INSTITUTO SUPERIOR DE ENGENHARIA DO PORTO
MESTRADO EM ENGENHARIA MECÂNICA




# Reduzir o tempo não produtivo no processo de fundição com o metodo "SMED"

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Outubro de 2017

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Instituto Superior de Engenharia do Porto

# REDUCING SETUP TIME IN INJECTION PROCESS USING SMED METHODOLOGY

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ISEP – School of Engineering
Masters in Mechanical engineering

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Dissertation presented to ISEP – School of Engineering to fulfill the requirements necessary to obtain a Master's degree in Mechanical Engineering, carried out under the guidance of Mr.Hermenegildo Manuel Cristina Pereira

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# JURY

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# ACKNOWLEDGEMENTS

I would first like to thank my thesis advisor Mr.Hermenegildo Manuel Cristina Pereira at Instituto Superior de Engenharia do Porto. He was always there for me whenever I ran into a trouble or had a question about my research or writing. He consistently allowed this paper to be my own work, but steered me in the right direction whenever he thought I needed it.

I would also like to thank Mr. Ricardo Pereira Production Manager & Joao Pedro Teixeira Process Engineer Nova Fundinio Portugal for their constant support, suggestions and engagement through the learning process and formation of this dissertation.

I would like to acknowledge Mr. Franciso J.G. Silva the Co Ordinator of Mechanical Engineering at Isep for his ideas and guidance in allowing me to choose this title for my master dissertation.

Finally, I must express my very profound gratitude to my parents, friends for providing me with unfailing support and continuous encouragement throughout my years of study and through the process of researching and writing this thesis. This accomplishment would not have been possible without them. Thank you.

***KEYWORDS***

*Machine setup, Changeover, SMED, Lean Manufacturing, Setup time, Operations involved*

# ABSTRACT

This dissertation is based on reducing the setup time in an aluminium die casting company. The main purpose of the Single Minute Exchange Die (SMED) is to eliminate waste of time. Longer set-up time means that the production line is not productive and will left behind by their competitor. Nowadays, everything is being done faster and just-in-time, where manufactures need to produce product in faster rate and without neglecting the quality issue and deliver it to customer right on time. In this project, SMED had provided the method to eliminate waste of time with their techniques which is introduced by Mr. Shigeo Shingo. In SMED mould or die exchange should be less in 10minute and it took lots of improvement involves by the employee. The project objective is to reduce the current setup time that's happening in the industry. In overall with the help of everyone, especially from top management of company to their employee, SMED is successfully done and achieve the objective.

***PALAVRAS CHAVE***

*Configuração da Máquina, Mudança, SMED, Lean Manufacturing, Tempo de Configuração, Operações envolvidas*

# RESUMO

Esta dissertação baseia-se na redução do tempo de configuração em uma empresa de fundição de alumínio. O objetivo principal do Single Minute Exchange Die (SMED) é eliminar o desperdício de tempo. Um tempo de configuração mais longo significa que a linha de produção não é produtiva e será deixada para trás pelo competidor. Hoje em dia, tudo está sendo feito de forma mais rápida e justa, onde os fabricantes precisam produzir produtos em uma taxa mais rápida e sem negligenciar o problema de qualidade e entregá-lo ao cliente no prazo. Neste projeto, o SMED forneceu o método para eliminar o desperdício de tempo com suas técnicas, que é introduzido pelo Sr. Shigeo Shingo. No molde de SMED ou na troca de trocas, deve haver menos em 10 minutos e levou muitos. A melhoria envolve pelo empregado. O objetivo do projeto é reduzir o tempo de configuração atual que está acontecendo no setor. No geral, com a ajuda de todos, especialmente da alta administração da empresa para o empregado, o SMED é feito com sucesso e atinge o objetivo.

# LIST OF SYMBOLS AND ABBREVIATIONS

List of abbreviations

| Term | Designation |
|---|---|
| SMED | Single Minute Exchange of Die |
| TPS | Toyota Production System |
| QDC | Quick Die Change |
| JIT | Just In Time |
| OEE | Overall Equipment Efficiency |

List of units

| Term | Designation |
|---|---|
| MIN | Minutes |

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# INTRODUCTION

# 1 INTRODUCTION

## 1.1 Scope

In this globalization world, the small and medium enterprise companies are competing each other to be the best. For them who involve in automotive industries they have another challenge, tax from government that been reduce periodically. Now a day, target to enhance level of productivity, the ability and efficiency in all production fields are being number one priority in industries they involve. Competition in this day is depending on time, production cost and the ability to sell in manufacturing field.(Charles 2001). Back in few years ago, industries just focus on marketing and customer demand. Therefore, automotive industries take an action to involve in lean production system.

Fluctuation order with the small amount caused by the supplier mostly for the small-scale industries (SME) Lean production system gives the better result for industries to apply, however they had to use techniques from lean production system such as Single Minute Exchange Die-SMED, takt time, kanban and others. (Suri, 1988). Based on the effort to success through Lean Production System (LPS), one study is conduct to one of the SME companies at Nova Fundinio an aluminium die casting company Portugal.

Day by day, the industry had to meet the increase in customer demand while the technologies keep on developing. So, this is challenge for to meet the customer demand based on quality, product variant and deliveries. In Lean, one of the wastes is waste of inventory (Liker,2004). Waste of inventory is very difficult to control if there are so many products indifferent shape and size.

More significant problem happens when got a very high order for every model.
This makes each product from injection division to run in schedule. It is also involving die exchange time to be faster so that they can meet the customer demand. The solution is Single Minute Exchange Die (SMED). The study will be focusing on the reduction in the mould exchange based on the SMED system methodology.

## 1.2 Objectives

The main objective of this dissertation is to apply the SMED methodology in the foundry of Nova Fundinio to reduce the setup time during their change of die. The industry produces numerous parts with different variants. Based on the order placed by the customer they schedule the production. To satisfy the demand of the customer and to manage the production of different variants of product they must change the die. For changing the die in a machine, the time taken is long so to produce different variants they have to change die frequently but to change the die frequently the time for changing the die should be reduced. For reducing the time during setup, the SMED method is used to reduce the time. The objectives are to reduce the time during setup and to reduce or eliminate the activities which does not produce value for the product or for the industry.

## 1.3 Methodology

The main objective of the dissertation is to fully understand the concept of SMED which is a part of Lean manufacturing. The SMED methodology has different phases to execute. Each phase has its own operation that should be performed to implement the SMED.
First analysis of the foundry is taken to know about the current condition of the foundry. This gives a detailed idea about how the foundry operates and what are the operations that are performed by the operator during the change of die.
Then the operations are measured and recorded to analyse the internal and external activities. Then the internal and external activities are identified and separated. Then from the internal operations some of the operations are converted to external operations. Then proposal is proposed to eliminate certain operations.

## 1.4 Company History synthesis

Nova Fundinio, S.A. is an aluminium die casting company which is located in Porto, Portugal. Funidino not only produces die casting parts they also do machining, trimming, assembling and painting based on the customer requirements.
For the die casting they use high pressure die casting machines which varies from 250 to 1250 tons.

Fundinio's history dates to 1969 with the foundation of INDUFER, a pioneer in Portugal in high pressure aluminium die casting. During that time their main business activity was the production of home appliances, ironware and cutlery. In 1984 with the new company designation EMOACO after that they had begun working for the automotive and lighting industries. Fundinio is born in 1995 because of a company bailout program, absorbing all of EMOACO, and keeping its line of business.

In August 2010 NOVA FUNDINIO, S.A. is established, as a spinoff of fundinio. Today they continue their previous work with the automotive industry but they have expanded the client base to other industries such as telecommunication, railway transportation, Sound Systems, Rifles and so on. Fundinio is a developing Small-scale industry steadily expanding its group of clients from automobile to other sectors. Fundinio currently employ 100 workers within a facility of 11.600 $m^2$ including 7.700 $m^2$ of built area in senhora da hora located near to port.

Their objective is to produce highly technical demanding parts, through continuous improvement management philosophy, providing clients with the best quality products and service, respecting their specific requirements, at the most competitive prices, and preserving the environment.

## 1.5 Dissertation Organisation

| | |
|---|---|
| Chapter 1 | Introduction, Scope, Methodolgies and Company history |
| Chapter 2 | Bibliographic Work |
| Chapter 3 | Thesis Development |
| Chapter 4 | Conclusions and Future works |

# BIBLIOGRAPHIC WORK

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# 2 Introduction

Globalization has made the requirement for companies to increase their production flexibility by producing in smaller batches. This sort of production leads to significant increase on the frequency of the setup. The skill to perform quick setup process is usually recognized as an essential for the flexibility and the production of small batches (McIntoshet al., 2000). Flexibility and responsiveness to client requests are very important for success of the organization.

During the last decade the requirement for shorter setup time has increased over a wide range of industries. Change in demands of market conveys high demand on flexibility and costs in part because of the change from customer to the service provider. Market demand contains more item variations in parallel to customization. This evolution is isn't constrained to specific sort of industries rather it is a general phenomenon (Mehmet Cakmakci 2008).

The companies have learned to identify and eliminate waste, increasing both production and quality. There is direct relationship between lot size and setup time. The shorter the setup time, smaller the lot size. Manufacturers have to consider the changing demand in the global market. Shingo considered product differentiation, high quality, and speedy delivery, reasonable price became important terms for customers (Sheigo shingo 1985).

## 2.1 Lead Time of Manufacturing System

Due to the difficulties in satisfying the customer needs and competition in industries among other companies. Most of the time companies were intense in producing and delivering products in short time (Melnyk and Christensen, 2000).

Lead time is defined as the time that need to delivery product to customer or buyer (Wikipedia, 2009). There is lot of component in manufacturing lead time and one of those

is production lead time. Productions lead time divide by four elements

1. Waiting time
2. Setup
3. Transfer time
4. Production time

Waiting time set-up time, and transfer time is one of the non-value added to product and consider as a waste. Meanwhile, production time is the only element that gives value added to product. This is very important to eliminate nonvalue added elements and shorten overall lead time.

## 2.2 Definition of Setup time

Set up time can be defined as the elapsed time between the last product A leaving the machine and the first good product B coming out of the machine (Goubergen et al. 2002 a). Setup is not referring to the changing of mould or other equipment and products, but the entire production of the previous stop production so that no defective products that have been issued for the next product (Maynard and Zandin 2001).

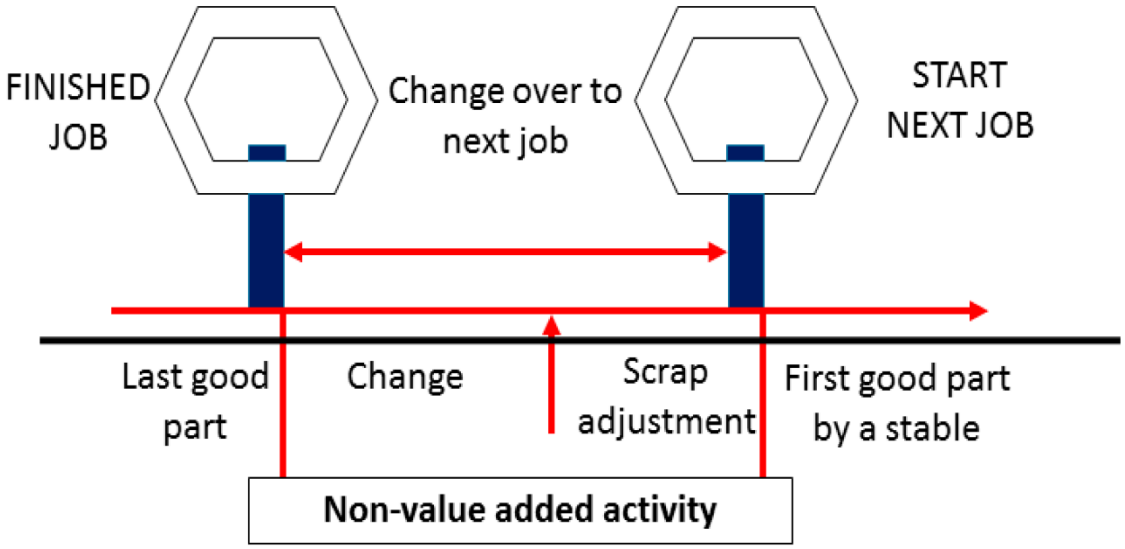



Figure 1 - Setup time

### 2.2.1 Reduce Setup Time

Reduction of setup time is always a great attention in the industries to reduce the downtime of the machine. Each time-consuming activity during the downtime of machine can increase the cost of production. Reduction of setup time and waste disposal is not as easy as it looks and can get very expensive if it is counted in detail. The highest achievement in the total session of downtime is to reduce the set-up time and changing time. This achievement can be achieved through good planning, redrawing the product, process sketching and upgrading existing machines and equipment if necessary (Roy 2005).

There are many reasons to improve setup time (Goubergen et al. 2002 a) categorizes those reasons in three main groups:
Flexibility: Due to an increasing number of products and product variants that must be offered to the customer and a decrease of the corresponding order quantities, a company must be able to react very quickly. If you need to produce small lot sizes, then you need to have short setup time (Shingo, 1985).

Bottleneck-capacities: Especially on these machines, every minute that is lost is wasted. Setups need to be minimized to maximize the capacity available for production.

Cost minimization: Since direct production costs are related to the machine performance, an overall equipment effectiveness (OEE) calculation can easily show the impact of setup reduction on overall machine performance (Nakkajima, 1988).

### 2.2.2 Importance of reducing Set up Time

Short set-up time can reduce the lot size and thus reduce inventory levels where existing products are delivered to customers more quickly. This will cause a reduction in inventory costs and other costs. Inventory costs can be reduced to a smaller lot size and a reduction in setup time by removing scrap, defects and restoration work. The benefits of reducing setup times/costs include: reduced expenses, increased production speed, increased output, reduced lead times, faster changeovers, increased competitiveness, increased profitability and satisfaction, enabling lean manufacturing, smoother flows, broader range of lot sizes, lower total cost curve, fewer stock outs, lower inventory, lower minimum order sizes, higher margins on orders above minimum, faster deliveries, and increased customer satisfaction (Mehmet Cakmakci 2008). Lead times play an important role in determining the ability of a company. the overall production costs can be reduced if production lead times are reduced. set-up time is one of the main components in the production lead times (production lead time). When the set-up time is reduced, eliminate indirect waste (Muda) in the production of excess (waste of overproduction).
Manufacturers have to take the changing market demand into consideration and take necessary actions to sustain in the global market for that they have to reduce the lead time, setup time, increase the production with different variants. At this point the terms “continuous process improvement” and “lean manufacturing” come into play (Mehmet Cakmakci 2008).

## 2.3 Lean Manufacturing

Lean manufacturing or lean production which is commonly known as “Lean”. Lean is a production practice that considers the expenses of resources for any objective other than creating values for the customers to be wasteful. Working from the perspective of the customers who consumes a product “value” is defined as any action or process that a customer would be willing to pay. Lean is centred on preserving value with less work. It is a wide-ranging set of techniques that is when combined and matures will allow you to reduce and then eliminate wastes (Lonnie Wilson). In an effort to be more productive many industries are adapting the lean manufacturing process in order to attain certain goals.

- Producing quality product

- Reducing the cost
- Total employee involvement
- Cultural approaches

By following lean methods, the results what the companies expect are:

- Higher annual profits
- Reduction of costs
- Lower delivery time
- Produce high quality products
- Retain employees
- Promote continuous improvement
- Willing to change

The lean production system makes all assembly and components from raw materials to a finished product into a single smooth flow. The lean production system offers for eliminating waste or excess in human resources, equipment, and materials (J. Temple Black, Steve L. Hunter). The main objectives of lean manufacturing are:

- Specify the customers value
- Identify all the actions to fetch a product from being a concept to being launch, from an order to delivery, from raw material to a finished product in customers hands.
- Remove the actions that does not add value and align every action to a add value as required by the customer.
- Analyse the results and start evaluating the process again

“Lean thinking banishes waste and create wealth in your corporation” which is stated in the foundation of lean philosophy (cholewicka-gozdik 2001). The heart of lean management is the act of “Polishing up” the company by the changes made I n their policies, particularly in the company’s assets and its management styles. The lean management concentrates on training their employees, shaping the staffs, attitude, and maintain positive public relation.

