenance and potential causes.

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ANNEXES

DATA COLLECTION:

TRANSPORT

ANNEXES

Data Collection:

As discussed earlier around 153 different parts are been manufactured in the plastic injection unit of preh. In order to make the supply plan it is very much necessary to understand the requirements of each parts. So the data collection was done and excel files were made for each product so that it can be easy to access the needs of all the parts.

CT Code:6463	Machine Num: 18	Time Horizon:	8
		Possible Production:	4264

Part Reference Num:	min/part	min/100 parts	Expected Production	Time required (mins)	Time Required (Hours)	Total number of Operator	Hourly production
12788-134/0001	0,1125	11,25	70000	7875	132	17	533

Total raw material demand (Kg)	
00698-224	140
00701-231	19
00701-290	200

Total Packaging demads	
Tray	2500
Box	NA
Paper	NA
Pallet	11

Hourly raw material cosumption (kg)	
00698-224	1,1
00701-231	0,2
00701-290	1,6

Hourly Packaging demands	
Tray	20
Box	NA
Paper	NA
Pallet	1 per shift

Setup time (Hr) : 1.5

Capacity(Parts/tray/Pallet)	
Tray	28
Pallet	6720

Lead Time Raw Material	
Average	0,166
Std Deviation	0,1

Lead Time Tray	
Average	0.75
Std Deviation	0.08

Lead Time Pallet	
Average	0.75
Std Deviation	0.08

Figure 21 Information of part 12788-134

As it can be seen in the figure, the file with the information of the part 12788-134 is been made. This part is been used in the assembly of the BMW Series 7. This file consists of different information along with the need of type of raw material and the packaging material.

This part 12788-134 consumes three different types of raw material they are 00698-224,00701-231, 00701-290. The quantities required are 140, 19, 200 kgs respectively. But this part uses the mixture of two different raw material. The hourly production of this part is 533 parts per hour.

Considering the packaging requirement of this part, it consumes a special type of tray which is 13099-364. One tray has the capacity of accommodating 28 parts per tray. The file has a feature of calculating its needs automatically. The data to be entered is just either the number of hours we have to produce the part or the number of the parts to be manufactured. Once this data is been introduced all the data about the needs of that part can be obtained directly. Also while making the logistic supply plan the lead time and deviation time is also considered along with the safety stock which is stored in the demudifier of the injection machine.

The hourly production is known so the hourly need of all parts can be calculated and it is easy to prepare the plan and make sure the machine work without the stoppage.