## 2.4 History of TPS

The Toyota Production System (TPS) arose out of necessity in response to the circumstances
surrounding the company. Many of the foundational concepts are old and unique to Toyota while others have their roots in more traditional sources. The oldest part of the production system is the concept of Jidoka which was created in 1902 by Toyoda founder Sakichi Toyoda. This concept pertains to notion of building in quality at the production process as well as enabling separation of man and machine for multi-process handling. The origins of this notion began in the Toyoda Spinning and Weaving company which was started by Sakichi Toyoda. Sakichi invented a loom that automatically

stopped whenever it detected that a thread was broken. This stopped the process from created defective material.
Later, in 1924 he created an automatic loom that allowed one person to operate multiple machines. The rights to manufacture the loom outside of Japan for were eventually sold to the Platt Brothers Ltd. in England. This money was then partially used to start an automotive division that was later spun off in 1937 as a separate business and company under Kiichiro Toyoda the son of Sakichi. The most famous element of the TPS is no doubt the Just-in-Time pillar of the production system. The phrase Just-in-Time was coined by Kiichiro Toyota in 1937 after the start of Toyota Motor Corporation. The company was quite poor and could not afford to waste money on excess equipment or materials in production. Everything was expected to be procured just in time and not too early or too late. Later elements developed in the 1950's including takt time, standardized work, kanban, and supermarkets added to the basis for JIT.

After World War II Taiichi Ohno a promising engineer in the Toyoda Spinning and Weaving Corporation was brought over to the automotive side of the business. He was given the task of improving operational productivity and driving in the concepts of Just-In-Time and Jidoka. He was eventually appointed machine shop manager of an engine plant and experimented with many concepts in production between the years of 1945-1955. His work and effort is largely what resulted in the formulation of what is now acknowledged as the Toyota Production System. There are numerous other people inside the company that contributed to the overall development of the company and the production system. The evolution of production system in the motor industry has been comprehensively covered has the story of Toyota production system which fuelled one of the greatest corporate success stories (Cusumano 1985, Ohno 1988, Fuji moto 1999).

## 2.5 Function of Toyota Production System

The Toyota production system symbolises manufacturing culture of continuous improvement based on setting morals aimed at eliminating waste through involvement of all the employees. The goal of the system is to reduce the timeline from the time an order is received up to the time the order tis delivered to the customer. This system produces the utmost quality, at lowest cost possible with the shortest lead time.
There are two primary pillars of the system. They are:

1. Just in Time (JIT)
2. Jidoka (Build in quality)

During the years many different principles, strategies, concepts and tools have been developed based on this single system. This system usually consists of eliminating of waste, continuous improvement, zero defects, multinational teams, integrating different functions, standardize practice of work (Bhat & Shetty 2013)

This figure below had a glance of the Toyota Production System (TPS). The picture shows us a glance of how the real production process in Toyota Motor is carried out. This shows how the system flows from one process to another and what the system to needed to make that happen.

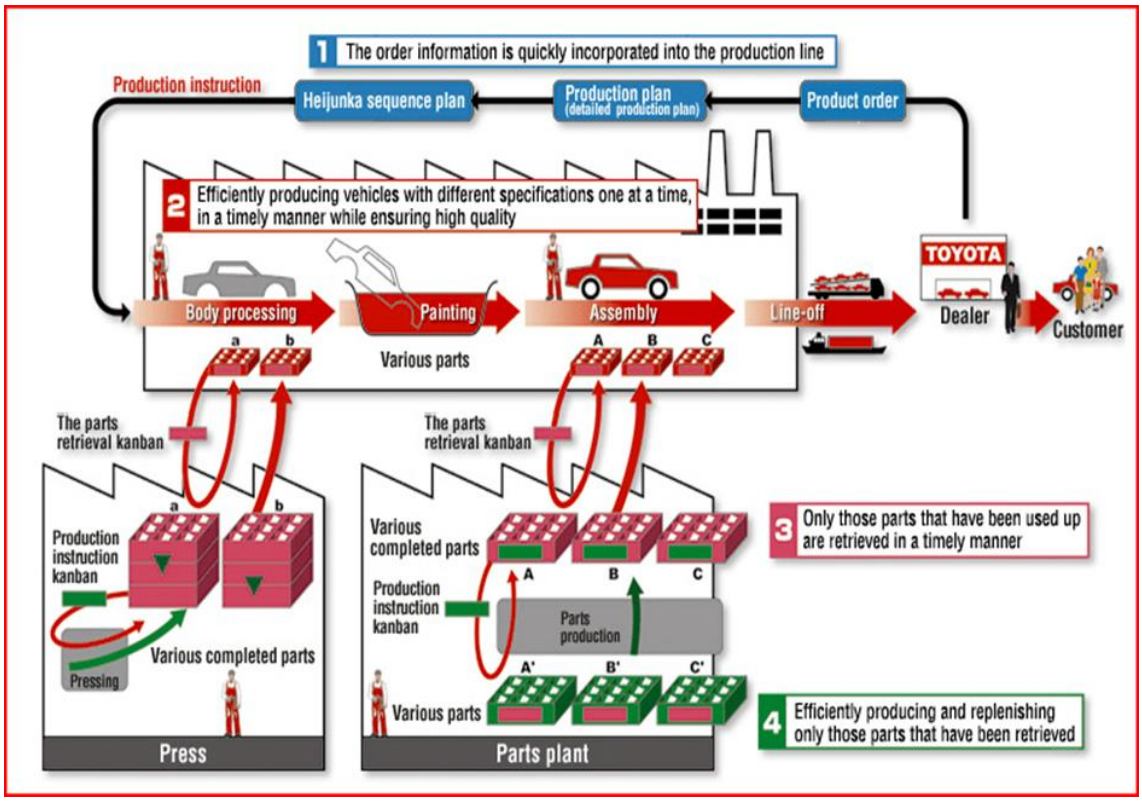



Figure 2 - Toyota Production System

### 2.5.1 JIT (Just In time)

The first one among the pillars of Toyota production system is Just in Time (JIT). The JIT concept targets to produce and deliver the right parts, in the right amount, at the right time using least essential sources. Just in Time is a tool that facilitates the internal process of an industry to adapt to sudden changes in customers demand by producing right product at the right time (Monden 1998). Just in Time is much more than a inventory reduction platform it structures the production process so that the part and the subassemblies are available at the shop floor when they are required “not too soon or nor too late”

Inventory and material flow is categorised into either push (traditional) or pull (Just in Time). The major difference between these is how they handle the demands from the customers. Just in Time aims to reduce the waiting time during the production process. By using this not only the cost of inventory is minimized but also the time for the production is also shortened. JIT concept is not stating about regulations or the way of organisation but it really focuses on the zero-inventory level (Canel 2000).

JIT begins as a method for reducing the inventories within the Japanese shipyards. Today JIT has advanced into a management philosophy enclosing a body of knowledge that is surrounding a thorough set of manufacturing principles and techniques. (Zipkin 1991) suggests that there is a misunderstanding in the concept so that leads to a different approach to JIT program in the west, which has the probability to cause more damage than causing more benefits. The development of JIT in Japan is accompanied by the solid cultural aspects. The development of JIT within the Toyota production plant did not take place independently of their strong cultural influence. The work ethics of Japan is one of the factors to be considered for their development. Their work ethics emerged shortly after the World WAR II and it was an essential part for the success of the Japanese economy. The Japanese work ethics involves the following models:

- Workers are highly motivated to pursue constant advancement even though current standards are met they think, there exit even higher standards for them to achieve.
- Companies focuses on group effort to achieve a common goal.
- Employees tend to keep on working in one company throughout their carer this allow them to hone their skills abilities and benefit the company by fulfilling their goals.
- They more likely to have high degree of group consciousness, sense of quality their individual differences are not celebrated.

### 2.5.2 Jidoka

Jidoka (Built in Quality) is the second pillar of the system. The Jidoka represents Building In quality at the process and facilitating separation of man from machine in work environment. Jidoka is a Japanese word which normally means automatic or automation. Toyota sets an explicit twist on this word by adding up what is known as “radical” in portraying kanji characters. The radical added to the left of one of the kanji characters in “Jidoka” means “human”.

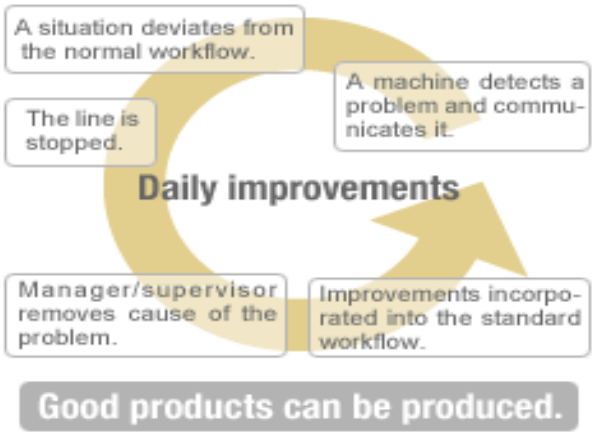



Figure 3 - Jidoka model

The original concept of Jidoka is very old and It goes back to the time of Toyoda Auto Loom Company. Mr. Sakichi Toyoda invented an automatic loom that would shut down as soon as a single thread is broke. This method saved a lot of materials from getting wasted and helped in highlighting the problems as soon as the problem occurred. This was the starting point of the Jidoka (Springer 2014). The TPS desires for processes that are efficient for making intellectual decisions and shutting down the machine automatically at the first sign of irregularity in its performance such as defect or any other problems. This automatic stop function supports from avoiding downstream, prevent injuries, limit machine damage, allows a better look at the current condition whenever there is a problem.

## 2.6 The Five Principles of Lean Production

The lean thinking is based on the Toyota production system and the system highly values five principles to achieve the customer demand They are:

1. Add value
2. Value stream mapping
3. Production flow
4. Pull system
5. Perfection

Add Value:

Value is defined as competence offered to the customer at the precise time and at a right price as recognised in each illustration by the customer. Value is the critical initial point of lean thinking and this is only being described by the end customer itself.

- Value added: Those activities definitely creates value.
- Type on waste: Activities that has no value but these are unavoidable with current technology or production techniques.
- Type two waste: Activities that creates no value but can be eliminated immediately.

Value stream mapping:

Value stream mapping is process of describing what happens to the product at each step of the production from design to order raw materials and to delivery. In the production line there will be certain activities required to design, order, and produce specific product from the concept to launch or from order to delivery. The details of these various activities are described through the value stream mapping.

Production flow:

The production flow is defined as progressive accomplishment of tasks along the value stream so that product continues from design to launch and raw materials delivered to customers with no stoppages.

Pull system:

This principle is defined as a system of pouring production and delivery instructions from the downstream to upstream in which nothing is produced by the upstream supplier until instructions or order is placed by the downstream suppliers for production.

Perfection:

This principle based on eliminating all the waste that are performed during the process. By completely eliminating all the waste activities down the value stream will create value (James P. Womack, Daniel T Jones 2003).

### 2.6.1 The Seven Wastes: Non value added activities in Lean Production

To fully understand the basic concept of the Toyota Production system or Lean manufacturing the phrase “waste “nature must be understood. In terms of Lean the phrase waste is stated as minimum amount of equipment, materials, parts and working time which would completely add value to the product.

The wastes are classified into 7 types:

1. Over production: Products are produced in greater quantities that needed by the customer. By producing higher products will create other wastes such as overstaffing, storage, and transportation costs because of inventory.
2. Waiting: This is the idle time created when the equipment’s, materials, information is stopped due to any fault or not ready when it is required.
3. Transporting: Transporting materials, parts, vehicles to and from the storage or moving the items in between the process.
4. Over processing: the process that does not create value or actions that are not important to the customers.
5. Inventories: This is about the parts, materials that are produced in excess of Just In Time requirements are to be settled in the inventory.
6. Moving: The unnecessary movements caused by the people which does not add value to the product.
7. Making defective parts: The parts that are produced with any kind of defects, error, rework or repair are considered as non-value added activities which does not have any values.

## 2.7 Lean Tools

There are different lean tools. They are:

1. 5S
2. Line balancing
3. Manufacturing cell
4. Continuous flow
5. Total productive maintenance
6. JIT
7. SMED
8. Kanban
9. Poke yoke
10. Kaizen
11. One-piece flow

## 2.8 Single Minute Exchange of Die (SMED)

### 2.8.1 Need for SMED

One of the main objectives of the any industrial companies has always been the improvement of its production system performance to achieve high quality products and increase the rate of production with different variants. For increasing the production with different variants, they needed to have change the variants frequently based on the customers demand. For achieving this the change in variants should be done in a minimum amount of time.

(Van goubergen.et.al 2002) indicated the three main reasons why the set-up reduction initiatives can be suitable any company to increase their flexibility by often conducting changeovers and lot size reduction, to increase the bottle neck capacity to increase the line availability for production, and to reduce the cost which production costs is related to efficiency of the equipment.

We obviously know that the time needed to change production from one product to another product is generally referred as product changeover time, and this time must be as minimum as possible for allowing manufacturing in very small quantities of different variety of products. This is the purpose of SMED methodology, one of the main important tools among the lean tools which provide great value in agile manufacturing. SMED aims in achieving the product changeover time in single digit values, i.e., less than 10 minutes.

### 2.8.2 History of SMED

Normally when we think of set-up reduction however our mind tends to automatically jumps to larger press machines found in stamping operations. Most set up reduction work today often goes by the more specific name of single minute exchange of die or SMED. This was not always the case however in the history of development of set-up reduction. Indeed, the term more widely used in the 1960's in Toyota and many companies was quick die change or QDC for short.

Where did QDC come from? (Michael Cusumano) points out in his history of the Japanese Automobile Industry, "It is one of the great ironies in the history of production management and technology transfer that the idea of rapid set-up, in addition to the time and motion studies that the Japanese used to cut cycle and idle times, were American.
Ohno first saw Danly stamping presses on a trip to the United States in the mid-1950's". In interviews in research books by Japanese authors entitled "Origins of the Toyota System" and "Formulation Development and Transformation of the Toyota Production System" both Mr. Taiichi Ohno and his early disciple Mr. Suzumura gave extensive credit to the Danly Corporation for development of the moving bolster mechanism and other key features for quick die change. These mechanisms greatly aided set-up reduction efforts in the company and are even today described by internal company history books as well as at the Toyota Commemorative Museum of Industry and Technology as revolutionary advances in stamping technology (Michael Cusumano 1985).

Once Mr. Ohno had successfully converted his engine, transmission, and chassis lines to the newer style of production that he envisioned he was rewarded with another promotion in the company to plant manager. Now in addition to the machine shops Mr. Ohno also picked up responsibility for the casting, forging, and stamping shops in the company. He now had responsibility for all the primary elements of manufacturing in the company and was a formidable presence. As such he was in a position starting in the early to mid-1950's to begin rolling out his methods more broadly to other areas of the company.

The pressure to reduce set-up time existed in the press shops before the mid 1950's. Frequently parts were needed downstream in welding or assembly as the presses had been making either the wrong type of item or the wrong quantity. Mr. Ohno insisted that parts be put on a renewal schedule and a basic form of a supermarket be implemented. This alteration in addition to targets requiring improved machine efficiency in turn put immense pressure on the press department to changeover stamping dies more rapidly than they had in the past.

In the late 1950's In the Honsha press shop there were about fifty stamping machines that were not in very good condition. The average changeover time on each varied from one to four hours depending upon the size and condition of the machine. Using a combination of operation instruction sheets and basic time studies of the process the department members observed there was much waste in the way they conducted changeovers and they started making small improvements. These changes included using carts for moving the dies as well as for loading and unloading operations. Adoptions of clamps and cylinders, visual markings, elimination of bolts, addition of locating pins, and standardization of die heights, as well as many other gradual improvements were added. Many ideas were adapted from the Danly machines. The net effect of all this was large however the average changeover time in the press shop was reduced to 15 minutes in 1962 and down to a mere 3 minutes in 1971. It is difficult in reflection to sort out the effects of the newer Danly style moving bolster type QDC machines and the set-up reduction endeavours on the older machines. Both were no doubt of great influence in reducing the noted average changeover times in the company.
The most popular name comes to mind when it comes to set-up reduction would be probably Mr. Shigeo Shingo. Due to his book that was originally published in 1983 and translated into English in 1985 the outer world of Japan learned that there was a method and a purpose to decrease lot sizes on stamping presses and other machines. The lessons were clear and logical. Separate internal work from external work. Move as much of the internal work to external work as possible. Eliminate needless fastening and minimize the use bolts. Use quick clamp devices. Reduce the need for any adjustment work. Standardize the method and improve it continuously. It was good sound advice and remains so to this day.

Mr. Shingo depicts the development of his SMED method in the following fashion. First, he notes two influential pre-events. The first was in 1950 at Toyo Kogyo (Mazda) where he realized there were fundamentally two types of work in press operations: internal set-up work and external set-up work. In 1957 he got a possibility to test his theory at the Mitsubishi Heavy Industry ship yards in Hiroshima. He encouraged the facility to set up a second planning table so that external work could be done in advance of needs. This eventually helped to increase productivity by 40% and help cut ship build time from four months to two months by his estimation.

Mr. Shingo's crowning moment with SMED development is in 1969 when he could put the pieces all together and reportedly helped reduce changeover time on Toyota's Honsha plant in a 1,000 ton press from four hours to one and a half hours. He was initially satisfied with that level of improvement but states that he was not satisfied with the results until when further instructions came from Toyota management to reduce the set-up time from that level to three minutes. After the initial shock wore off he states

that a flash of sudden inspiration occurred to him and he realized a further chance to shift more of the internal work to external work and scribbled several improvement ideas on a board. With this event a “systematic technique” for achieving SMED was born according to Mr. Shingo. Also, he states that the technique that spread from this event throughout Toyota and then other plants around the world.

The need for set-up reduction was likely obvious to many different people from the standpoints of machine availability, productivity improvement, minimizing capital expenditures, and reducing work-in process, etc. Thus, it should not be surprising that setup reduction, as we know it today, was the product of many people’s efforts. Even so, there are key events which are important in tracing the origins and development of set-up reduction.

### 2.8.3 SMED Approach

Single Minute Exchange of Die methodology is a theory and set of techniques which make it feasible to perform the set up and changeover operations in less than ten minutes (Shingo 1985). A set up or changeover embodies the whole process necessary to change from a production a product to a production of another variant until it is accomplished a definite production rate with quality (McIntosh 1996).

The implementation of SMED involves previous analysis to clearly apprehend the changeover process, to know each set of operations carried out during the changeover (Sousa 2009). (Shingo 1985) mentions that the setup operations are divided into two types: internal operations (which can only be performed while the machine is stopped) and external operations (that can be performed while the machine is operating). The implementation of this methodology consists of five distinct stages:

Stage 1: Classify activities into external, internal or to be eliminated.

Stage 2: Separate external work and internal work.

Stage 3: Convert internal work into external.

Stage 4: Streamline and reduce internal works.

Stage 5: Streamline and reduce external works.

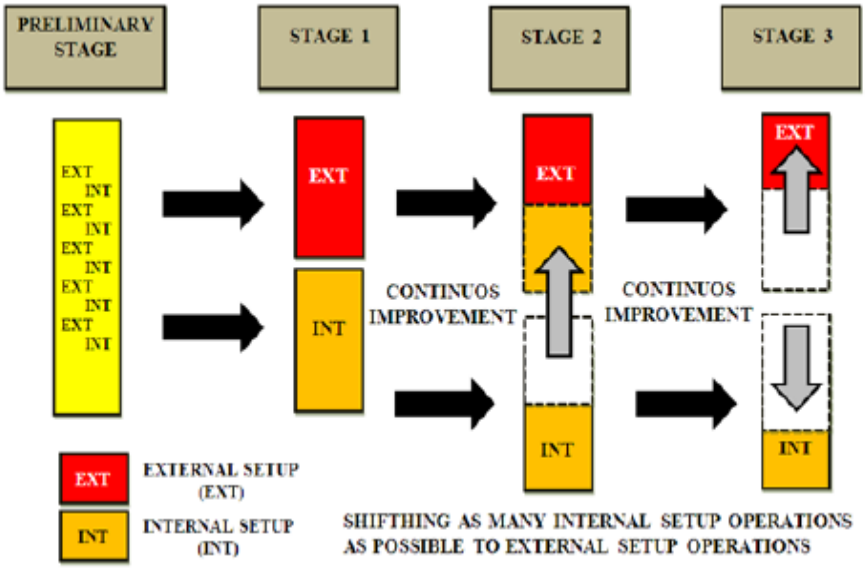



Figure 4 - Stages Of SMED

Stage 1: Classify activities into external, internal or to be eliminated
During the first stage all the activities must be organized based on whether they can be executed while the machine is working or not. These activities can be categorized using video recordings and routing diagrams. (Shingo 1985) suggests that interviewing the shop floor staff for collecting improvement ideas.

Stage 2: Separate external work and internal work
External work must be moved either at the beginning or the end of the changeover. Two options are considered for achieving it either organization and distribution of all external activities among operators involved in the changeover, resulting in external work remaining as it was. On the other hand, all the external work can be allocated to one specific operator called “external operator”. This can minimize waste by allocating movements and transportations in one single person.
After external work has been separated, internal work must be standardized, trying to balance tasks between different operators involved. Additionally, activities not required can be directly eliminated. Appropriate training is critical for achieving good results after this stage. Operators must be trained on the new changeover methodology (Shingo 1985). Some techniques suggested by Shingo include setting checklists for guaranteeing that external activities are performed before changeover starts, and establishing function checks. Also, layout analysis might be useful in combination with a 5S programme, to set in order all the elements necessary for the changeover. Dies, tools, and raw materials must be as close as possible to work area before changeover starts.

Stage 3: Convert internal work into external

This stage contains two important activities to be performed by the improvement team the detailed analysis of internal operations to detect wrong assumptions, and the research of different ways to convert these activities into external work.

Stage 4: Streamline and reduce internal works

At this stage, all the work is placed on optimizing all internal tasks. Some technical principles can be applied to reduce duration of internal activities. It is mentioned that some possible options to achieve this such as implementing parallel operations, using functional clamps, increasing mechanization of different machine components, reducing adjustments to minimum and designing effective tools to help on internal tasks. This step is time consuming and usually requires medium to high cost implementation ideas. It is necessary to evaluate the benefits of each proposal carefully to discard ideas that would not improve changeover time significantly (Shingo 1985).

Stage 5: Streamline and reduce external works

This is the result of breaking third stage into two separate phases. The purpose of this modification is to concentrate all resources on reducing internal times prior to streamlining external work. Reducing external work will not affect the changeover time all the activities are performed before and after the line has stopped. However, added value is gained when reducing internal time. Many companies focus on reducing duration of external activities with no results in changeover times.

# THESIS DEVELOPMENT

# 3 Methodology

## 3.1 SMED

A standout amongst the most critical destinations of SMED is to reduce the setup times through the disposal of the inefficiency identified with the change of tools. In this way what is planned with SMED is to attempt to separate the internal operations (i.e. to be specific the change of die or fitting of the equipment) which must be performed while the machine is in switched off condition and for external operations which are performed with the machine in switched on condition as in the case of preparation of tools.

Shigeo shingo establish in “Revolution in Manufacturing: the SMED system” (1985), this method should be implemented in four different phases.

Phase A: To find that there is no difference amongst internal and external setup operations was performed and subsequently manufacturing equipment’s stay put without moving for very long time. The primary goal, implementing the SMED strategy, is to think about the shop floor conditions in extraordinary detail through a production analysis, interviews with workers and recording of the setup operations.

Phase B: To isolate the external operations from the internal operations. Typically, this action spares 30% to 50% of the idle time for the setup operation. Pointing out this distinction is the key for making progress in implementing the SMED with string impact.

Phase C: To convert the maximum number of internal setup operations into external ones. It is imperative to review all the operations with a specific end goal to assess if some of the operations were wrongly considered as internal ones and change over those set of operations to external ones.

Phase D: To look for a very deliberate change of every essential operation of internal and external setup operations developing solutions to accomplish distinctive tasks in a less demanding, faster and more secure way.

The Table systemizes the four phases of SMED methodology

| SMED Phase | Scope | Tasks and Tools |
|---|---|---|
| A | Kick off a setup improvement | (1) Analyse the shop floor activities to differentiate internal from external operations |
| B | Separate internal and external operations | (2) Reporting checklists<br>(3) Stating tasks by worker<br>(4) Improvising tool transportation |
| C | Convert internal to external operations | (5) Previous preparation of tasks<br>(6) Automation of operations<br>(7) Applying different tools |
| D | Improve all aspects of the setup operation | (8) The improvement of tool transportation and warehousing<br>(9) Elimination of settings, calibrations and adjustments<br>(10) The automation of operations |

Table 1 - SMED in a setup improvement

## 3.2 DMAIC

These four different phases are carried out by using DMAIC method which is also a lean method. SMED is a step by step process which follows the DMAIC. It provides categories for the analysis phase and a procedure for the improvement phase. Control is provided by the development of a standard procedure.

It refers to:

1. Define
2. Measure
3. Analyse
4. Improve
5. Control

This is a five phase iterative method and the results we obtained will be better and after several implementation and improvement of process.

The Table systemizes the five phases of DMAIC method.

| DMAIC Phase | Scope | Discerption | Tools to can be used | SMED Phase |
|---|---|---|---|---|
| 1 | Define | Define your goals, | SIPOC diagram<br>Project charter | A |
| 2 | Measure | Measure the parameters example data collected. | Box plot<br>Process observation*<br>histogram<br>FMEA | A<br>B |
| 3 | Analyse | Analyse the data and find the root cause for the problem. | Pareto chart,<br>Correlation analysis<br>Scatter plot.<br>Pareto chart*<br>Brainstorming*<br>Nonvalue analysis | C |
| 4 | Improve | Suggesting the improvement action | 5S*<br>Kaizen*<br>TPM | D |
| 5 | Control | Controlling the new or the process that is in action. | SPC<br>Control chart<br>Quality checks* | |

Table 2 - Phases of DMAIC

* -Indicates that they are used

## 3.3 Setup Improvement

### 3.3.1 Define

The main objective of this project is to reduce the current setup time in die casting machine using the SMED methodology. For that detailed description of the process that is performed during the setup is explained by explaining the different parts that are involved

The die casting technology used is cold chamber die casting. The molten aluminium is poured into the sleeve by a spoon and injected into the die using the force generated by a hydraulic piston. The setup takes by moving and replacing certain parts of the casting equipment to install the die going to be used.

The parts of die casting, usually moved on change are as follows.

- Fixed part of die
- Movable part of die
- Sleeve
- Block
- Piston
- Spoon

### 3.3.2 Measure

For the measurement the data is collected from June to September of year 2017. The data is taken from various machines but mainly concentrated on the 1000-ton machines (IP 1000 & C 1000) and there are data regarding the other machines IP 360, IP 700, C 250.
The data are measured using stopwatch. The time is noted for each operation performed by the operator. By this we get to know what is done by operator during the change of die. The data has different parts based on that it is measured. The different parts are as follows.

- Removal of fixed part of die
- Removal of movable part of die
- Removal and assembly of sleeve, block & plunger
- Insert fixed part
- Insert movable part of die
- Preheating
- First good piece

The Table shows IP 1000 data with change of sleeve :

IP 1000 data with change of sleeve

| | ASSEMBLY OF DIE | | | |
|---|---|---|---|---|
| | | | | |
| | | | | |
| Machine No | **IP 1000** | Date | **20-07-17** | |
| Part No | **4841 TO 4229** | Start Time | **7.30 AM** | |
| Part Name | **SUNVIAUTO TO MNPO** | End Time | **3.30 PM** | |
| S.NO | Activity Description | Internal | External | Time(MIN) |
| | | | | |
| | | | | |
| | | | | |
| | **REMOVAL OF FIXED PART OF DIE** | | | **22** |
| | | | | |
| | **REMOVAL OF MOVABLE PART OF DIE** | | | **18** |
| | | | | |
| | **REMOVAL AND FIXING OF SLEEVE&BLOCK&PLUNGER** | | | |
| 1 | Search of tools | External | | **6.42** |
| 2 | Remove sleeve from bed | Internal | | **2.22** |
| 3 | Carry sleeve from M F | Internal | | **3.43** |
| 4 | Clean the sleeve | External | | **0.38** |
| 5 | Went to take measuring tape to measure dia of new sleeve | External | | **3.13** |
| 6 | Unhook the old sleeve and clean the new sleeve | External | | **1.34** |
| 7 | Hook the new sleeve carry from F M | Internal | | **4.16** |
| 8 | Clean the bed and apply grease to the sleeve and the block | Internal | | **1.01** |
| 9 | Place the sleeve in position to insert it into the block | Internal | | **2.44** |
| 10 | Operator went to take the wooden blocks | External | | **6.39** |
| 11 | Insert the sleeve into the block | Internal | | **5.18** |
| 12 | Went to keep the wooden blocks | External | | **17.05** |
| 13 | Remove the plunger and check the bed | Internal | | **5.36** |
| | | | | |
| | **INSERT THE FIXED PART OF DIE** | | | |
| 14 | Carry the crane from M F | Internal | | **0.33** |
| 15 | Hook the new fixed part and carry it to from F M | Internal | | **4.2** |
| 16 | Insert the die into the bed | Internal | | **1.58** |
| 17 | Insert and tighten the clamps | Internal | | **21.16** |

| | | | | |
|---|---|---|---|---|
| | **INSERT THE MOVABLE PART OF DIE & PLUNGER** | | | |
| 18 | Carry the die from M F | Internal | | **1.24** |
| 19 | Hook the movable die to the crane | Internal | | **1.43** |
| 20 | Carry the die from F M | Internal | | **3.47** |
| 21 | Place the movable parallel to the fixed part of die | Internal | | **5.45** |
| 22 | Adjust the machine | Internal | | **2.09** |
| 23 | Insert movable to the fixed | Internal | | **9.18** |
| 24 | Insert and tighten the rods | Internal | | **8.16** |
| 25 | Insert and tighten the backscrews | Internal | | **3.31** |
| 26 | Insert and tighten the clamps | Internal | | **8.53** |
| 27 | Tighten the backscrews | Internal | | **1.41** |
| 28 | Search for suitable clamps | External | | **18.08** |
| 29 | connect hosepipes | Internal | | **70** |
| 30 | Operator went to take the new plunger | External | | **8.5** |
| 31 | Operator changing the piston of plunger | Internal | | **8.29** |
| 32 | Hosepipes | | | **69** |
| | | | | |
| | **PREHEATING THE DIE** | | | |
| 33 | Preheat | Internal | | **47** |
| | | | | |
| | | | | |
| | **FIRST GOOD PIECE** | | | |
| 34 | Production Approval | | External | **43.45** |
| 35 | Quality Approval | | External | **30** |
| | TOTAL HOURS | | | 8 Hrs |

Table 3 - IP1000 Data Change with Sleeve

## IP 1000 Without change of sleeve

| | ASSEMBLY OF DIE | | | |
|---|---|---|---|---|
| Machine No | **IP 1000** | Date | **27-07-17** | |
| Part No | **4843 TO 4553** | Start Time | **7.30 AM** | |
| Part Name | **SUNVIAUTO TO BORGWARNER** | End Time | **1.45 PM** | |
| S.NO | Activity Description | Internal | External | Time(MIN) |
| | **REMOVAL OF FIXED PART OF DIE** | | | **40** |
| | **REMOVE THE MOVABLE PART OF DIE** | | | |
| 1 | Hook the die to crane and remove clamps | Internal | | **2.55** |
| 2 | Remove the die from bed | Internal | | **4.07** |
| 3 | Remove the rods | Internal | | **3.02** |
| 4 | Carry die from M F | Internal | | **6.36** |
| | Waiting for the forklift to take the old die | External | | |
| | **REMOVAL AND INSERT SLEEVE & BLOCK & PLUNGER** | | | **No Change** |
| | **INSERT FIXED PART OF DIE** | | | |
| 5 | Hook the fixed part of die to the crane | Internal | | **2.17** |
| 6 | Carry the die from F M | Internal | | **1.34** |
| 7 | Insert the die to the bed | Internal | | **3.26** |
| 8 | Adjusting the die position | Internal | | **3.07** |
| 9 | Insert and tighten the clamps on one side | Internal | | **2.4** |
| 10 | Operator takes break | External | | **1.57** |
| 11 | Insert and tighten the clamps on other side | Internal | | **18.19** |
| 12 | Unhook the crane and carry itfrom M F | Internal | | **1.59** |
| 13 | Hook the die to the crane | Internal | | **1.16** |
| 14 | Operator went to take hosepipes | Internal | | **4.32** |
| 15 | Break | | External | **17.4** |
| 16 | Operator connects hosepipes | Internal | | **3.01** |
| | **INSERT MOVABLE PART OF DIE** | | | |
| 17 | Carry die from F M | Internal | | **2.34** |
| 18 | Postioning the movable parallel to fixed part of die | Internal | | **0.57** |
| 19 | Adjust the ramp of the machine | Internal | | **4.54** |
| 20 | Waiting time for the bed to attain pressure | Internal | | **2.55** |
| 21 | Insert the movable into fixed | Internal | | **5.5** |
| 22 | Insert and tighten the rods | Internal | | **8.02** |
| 23 | Insert and tighten the clamps by chief | Internal | | **15.15** |
| | Operator inserts and tighten the backscrew | Internal | | |
| 24 | Unhook the crane and carry it from M F | Internal | | **2.49** |
| 25 | Break taken by operator | External | | **3.05** |
| 26 | Connect the hosepipes | Internal | | **26.27** |
| 27 | Operator went to help another operator | External | | **3.26** |
| 28 | Continue connecting hosepipes | Internal | | **14.51** |
| 29 | Chief instructs operator about the connection of hosepipes | External | | **2.39** |
| 30 | Connect the oil hoses from thermoregulator | | | **37.25** |
| | **PREHEATING THE DIE** | | | |
| 31 | Preheat | Internal | | **69** |
| | **FIRST GOOD PIECE** | | | |
| 32 | Production Approval | | External | **40.23** |
| 33 | Quality Approval | | External | **35** |
| | TOTAL HOURS | | | **5 hr 10 min** |

Table 4 - IP 1000 Data without change of sleeve

## C1000 with change of sleeve

| | ASSEMBLY OF DIE | | | |
|---|---|---|---|---|
| | | | | |
| | | | | |
| Machine No | **C 1000** | Date | **07-09-17** | |
| Part No | **4827 TO 4824** | Start Time | **7.20 AM** | |
| Part Name | **HUTCHINSON** | End Time | **4.16 PM** | |
| S.NO | Activity Description | Internal | External | Time(MIN) |
| | | | | |
| | | | | |
| | **REMOVAL OF FIXED PART OF DIE** | | | |
| | Fixed part removed by 8 | | | **40** |
| | | | | |
| | | | | |
| | **REMOVAL OF MOVABLE PART OF DIE** | | | |
| 1 | Remove the movable part from the bed | Internal | | **1.54** |
| 2 | Remove the rods | Internal | | **1.53** |
| 3 | Remove the hosepipes | Internal | | **7.38** |
| 4 | Operator went to take tool | External | | **1.31** |
| 5 | Lower the actuators | Internal | | **1.02** |
| 6 | Carry the die from M F | Internal | | **2.13** |
| 7 | No work done by the operator | External | | **2.49** |
| 8 | Insert stand to keep the die down | External | | **4.51** |
| 9 | Unhook the crane from the die | Internal | | **1.21** |
| | | Internal | | |
| | | | | |
| | **REMOVAL AND FIXING OF SLEEVE & BLOCK** | | | |
| 10 | Carry the crane from F M | Internal | | **1.5** |
| 11 | time taken by operator place the plunger in position to push the sleeve out | Internal | | **2.35** |
| 12 | Remove the sleeve and tie it to the rope and hook it to the crane | Internal | | **3.1** |
| 13 | Remove the sleeve out of bed | Internal | | **1.57** |
| 14 | break ( 9 to 9.15 ) | | External | **18.23** |
| 15 | Carry the sleeve from M F | Internal | | **1.13** |
| 16 | Remove the bolts from block and insert a screw to hook the crane | Internal | | **2.36** |
| 17 | Carry the crane from F M | Internal | | **2.32** |
| 18 | Hook the crane to the block | Internal | | **1.2** |
| 19 | Operator went to help other operator | External | | **4.05** |
| 20 | Adjust the plunger position to push the block out of bed | Internal | | **3.06** |
| 21 | Remove the block from the bed | Internal | | **1.1** |
| 22 | Carry it from M F | Internal | | **1.58** |
| 23 | Search for Suitable screw to insert it into the new block | External | | **1.43** |
| 24 | Hook the new block to the crane | Internal | | **2.31** |
| 25 | Clean the blocko | External | | **2.42** |
| 26 | Carry it from F M | Internal | | **1.52** |
| 27 | Insert the block into the bed | Internal | | **3.01** |
| 28 | Insert and tighten the screws into the blocko | Internal | | **1.56** |
| 29 | Carry the crane from M F | Internal | | **2.29** |
| 30 | No work done by the operator | External | | **3.41** |
| 31 | Hook the sleeve to the crane and clean the sleeve | Internal | | **3.49** |
| 32 | Carry the sleeve from M F | Internal | | **3** |
| 33 | Operator went to take the grease | External | | **3.37** |
| 34 | Hook the new sleeve and carry it from F M | Internal | | **1.1** |
| 35 | Operator went to take wooden tools | External | | **1** |
| 36 | Waiting time for the machine to attain pressure | Internal | | **5.53** |
| 37 | Insert the camisa into the blocko | Internal | | **4.5** |
| 38 | Operator went back to keep the wooden blocks | External | | **2.4** |
| 39 | Carry the crane from M F | Internal | | **1.05** |
| 40 | No work done by the operator | External | | **2.46** |
| | | | | |

| | | | | |
|---|---|---|---|---|
| | **INSERT FIXED PART OF DIE** | | | |
| 41 | Carry the crane from machine to die storage | Internal | | **2.06** |
| 42 | Hook the Fixed part of die to the crane | Internal | | **1.31** |
| 43 | Carry the die from F M | Internal | | **4.27** |
| 44 | Insert the die to the bed | Internal | | **3.52** |
| 45 | Insert and tighten the clamps | Internal | | **34.03** |
| 46 | No work done by the operator | External | | **2.47** |
| 47 | Unhook the crane from the die and carry it from M F | Internal | | **3.14** |
| | | | | |
| | | | | |
| | **INSERT MOVABLE PART OF DIE** | | | |
| 48 | Hook the movable to the crane | Internal | | **5.19** |
| 49 | Carry the die from F M | Internal | | **4.32** |
| 50 | Clean and connect the hosepipes to the die | External | | **8.08** |
| 51 | Carry the die from F M | Internal | | **2.27** |
| 52 | Position the die paralle to the fixed part of die | Internal | | **5.5** |
| 53 | Lunch | | External | **40.41** |
| 54 | Insert the movable to the fixed part of die | Internal | | **4.43** |
| 55 | Insert and tighten the rods | Internal | | **8.13** |
| 56 | Insert and tighten the clamps | Internal | | **11.31** |
| 57 | Connect the hosepipes | Internal | | **57.01** |
| | | | | |
| | | | | |
| | **PREHEATING THE DIE** | | | |
| 58 | Preheat | Internal | | **41.27** |
| 59 | Shift change ( 2.41 pm to 3.22 pm ) | External | | **41.36** |
| | | | | |
| | | | | |
| | **FIRST GOOD PIECE** | | | |
| 60 | Production Approval | | External | **43.29** |
| 61 | Quality Approval | | External | **30** |
| | TOTAL HOUR | | | 8 hr 56 min |
| | | | | |

Table 5 – C 1000 Data with change of sleeve

## C 1000 Without change of sleeve

| | ASSEMBLY OF DIE | | | |
|---|---|---|---|---|
| | | | | |
| | | | | |
| Machine No | **C 1000** | Date | **24-08-17** | |
| Part No | **4824** TO **4909** | Start Time | **7.40 AM** | |
| Part Name | **HUTCHINSON** TO **NTN** | End Time | **14.52 PM** | |
| S.NO | Activity Description | Internal | External | Time(MIN) |
| | | | | |
| | **REMOVAL OF FIXED PART OF DIE** | | | |
| | Fixed removed by 8.15 | | | **35** |
| | **REMOVAL OF MOVABLE PART OF DIE** | | | |
| 1 | Carry the die from M F | Internal | | **5.55** |
| 2 | Unhook the die from crane and carry it from F M | Internal | | **3.22** |
| 3 | No work done by operator | External | | **1.28** |
| 4 | Clean the bed | External | | **1.34** |
| 5 | No work done by operator | External | | **1** |
| | **REMOVAL AND FIXING OF SLEEVE & BLOCK** | | | **No change** |
| | **INSERT FIXED PART OF DIE** | | | |
| 6 | Hook the fixed part of die to the crane | Internal | | **1.52** |
| 7 | Carry the die from F M | Internal | | **3.48** |
| 8 | Fix te die to the bed | Internal | | **6.37** |
| 9 | Break ( 9 to 9.15 ) | | External | **7.24** |
| 10 | Insert and tighten the clamp (Shift chief continues the setup) | Internal | | **4.2** |
| 11 | Chief went to other machine | Internal | | **2.14** |
| 12 | Chief went solve the problem | External | | **7.09** |
| 13 | Operator return back from break and continues to tighten the clamps | Internal | | **19.11** |
| 14 | Connect the hosepipes | Internal | | **9.11** |
| | **INSERT MOVABLE PART OF DIE** | | | |
| 15 | Unhook and Carry the crane from M F | Internal | | **1.01** |
| 16 | Hook the die and carry the crane from F M | Internal | | **3.04** |
| 17 | Position the die paralle to the fixed part of the die | Internal | | **0.31** |
| 18 | Waiting time for the machine to attain pressure | Internal | | **11.59** |
| 19 | Insert the die into the fixed part | Internal | | **11.08** |
| 20 | Insert and tighten the rods | Internal | | **5.51** |
| 21 | Insert and tighten the clamps | Internal | | **13.47** |
| 22 | Unhook the crane the die | Internal | | **0.27** |
| 23 | Connect the hosepipes | Internal | | **28.31** |
| 24 | Time taken to repair the sprayer | External | | **20.25** |
| | **PREHEATING THE DIE** | | | |
| 25 | Preheat | Internal | | **75** |
| | Sprayer repair | External | | **85** |
| | Clean the machine | External | | **34.47** |
| | **FIRST GOOD PIECE** | | | |
| 26 | Production Approval | | External | **30.45** |
| 27 | Quality Approval | | External | **45** |
| | TOTAL HOURS | | | **7hr12min** |

Table 6 - C 1000 without change of sleeve

The above data represents two different situations during the change of die. The two different situations are:

- Only the die is changed
- Die is changed along with the sleeve and block

Sometimes only the sleeve is changed there is no need for the operator to change the block because if the die that has to be replaced has different diameter but to be placed in the same position of the previous die then the same block is used there is no need for the operator to change the block.
Regarding the data for measuring the time for set up usually the company uses a chart and it is given to all the operators in foundry. This chart is mainly for the production oriented. This chart doesn't have any description regarding the setup duration time. This chart contains timing of entire shift in a format of 30 minutes. The operators have to fill the chart regarding the shift every day. With this chart the management can get to know about the timings of each machine and the chart contains details if the machine is stopped running the operator has to mark the reason the chart consists of various reasons that contribute to stoppage of machine.
The company doesn't have the data regarding detailed description of the operations that are performed by the operators. These recorded data gave the detailed picture about how each small factor that contribute in affecting the total time of the die change. The setup change in IP 1000 & C 1000 are not frequent it occurs weekly once sometime two weeks per once but in other small machine C250, IP 360, IP 700 the frequency of setup change is high once or twice per week or even higher. This based on the clients demand and their production and their inventory.
One of the main phase in SMED is to identify the internal and external works from the set of operations during die change and convert some of the internal works into external works. With this data we could Identify which are the external works and which are the internal works and even some of the internal operations which could be done as external operations are mentioned in the data itself. The external works which are done before converting are transportation of die from maintenance to foundry, break, lunch, approval of production and approval of quality are the only external works.

The other data that are collected is attached in annexure

### 3.3.3 Analyse

The data collected are now analysed using the lean tools, pareto diagram and with spaghetti diagram. The pareto analysis is done for each part of the operation and also for the whole combined.

PARETO DIAGRAM:

Pareto diagram is defined by Vilfredo Pareto an Italian economist in the 19th century to show that a percentage of wealth is occupied by a relatively very few percentage of population.

This lead to the pareto principle which states that 80% of any problem is accounted by 20 % of the factors. The main idea is to analyse as priority, the vital few problems rather than the trivial many.

C1000 WITH CHANGE OF SLEEVE:

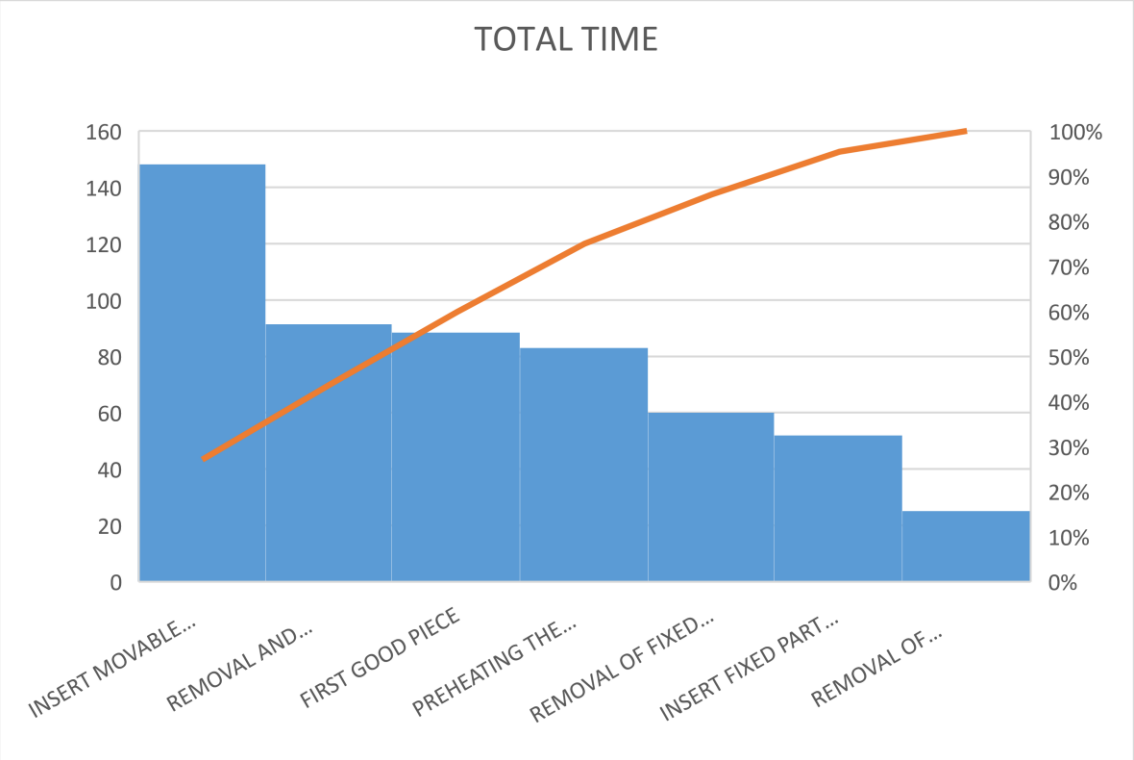



Figure 5 - Graph – Total time of C 1000 with Change of sleeve

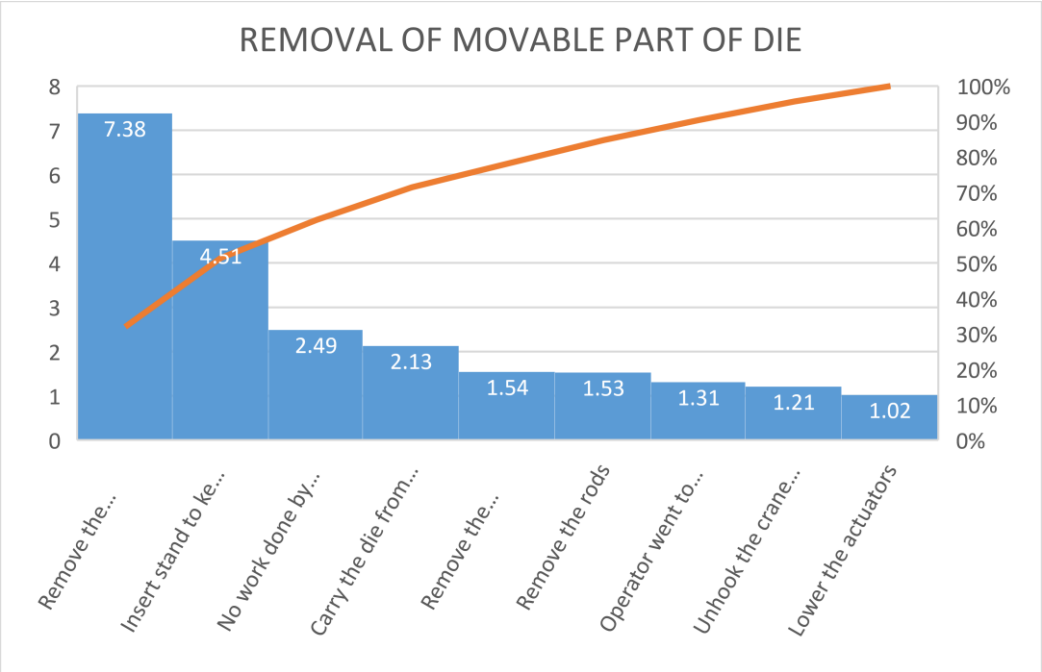



Figure 7 - Graph- C 1000 Removal of Movable part of die

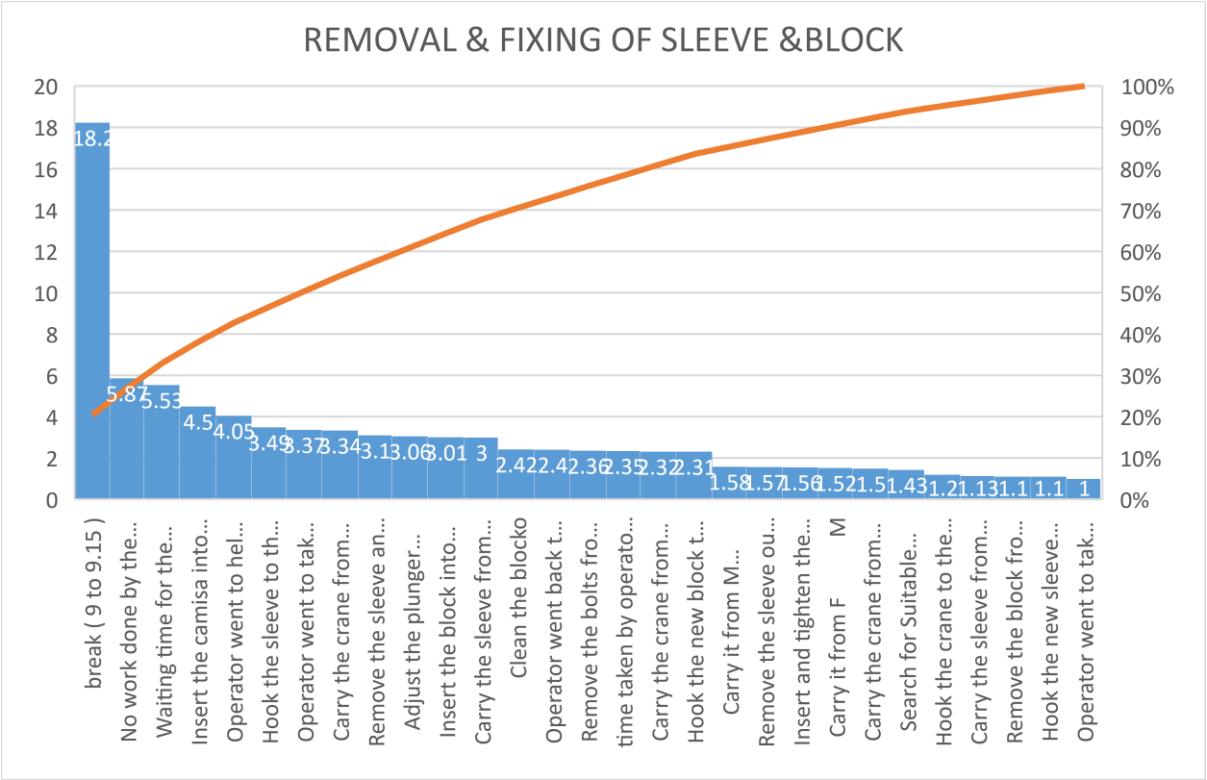



Figure 6 - Graph – C 1000 Removal & Fixing of Sleeve

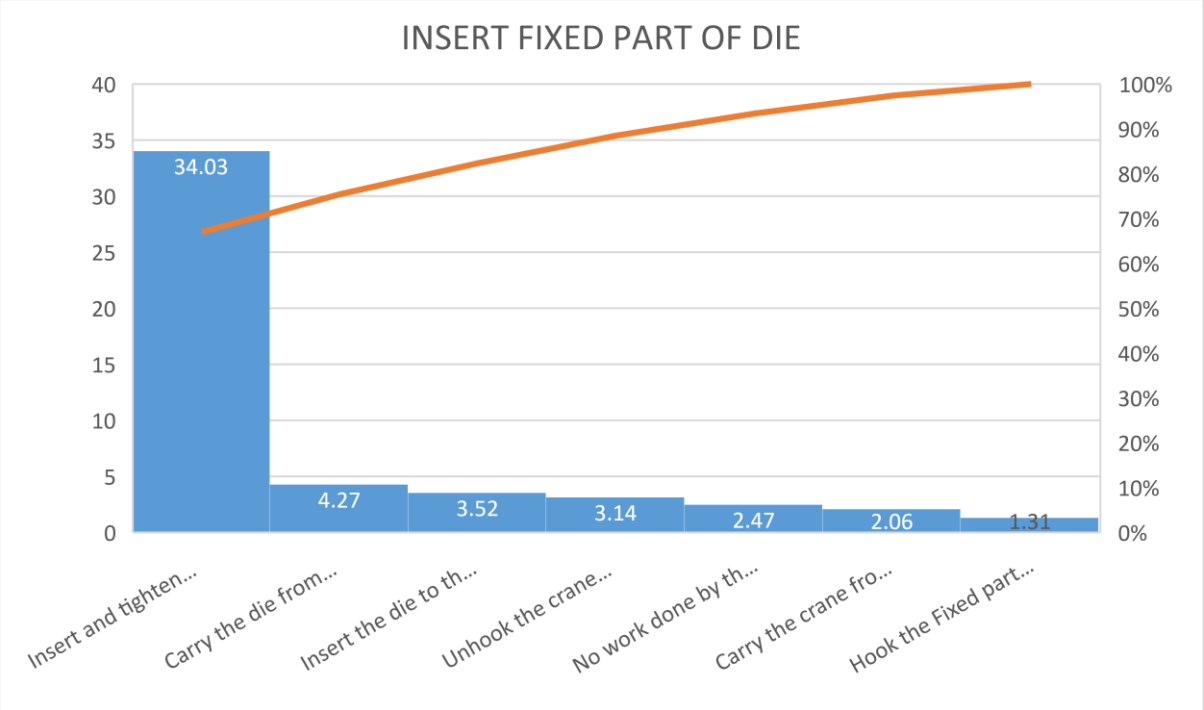



Figure 8 - C 1000 Insert fixed path of die

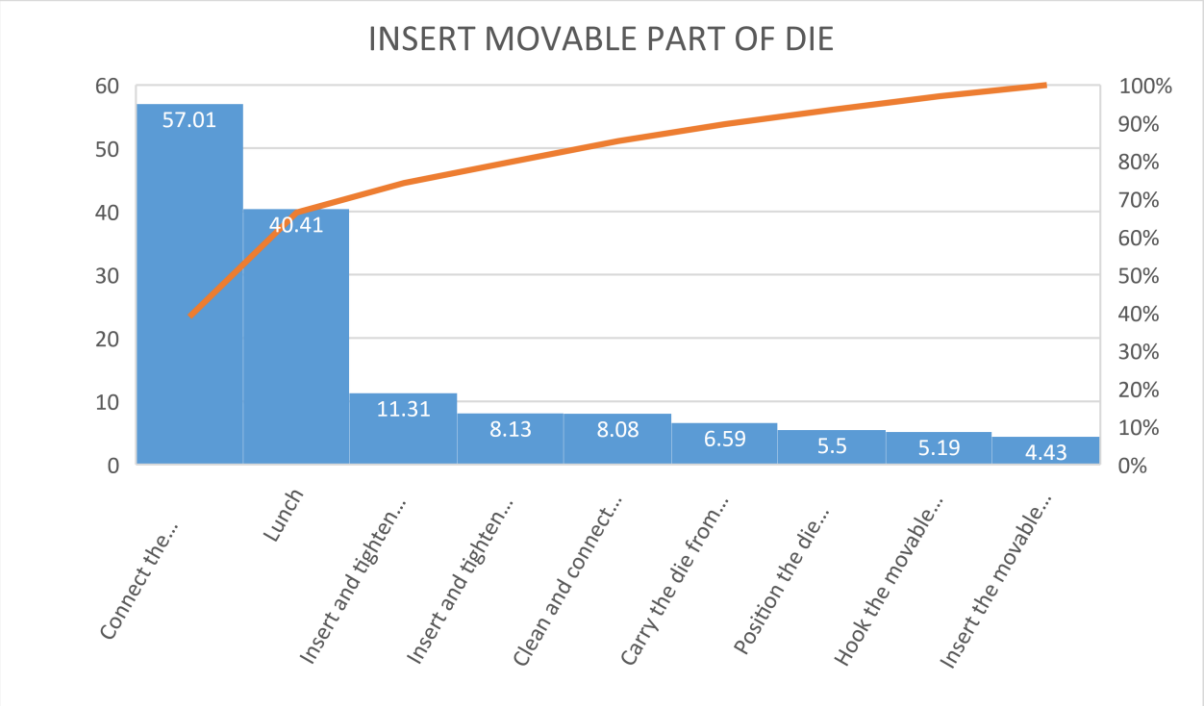



Figure 9 - Graph - C 1000 Insert movable part of Die

## IP 1000 with Change of Sleeve

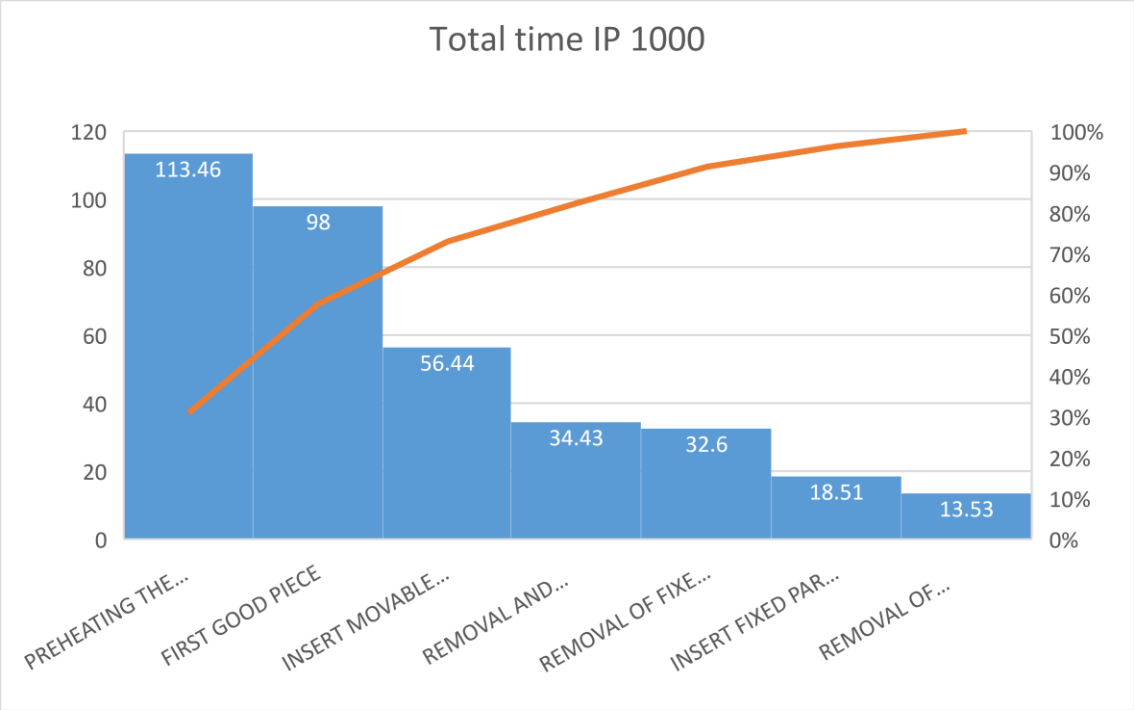



Figure 10 - Graph - IP 1000 Total Time for Setup with change of Sleeve

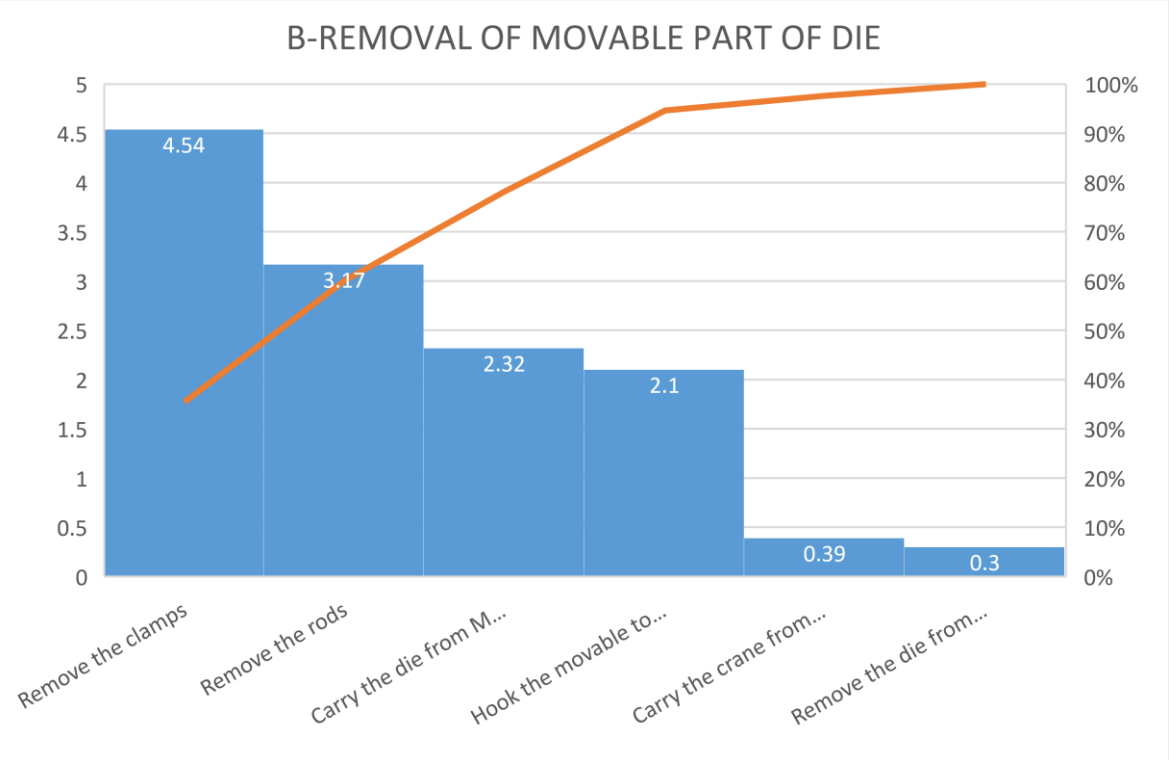



Figure 11 - Graph - IP 1000 Removal of Movable Part

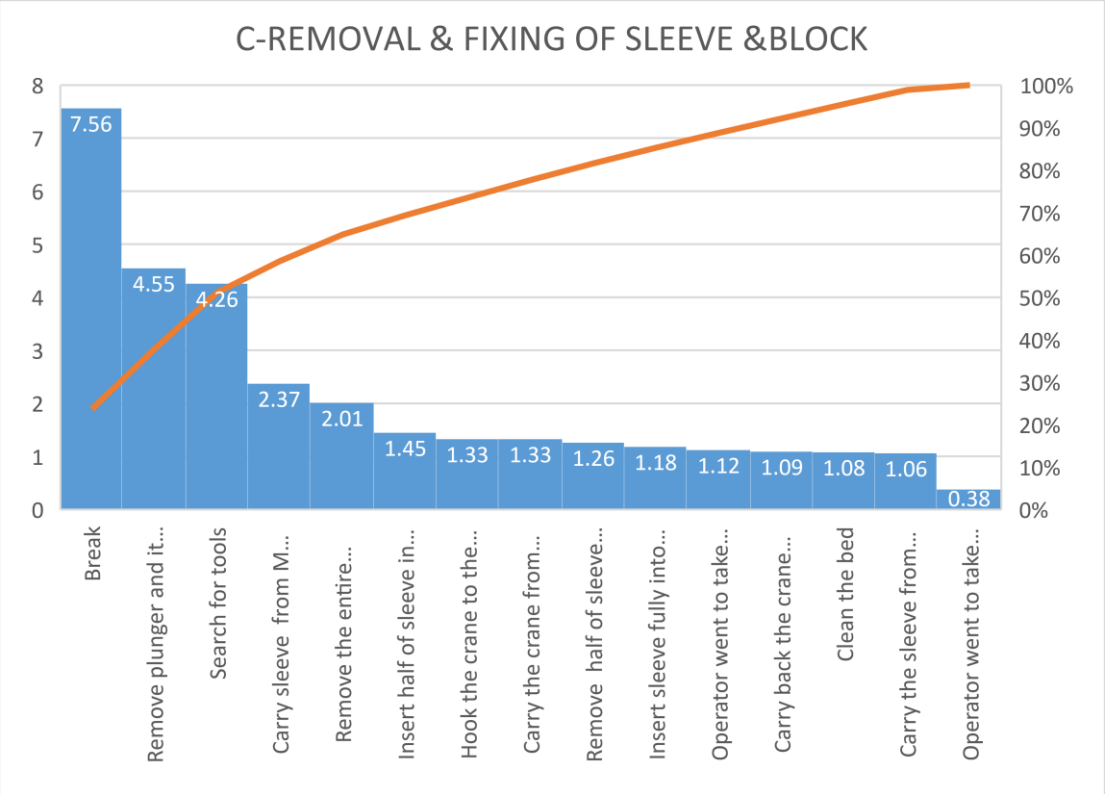



Figure 13 -Graph - IP 1000 Removal & Assembly of Sleeve and Block

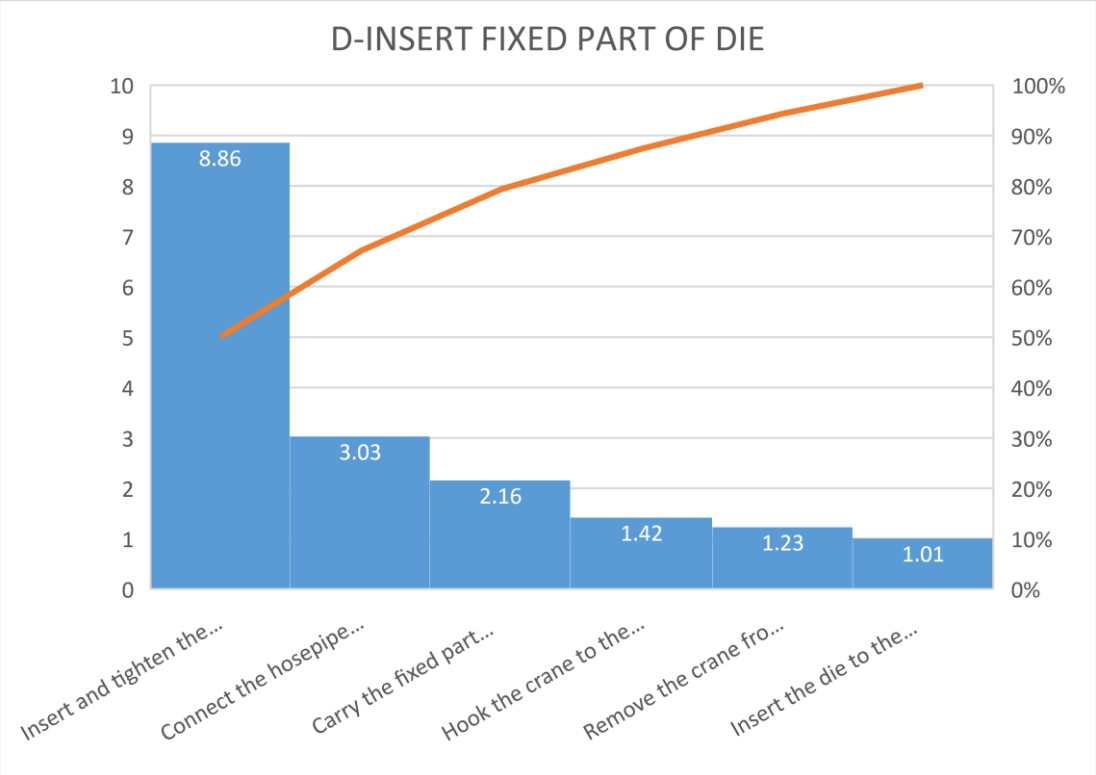



Figure 12 - Graph - IP 1000 Insert fixed part of Die

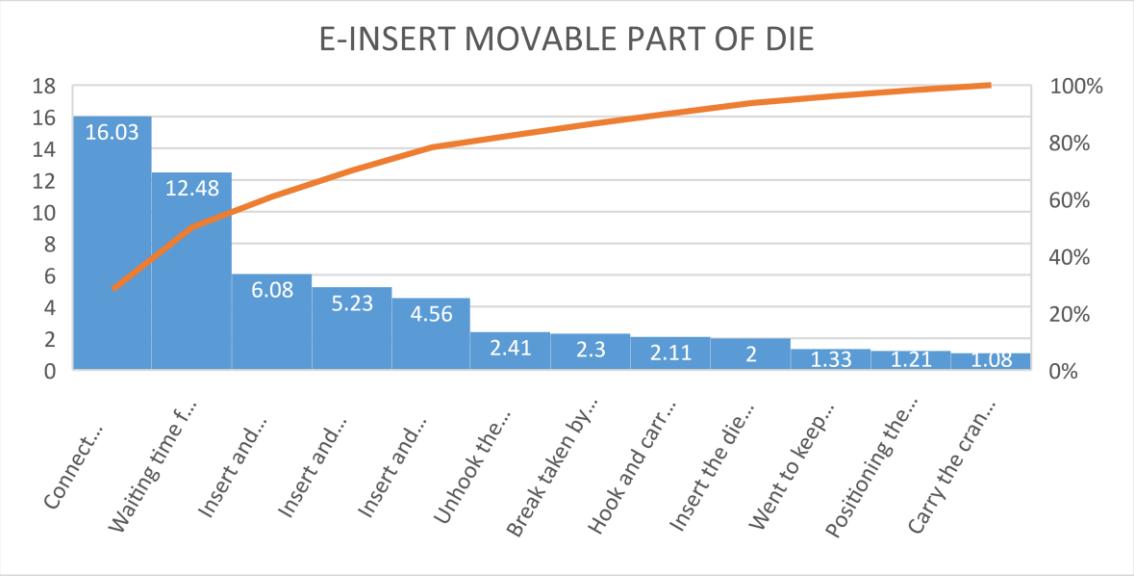



Figure 14 - Graph - IP 1000 Insert movable part of die

These pareto diagrams on based on a single data, the factors that are available in this graph are all performed in single operation. There are six set of data collected and studied among them only one set of data is displayed here, the other set of data are attached in an annexure

A pareto diagram was designed for each separate part of tasks involved in change of die. The left side of the pareto indicates the time of each tasks performed during the set up and the right-hand side of the pareto indicates the cumulative percentage of the timing of each one.

From this graph we could point out that which are the tasks that takes more time during each part of the set-up change. To get better results, it's important to know about the each and every tasks performed this gives a detailed structure of how the operator does the set-up change. And from this we may know that where the problem lies and to define a solution to solve the major issues concerned with the vital problems with a great impact in the time for changing the die.

## Spaghetti diagram

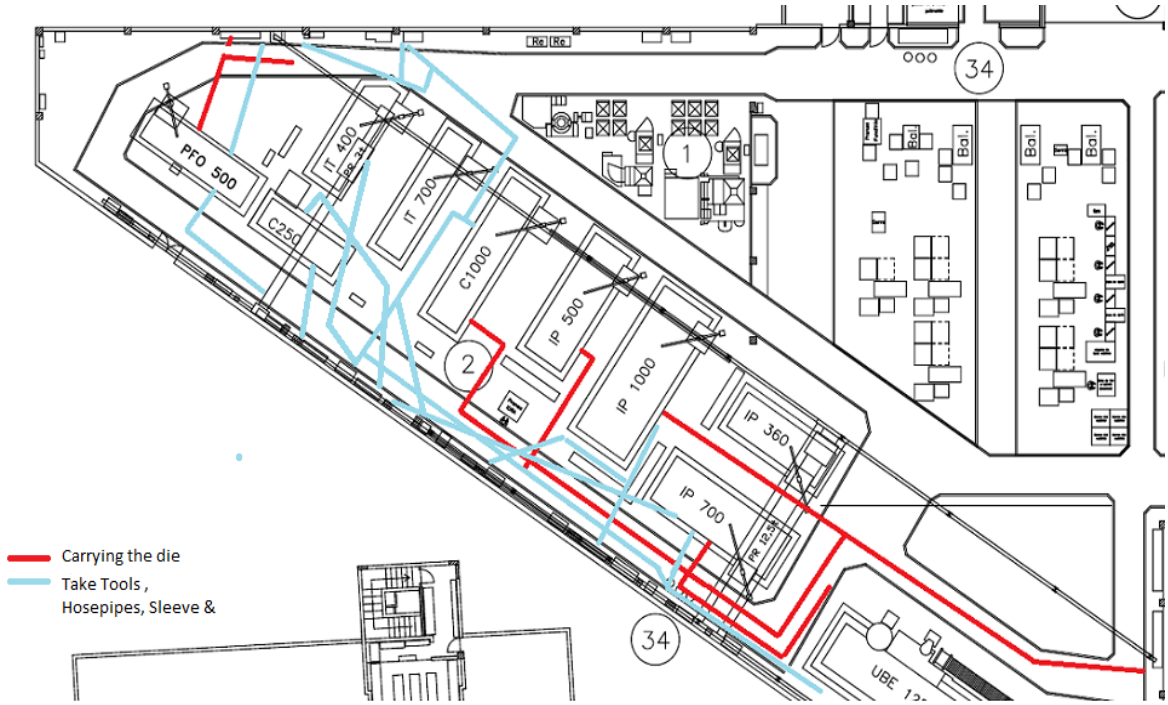



Figure 15 - Spaghetti diagram of the foundry

A spaghetti plot or spaghetti diagram is a lean visual tool to show the current flows through the system. While marking the flow of the system it appears to be in shape of noodles that seems the term spaghetti coined. It's used in the industries to track the routing within the factory, marking the flow in this manner can lower the inefficiency within the flow of the system.

The tool is used to record or visualize the flow of work carried out during the set-up change within the foundry. In this the layout of the foundry is taken and the movement of the operator during the setup is marked. It is marked in two different colours.

Red colour indicates the flow of workers carrying the dies removed or to be assembled from the storage area to a machine or from a machine to die storage area.

Blue colour indicates the flow of workers in search of tools, wooden blocks, sleeve, block, hosepipes. Each machine has a separate rack in that the sleeve and block for the machine is placed. From this we get to know how the operators move in an inefficient manner. If we eliminate these unnecessary movements the setup flow will be fluent and it has a greater impact during die change.

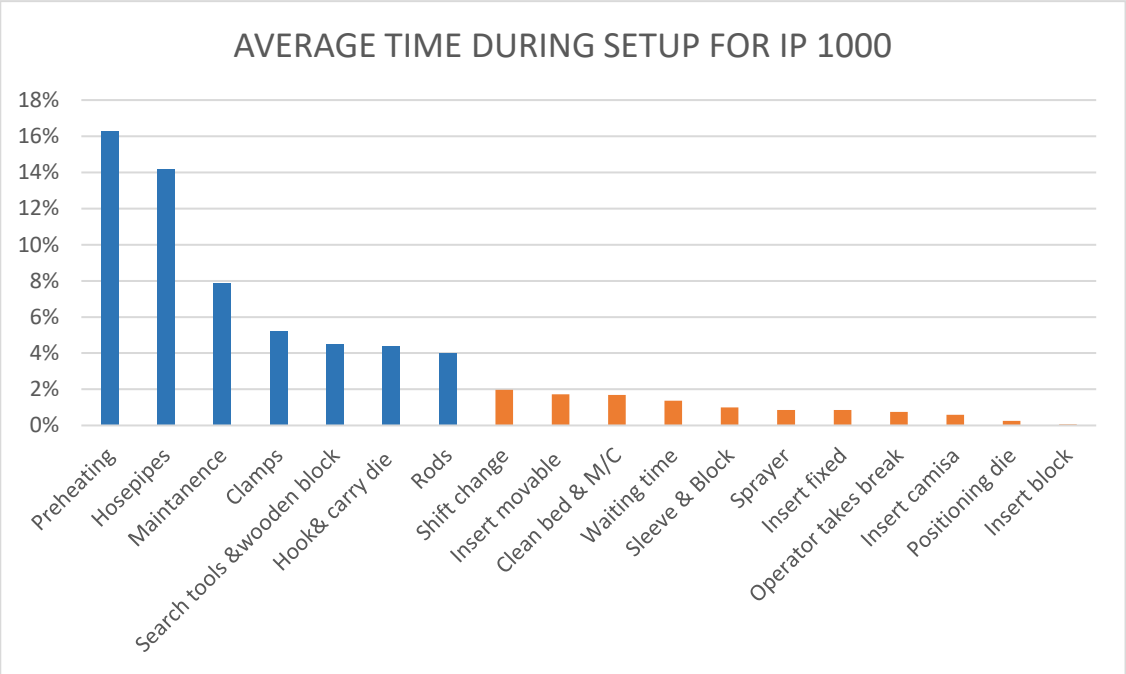



Figure 16 - Graph - Average time during setup in IP 1000

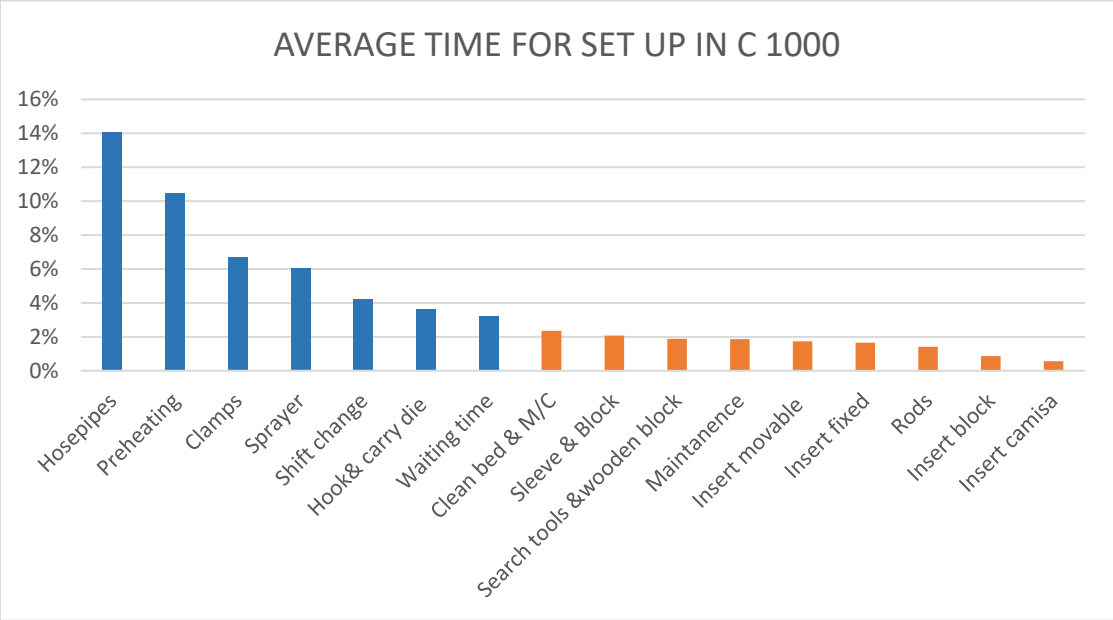
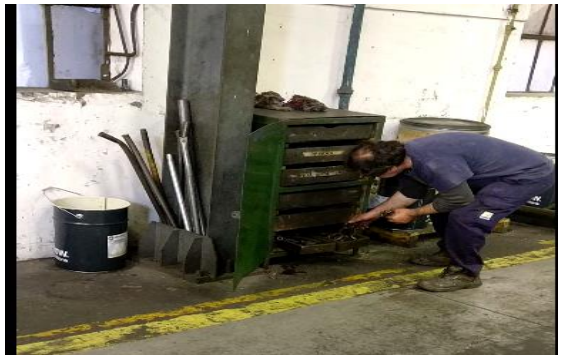


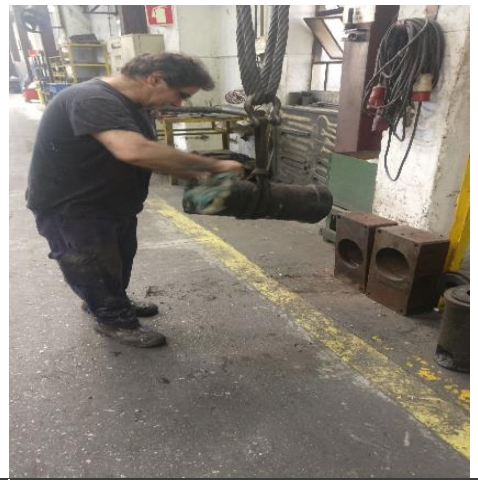

Figure 17 - Average time for setup in C 1000

This graph is about average of the six data of IP1000 & five data of C 1000 which is shown separately. The tasks reported in the graph is performed in both removal and assemble of die. In the pareto we analyse each and every tasks to identify these with the huge impact. This graph shows the average of them, identified in pareto diagram

The set of tasks performed during the set-up change for all the machines are all similar and only amount of time required varies from small machines to large machines. From the pareto and spaghetti diagram we got the quantitative data.
The qualitative analysis during the change of dies is done and the main reasons for that are mentioned in Table 7 including root cause and priority of the proposal.

| PROBLEMS | ROOT CAUSE | **PROPOSAL** | **EVIDENCE** | PRIORITY |
|---|---|---|---|---|
| 1.Search for tools | Tools are scattered and or not available at one place | Make a trolley for tools so that they can move the trolley close to machine when they perform change. |  | 1 |
| 2.Search for wooden tools & block | These are needed to push sleeve into the bed they are placed far from the machine and some of them are broken old blocks. They are not available in its position. | Either each machine can have separate blocks and kept near to the machine or should be brought to the machine before the set up itself. |  | 1 |

| PROBLEMS | ROOT CAUSE | **PROPOSAL** | **EVIDENCE** | PRIORITY |
|---|---|---|---|---|
| | | | | 1 |
| 3.Search of measuring tape | Measuring tape is not in the tool box it is given to operators and they lock it in their locker. When they need the tape, they go to the locker and bring it to measure and again went back to keep the tape in locker. | Always there should be a tape with tool box or the operators should carry with them or they can hang the tape in their job table | | |

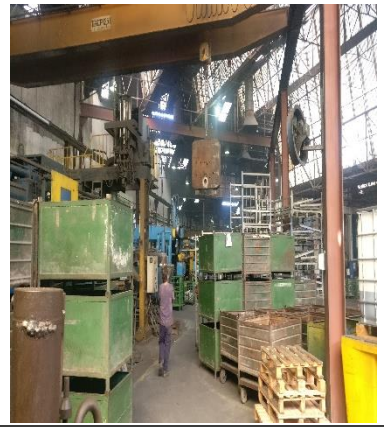
| PROBLEMS | ROOT CAUSE | **PROPOSAL** | **EVIDENCE** | PRIORITY |
|---|---|---|---|---|
| 5. Cleaning of sleeve & block they are cleaned during setup | If the die changes sleeve must be changed to suitable die the old sleeve will be covered by dried grease and dust It is not cleaned so when they reuse the same sleeve for its still be dirty so they clean the sleeve to fit into the bed | It can be solved by cleaning the sleeve not during the setup maybe before or after setup. (new sleeve can be cleaned before setup and old sleeve can be cleaned after setup) |  | 1 |
| 6. Connect hosepipes | Operator gets confused that which should be connected to outlet and inlet. Some connections are under the die. | Should have only three set connections.<br>Inlet to die.<br>Die to die.<br>Die to outlet.<br>There should be no connections under the die. | | **2** |

| PROBLEMS | ROOT CAUSE | **PROPOSAL** | **EVIDENCE** | PRIORITY |
|---|---|---|---|---|
| 7. Waiting time for die | Improper communication & planning. Bringing the die separately to the foundry | The die should be brought together to the foundry. Communication should be given clearly to the maintenance | | **1** |

| | | | | |
|---|---|---|---|---|
| 8Automatic coolant sprayer | Due to continuous use the aluminium dust particles got settled in sprayer tubes and cause blockage due to this the chief must clean once the new die got fixed and it is not done by operator so the operator has to wait for chief or the chief will do it once he is free from other works | Instead of having external sprayer we can have the sprayer inside the die itself. The cleaning can done by chief during the preheating time of mould or during the break or lunch hour of operator or the sprayer can be removed and cleaned beforehand if the sprayer not needed for ongoing mould. |  | **3** |

| PROBLEMS | ROOT CAUSE | **PROPOSAL** | **EVIDENCE** | PRIORITY |
|---|---|---|---|---|

| | | | | |
|---|---|---|---|---|
| 9.Insert and tightening of clamps | Interference of the hydraulic tubes in the path of clamps due to this the operator doesn't have enough room to tighten it. | Instead of doing manually using airgun can reduce the struggle to tighten the clamps. Each machine should have its own set of clamps should not borrow clamps from other machines. |  | **3** |
| 10.Preheating of die | Die is heated after assembling it is heated internally by oil for some dies heated using burners it takes an hour or more to heat the die | Die can be preheated before assembling it or we can also heat it externally by using burners while it is heated internally. Also using new technologies like heating by laser, flameless burners, radiations with blasting hot air at the same time or the die can be preheated before bringing it to the machine. | | **3** |

| PROBLEMS | ROOT CAUSE | **PROPOSAL** | **EVIDENCE** | PRIORITY |
|---|---|---|---|---|
| 11.Time taken to carry the die from floor to machine is high | Distance between the machine and the place where die is placed sometimes for IP 1000 & C 1000 machines the die is placed about 15 or 20 metres apart from machine | The die should be placed as close as possible to the machine. Double hoist cranes are more useful in these kinds of works. |  | **2** |
| 12.Time for removal of both fixed and movable part | Both fixed and movable parts are removed separately | Both parts can be removed at a time by joining both the dies before removal and have a lock to prevent both the parts from loosening while removal. | | **3** |
| 13.Oil in thermo regulator | low level of oil in thermo regulator<br>the operator doesn't know it until problem occurs during the heating of die | The operator must check the level of oil every day or before the setup itself should make record of it | | **1** |

| PROBLEMS | ROOT CAUSE | **PROPOSAL** | **EVIDENCE** | PRIORITY |
|---|---|---|---|---|
| 14.Number of operators | Each setup is performed by single operator that takes more time to perform the setup single handily. | Co-operation and synchronised work of two or more operators would reduce the time of setup tremendously. |  | **3** |
| 15.Quality Approval | The approval from the quality department is the final part of the setup change for that the quality department member must collect the samples to check it. | To get the report earlier the operator or chief itself can give the first ok part to the quality department instead of waiting for the quality department members to come and collect the first ok part | | **1** |

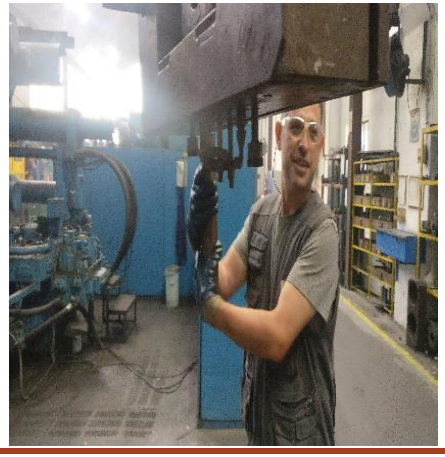
| | | | | |
|---|---|---|---|---|
| 16.Sleeves | Sleeves have different diameters and they are used based on the need but the operator must verify or he should check by measuring its diameter because it doesn't have any indications regarding diameter. | Each diameter sleeve types should have identification on it or it should be organised and placed according to the diameter |  | **2** |
| 17.Fixing stand to place the die down | For some of the die while removing a stand is fixed to place it down on the floor because these dies has a hydraulic actuator unit that placed under it to prevent it from hitting the ground while keeping the die to floor these stands are fixed | Instead of fixing we can place a stand of certain height that can prevent the actuators from hitting the ground while keeping it. |  | **2** |

Table 7 - Reasons & priority table

The priority given to these qualitative collections of data are in the form of numbers 1<2<3

# PRIORITY MATRIX:

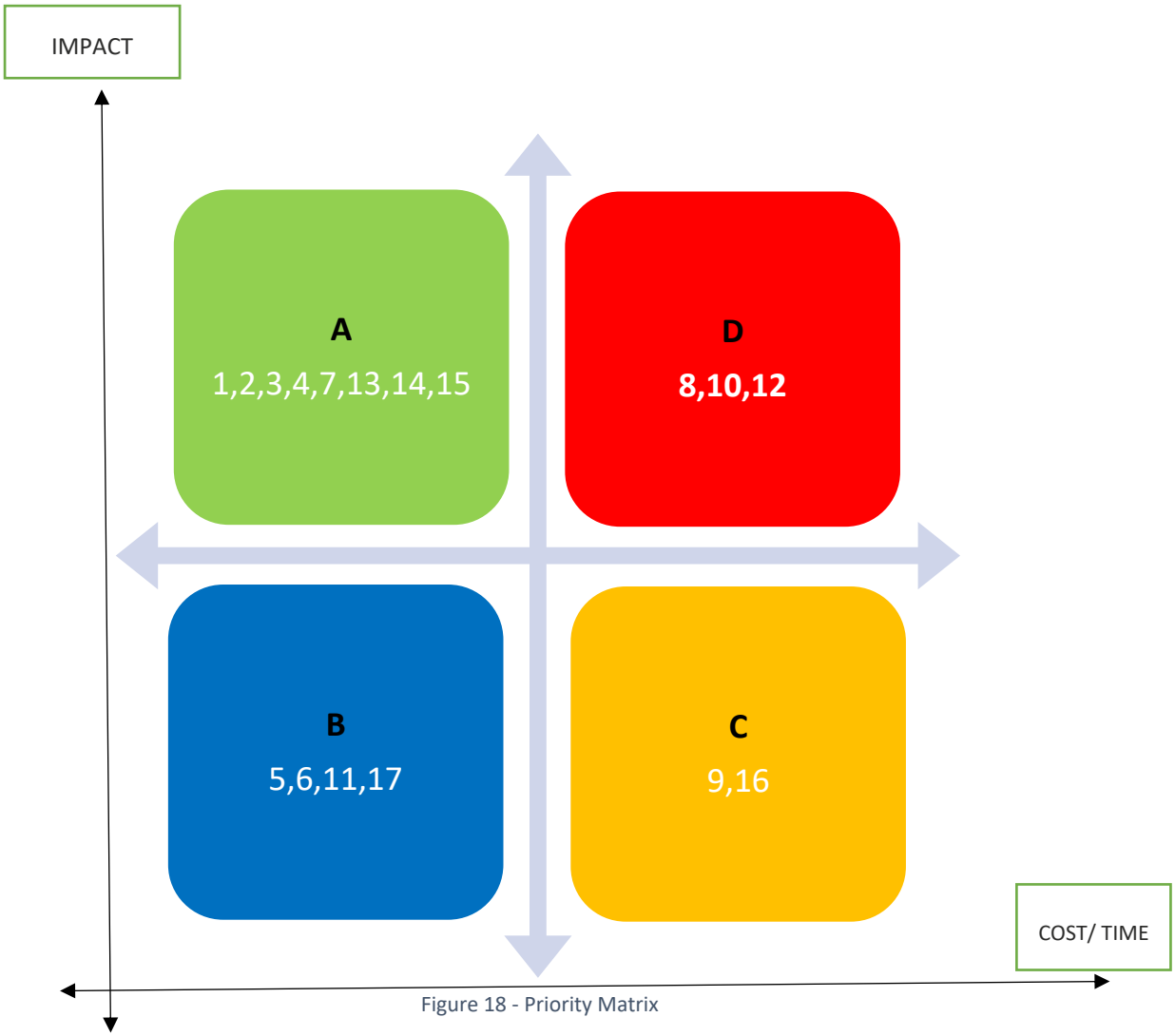



Figure 18 - Priority Matrix

These four quadrants explain the necessity of the solutions that can be implemented. The numbers inside the quadrant are the numbers from the previous table which indicates the problems and the solutions that are suggested. The x axis is taken as impact and the y axis is taken as cost and time.

A – This has the suggestions that has low cost and time to implement with (priority 1)

B – This has suggestions that has low cost but has low impact (priority 2)

C – This one has high cost but low impact for implementing the suggestions (priority 3)

D – Suggestions under this category takes too much to implement and also it takes high cost and high impact for the implementation of suggestions. (priority 3)

The suggestions under the A & B are easy to implement. C & D has quite some high valued tasks that cannot be done currently but in future based on decision of management they can be implemented.

## 3.4 Implement (Before SMED)

| | ASSEMBLY OF DIE | | | |
|---|---|---|---|---|
| | | | | |
| | | | | |
| Machine No | **IP 700** | Date | **29-06-17** | |
| Part No | | Start Time | **3.15 PM** | |
| Part Name | | End Time | **7.06 PM** | |
| S.NO | Activity Description | Internal | External | Time |
| | | | | |
| | | | | |
| | | | | |
| | **REMOVE FIXED PART OF DIE** | | | |
| 1 | Remove the rods on the back of movable | | | **1.52** |
| 2 | Waiting time | | | **4.27** |
| 3 | Carry crane from F M | | | **1.1** |
| 4 | Hook the crane to the fixed part | | | **1.04** |
| 5 | Remove the clamp | | | **3.04** |
| 6 | Remove the die from the bed | | | **0.44** |
| 7 | Carry the die from M F | | | **3.06** |
| 8 | Fix a stand to keep the die on the floor | | | **4.29** |
| 9 | Remove crane from the die | | | **0.13** |
| | **TOTAL** | | | **20.09** |
| | | | | |
| | **REMOVE MOVABLE PART OF THE DIE** | | | |
| | | | | |
| 10 | Carry crane from F M | | | **1.17** |
| 11 | Wait for the other operator to finish removing hose pipes | | | **1.07** |
| 12 | Hook the crane tioo the movable part | | | **1.03** |
| 13 | Remove the clamps | | | **1.54** |
| 14 | Remove the rods | | | **1.02** |
| 15 | Remove the die from the machine | | | **16.16** |
| 16 | Carry the die from M F | | | **0.39** |
| 17 | Fix a stand to keep the die on the floor | | | **2.24** |
| 18 | Keep the die on the floor | | | **0.58** |
| | **TOTAL** | | | **26.4** |
| | | | | |
| | **ASSEMBLE BOTH CAMISO & FIXED PART OF DIE** | | | |
| | | | | |
| 19 | Waiting time for the new die | | | **8.5** |
| 20 | Search for rope to remove camisa | | | **0.38** |
| 21 | Change the rope that fits to remove camisa | | | **7.14** |
| 22 | Remove camiso from blocko | | | **0.36** |
| 23 | Carry camisa from M F | | | **2.11** |
| 24 | Hook the crane to new camisa | | | **0.33** |
| 25 | Carry camisa from F M | | | **1.11** |
| 26 | Place half of the camiso into blocko | | | **1.11** |
| 27 | Carry the crane from M F | | | **0.48** |
| 28 | Search for wooden block | | | **1.16** |
| 29 | Carry fixed part from F M | | | **1.23** |
| 30 | Insert the camisa into bed using the die | | | **0.5** |
| 31 | Insert the die and camisa into the bed | | | **4.42** |
| 32 | Fix the die and insert the clamps | | | **12.48** |
| 33 | Reassemble evrything again and insert clamp | | | **2.16** |
| 34 | Carry crane from M F | | | **0.36** |
| 35 | Fix the hosepipes | | | **5.32** |

| | | | | |
|---|---|---|---|---|
| | **ASSEMBLE MOVABLE PART OF THE DIE** | | | |
| | | | | |
| 36 | Waiting for the movable part | | | **8.33** |
| 37 | Carry the die from F M | | | **0.57** |
| 38 | Place the die parallel to the bed | | | **0.44** |
| 39 | Fix the die into the fixed part | | | **6.38** |
| 40 | Insert and tighten the rods | | | **4.52** |
| 41 | Tighten the back of the rod | | | **4.15** |
| 42 | Carry crane from M F | | | **2.11** |
| 43 | Waiting time | | | **4.42** |
| 44 | Connect the hose pipes | | | **5.42** |
| | **TOTAL** | | | **38.34** |
| | | | | |
| | **PREHEAT** | | | |
| | | | | |
| 45 | Pre heat | | | **46.28** |
| 46 | Maintanence | | | **15.1** |
| | **TOTAL** | | | **1 Hr I Min** |
| | | | | |
| | **CYCLE START AND FIRST PIECE OK TIME** | | | |
| | | | | |
| 47 | Production Approval | | | **32.12** |
| 48 | Quality Approval | | | **45.15** |
| | | | | |
| | | | | |
| | | | | |
| | **TOTAL TIME FOR SETUP** | | | **4 Hr 15 Min** |
| | | | | |

Table 8 - IP 700 Before implementing SMED

This is the data taken before the implementation of proposals. After the analysing the data the management get to know the actual problems and the management formed a team of four members said to be a SMED team to implement the proposals and record the data for the further improvement and analysis. The proposals that are implemented are from the quadrant A which is easy to implement and have greater effect.

The main objective of forming the team is to record the data during each setup and report it to the management. And also coming up with the other alternative solutions for reducing the set-up time.

## After SMED

| | ASSEMBLY OF DIE | | | |
|---|---|---|---|---|
| | | | | |
| | | | | |
| Machine No | **IP 700** | Date | **14-07-17** | |
| | | Internal | External | Time (Min) |
| S.No | **REMOVAL OF FIXED PART OF DIE** | | | |
| 1 | Maintanence work | | External | 48.09 |
| 2 | remove the clamps | Internal | | 1.01 |
| 3 | Remove the die from bed | Internal | | 0.29 |
| 4 | Remove the sensors | Internal | | 2.38 |
| 5 | Carry the die from M to F | Internal | | 4.43 |
| | | | | |
| | **REMOVAL OF MOVABLE PART OF DIE** | | | |
| 6 | Unhook the crane and carry it to machine | Internal | | 2.47 |
| 7 | Hook the movable to the crane | Internal | | 1.01 |
| 8 | Rremove the clamps | Internal | | 2.45 |
| 9 | Remove the rods | Internal | | 2.29 |
| 10 | Remove the sensors | Internal | | 1.06 |
| 11 | Carry the die from M to F | Internal | | 1.57 |
| | | | | |
| | **REMOVAL AND FIXING OF SLEEVE & BLOCK** | | | |
| 12 | Keep the die in floor | Internal | | 2.3 |
| 13 | Fix the rod in bed | Internal | | 5.09 |
| 14 | Search for rod to push sleeve out | External | | 1.01 |
| 15 | Break(9 to 9.15) | | External | 13.5 |
| 16 | Carry the crane to machine & clean the bed | Internal | | 3.04 |
| 17 | Hook the crane to sleeve | Internal | | 1.08 |
| 18 | Remove the sleeve out of bed & plunger | Internal | | 1.58 |
| 19 | Carry the sleeve from M to F | Internal | | 3.28 |
| 20 | Hook the crane to the new sleeve & carry it to the machin | Internal | | 6.42 |
| 21 | Insert the sleeve into the bed | Internal | | 3.42 |
| | | | | |
| | **INSERT FIXED PART OF DIE** | | | |
| 22 | Maintanence work | | | 7.57 |
| 23 | Hook the crane to fixed and carry it to machine | Internal | | 1.26 |
| 24 | Insert the fixed part into the bed | Internal | | 3.45 |
| 25 | Measuring and adjusting the die | Internal | | 4.23 |
| 26 | Insert anf tighten the clamps | Internal | | 7.06 |
| 27 | Unhook the crane and carry it to floor | Internal | | 2.38 |
| | | | | |
| | **INSERT MOVABLE PART OF DIE** | | | |
| 28 | Hook the movable to the crane & carry it to the machine | | External | 7.09 |
| 29 | Positioning the die parallel to the fixed part of the die | Internal | | 1.1 |
| 30 | Waiting time for the machine to attain pressure | Internal | | 6.01 |
| | Plunger and its hosepipe are connected | Internal | | |
| 31 | Insert the movable into fixed | Internal | | 3.15 |
| 32 | Insert and tighten the rods | Internal | | 3.52 |
| 33 | Insert and tighten the clamos and back screws | Internal | | 7.15 |
| 34 | Unhook the crane and carry it to the floor | Internal | | 3.29 |
| 35 | Connect hosepipes | Internal | | 10.16 |
| | | | | |
| | **PREHEATING THE DIE** | | | |
| 36 | Pre heating | Internal | | 60 |
| | lunch | | External | 30 |
| | | | | |
| | **FIRST GOOD PIECE** | | | |
| 37 | Production Approval | | External | 31.41 |
| 38 | Quality Approval | | External | 40.02 |
| | Total hours | | | 329.11 |

Table 9 - IP 700 after implementing SMED

The things that are implemented are:
SMED trolley:
The required tools are not available to the operator while changing the die so he have to make unnecessary movements to take and keep the tool or he have borrow tools from other machines that cause some loss of time. This situation is illustrated in spaghetti chart in the previous chapter.

Figure 19 - Before SMED


Figure 20 - After SMED

Using two workers:
Before the implementation only one worker involves in set up. After analysing the data, they find it necessary for an additional person to be involved when the die is changed. So, for that the management allocated a person from maintenance to work with the operator during set up.


Figure 21 - Before SMED

Figure 22 - After SMED

## 3.5 Results of the Implementation

Since the implementation is started by the end of the intern I could get only one set of result from the machine IP 700. The management decide it to try it out first in the small machine to check how the implementation goes. By comparing the two data we could find a improvement in the process.
The unnecessary movements made by the operator to take tools or any other objects is constrained in a high rate when compared to the older set up it is because of the trolley with tools. By implementing the basic problems faced by the operators is rectified. Two operators instead of one also makes a huge contribution in the reduction of time during this setup.
By comparing the data, we could find that after implementing the amount of external works done internally are reduced. Every operation is performed little bit quickly due to two men working during the setup. From the data its shows that the timing for individual operation is reduced even though the total time of data after implementing is high because of the sudden maintenance that occurred during the removal of die. They removed the column of the machine to remove the die in a fastest way separately.

### 3.5.1 Control

- Train the operator.
- Ask suggestions from operator about any chance of improvement in and out of machine.
- Repeated implementation of process and record the progress and continue to evolve the process.
- Regular audit of the machine to make corrective and preventive maintenance.
- Set a time limit and motivate them to finish within the time.
- The operators should not be involving in other activities such as helping other operators during set up change.
- While performing the set up the operator should not move from his work place making unnecessary movements during the setup.
- Tools supporting die change should be maintained in god condition periodically all the parts should be checked or calibrated.

According to shigeo shingo “Improvement usually means doing something that we have never done before”.

# CONCLUSIONS

**4.1 CONCLUSIONS**

**4.2 Future works**

4.2.1 Preheat

4.2.2 Hosepipes (Removal and Assembly)

4.2.3 Clamps (Removal and Assembly)

4.2.4 Quality Approval

# 4 CONCLUSIONS AND PROPOSALS OF FUTURE WORKS

## 4.1 CONCLUSIONS

Staying aware of the competitiveness in today's global market is characterized by increasing the product customization requires effective utilization of resources and customer satisfaction. In manufacturing it is very reliant on product flexibility. This implies the ability to change production from one product to another without relevant additional costs. This adds to both customer service effectiveness by providing quick response to demand and to production efficiency at various dimensions. On the other hand, the product flexibility should not be a burden on production capacity. To deal with it SMED methodology gives an essential impact on the production.
The proposals were made with perceptible and imposing impact on changeover process in terms of time saving and the distance travelled by operator during the changeover process. Quick changeover endorsed reducing the batch sizes and increasing the product flexibility and due to that the number of changeovers can be increased without burdening the capacity of production.

Continuous training and awareness program from top management to bottom management is essential for benefiting the true potential of SMED. For increasing the effect of SMED other lean tools can be combine with SMED to attain even greater results. In this thesis work some of the proposals were implemented which takes low cost and time and the results obtained were better when compared to the previous changeovers. Due to time constrain only few were implemented but some proposals needed top level management approval because of its complexity. Due to this work the management gets to know what are the non-value added operations that are done during the setup. The operators get to know about the inefficient things that they were doing these times. It's like the famous saying "Rome was not built in a day" it takes time for attaining the perfect result. By implementing the proposals repeatedly and monitoring the results only will lead to the future goals. We should not focus only on the process improvement but we should also focus on the hardware improvement, and equipment. Some the given proposals are based on hardware improvement. Still there is room for improvement in this process and equipment so the betterment can be achieved by implementing new things and techniques and evolve along with the current phase of the worlds technical and management advancement in order to be a leading successful industry.

## 4.2 Future works

Some of the proposals that have been submitted have not been been implemented due to time constrain and those proposals can be implemented only based on the acceptance of management.

### 4.2.1 Preheat

Preheating is one of the major operation that takes time. The preheating can be done before the start of set up by allocating a place near machine. So that the die is heated before assembling it into bed but this is possible only when they have faster assembly of die so that the die won't lose heat. They can use the extra unused thermo regulators To pre heat the die instead of using external burners.
The other way is by implementing new technologies in preheating, the die can be heated with laser, Flameless burners which is attached to robotic hand and preheats the die evenly and in a faster rate, using heat radiation coils along with it hot air is blasted on the die. These techniques involve high investment with additional equipment.

### 4.2.2 Hosepipes (Removal and Assembly)

Instead of having multiple inlet and outlet connections there should only three-point connection like one inlet one intermediate connection between the die and one outlet. The diameter of the pipes should be same and the pipes should be maintained. Instead of having the connection at the bottom of the die all the connections can be on a single side of the die. Inlet and outlet from the thermo regulator and the die should be differentiated. This involves change of design in dies and in the equipment, itself.

### 4.2.3 Clamps (Removal and Assembly)

Clamps are removed and assembled manually by the operators. Rather than doing it manually it can be done by using pneumatic gun, it can remove and insert the clamps in a faster rate to implement that all the clamps should be of same measurement for each machine. The tubes for connecting hosepipes should not interrupt the path of clamps.

### 4.2.4 Quality Approval

The quality team picks the part after the production starts to produce good parts. Instead of waiting for the quality member to pick up the good part, once the production starts producing the good part the production team can submit that part for the inspection to obtain the quality approval. The quality team should give higher priority for the changeover product and should try to inspect the product as soon as possible.

# REFERENCES AND OTHER SOURCES OF INFORMATION

**5.1 Websites**

**5.2 Research papers**

# 5 REFERENCES AND OTHER SOURCES OF INFORMATION

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# ANNEXES

# 6 ANNEXES

## 6.1 IP 1000 Data with change of sleeve

| | | ASSEMBLY OF DIE | | | |
|---|---|---|---|---|---|
| | Machine No | **IP 1000** | Date | **14-07-17** | |
| | Part No | **4875 TO 4864** | Start Time | **8.00 AM** | |
| | Part Name | **DEVIALET TO MPO** | End Time | **2.00 PM** | |
| | S.NO | Activity Description | Internal | External | Time(MIN) |
| | | **REMOVAL OF FIXED PART OF DIE** | | | |
| **A** | 1 | Hook the crane to the fixed | Internal | | **1.16** |
| | 2 | Remove the clamps | Internal | | **1.37** |
| | 3 | Remove the die from the bed | Internal | | **0.27** |
| | 4 | Carry the die from M F | Internal | | **2.27** |
| | 5 | Remove the die from the crane | Internal | | **0.23** |
| | | **REMOVAL OF MOVABLE PART OF DIE** | | | |
| **B** | 6 | Carry the crane from F M | Internal | | **0.39** |
| | 7 | Hook the movable to crane | Internal | | **2.1** |
| | 8 | Remove the clamps | Internal | | **4.54** |
| | 9 | Remove the die from the bed | Internal | | **0.3** |
| | 10 | Remove the rods | Internal | | **3.17** |
| | 11 | Carry the die from M F | Internal | | **2.32** |
| | | **REMOVAL AND FIXING OF SLEEVE & BLOCK** | | | |
| **C** | 12 | Carry back the crane from F M | Internal | | **1.09** |
| | 13 | Operator went to take rope to remove the sleeve | External | | **1.12** |
| | 14 | Clean the bed | External | | **1.08** |
| | 15 | Operator went to take rod to push sleeve out | External | | **0.38** |
| | 16 | Remove half of sleeve out of bed and tie it to the rope | Internal | | **1.26** |
| | 17 | Remove the entire sleeve out of bed | Internal | | **2.01** |
| | 18 | Carry sleeve from M F | Internal | | **2.37** |
| | 19 | Remove plunger and its hosepipes | Internal | | **4.55** |
| | 20 | Search for tools | External | | **4.26** |
| | 21 | Hook the crane to the new sleeve | Internal | | **1.33** |
| | 22 | Break | | External | **7.56** |
| | 23 | Carry the sleeve from F M | Internal | | **1.06** |
| | 24 | Insert half of sleeve into the die | Internal | | **1.45** |
| | 25 | Insert sleeve fully into bed by hiting with piston | Internal | | **1.18** |
| | 26 | Carry the crane from M F to hook new die | Internal | | **1.33** |
| | | **INSERT FIXED PART OF DIE** | | | |
| **D** | 27 | Hook the crane to the new fixed part of die | Internal | | **1.42** |
| | 28 | Carry the fixed part from F M | Internal | | **2.16** |
| | 29 | Insert the die to the bed | Internal | | **1.01** |
| | 30 | Insert and tighten the clamps | Internal | | **2.38** |
| | 31 | Insert and tighten the clamps | Internal | | **6.48** |
| | 32 | Remove the crane from die and carry the die from M F | Internal | | **1.23** |
| | 33 | Connect the hosepipes in fixed part | Internal | | **3.03** |

| | | | | | |
|---|---|---|---|---|---|
| | | **INSERT MOVABLE PART OF DIE** | | | |
| **E** | 34 | Hook and carry the movable from F M | Internal | | **2.11** |
| | 35 | Positioning the movable parallel to fixed part | Internal | | **1.21** |
| | 36 | Waiting time for the bed to attain pressure | Internal | | **12.48** |
| | 37 | Insert the die fully into the fixed part | Internal | | **2** |
| | 38 | Insert and tighten rods | Internal | | **5.23** |
| | 39 | Insert and tighten the clamps | Internal | | **6.08** |
| | 40 | Insert and tighten the back screws | Internal | | **4.56** |
| | 41 | Unhook the crane from die | Internal | | **2.41** |
| | 42 | Went to keep the tools | External | | **1.33** |
| | 43 | Carry the crane from M F | Internal | | **1.08** |
| | 44 | Break taken by operator | External | | **2.3** |
| | 45 | Connect hosepipes in movable part of die | Internal | | **16.03** |
| | | | | | |
| | | | | | |
| | | **PREHEATING THE DIE** | | | |
| **F** | 46 | Preheat started | Internal | | **55.02** |
| | 47 | Adjusting the sprayer | External | | **19.55** |
| | 48 | Connect hosepipes | Internal | | **10.56** |
| | 49 | Checking and cleaning machine | External | | **27.43** |
| | | | | | |
| | | | | | |
| | | **FIRST GOOD PIECE** | | | |
| **G** | 50 | Cycle start | | External | **1hr05min** |
| | 51 | Quality assuarence | | External | **35 min** |
| | | TOTAL HOURS | | | 6 Hrs |

Annex 1 - IP 1000 with change of sleeve

# ASSEMBLY OF DIE

| | | | | | |
|---|---|---|---|---|---|
| | Machine No | **IP 1000** | Date | **06-09-17** | |
| | Part No | **4898 TO 4875** | Start Time | **7.45 AM** | |
| | Part Name | **DEVIALET** | End Time | **5.00 PM** | |
| | S.NO | Activity Description | Internal | External | Time(MIN) |
| **A** | | **REMOVAL OF FIXED PART OF DIE** | | | |
| | | **REMOVE THE MOVABLE PART OF DIE** | | | |
| **B** | 1 | Hook the crane to the die | Internal | | **1.27** |
| | 2 | Remove the clamps on both sides | Internal | | **6.59** |
| | 3 | Remove the die from the bed | Internal | | **1.55** |
| | 4 | Remove the rods | Internal | | **2.55** |
| | 5 | Carry the die from M F | Internal | | **2.55** |
| | 6 | Time to keep the die on forklift | External | | **5.26** |
| | | **REMOVAL AND INSERT SLEEVE & BLOCK & PLUNGER** | | | |
| **C** | 7 | Carry the crane F M | Internal | | **1.35** |
| | 8 | Operator went to take a rope to remove the sleeve | External | | **2.56** |
| | 9 | Remove the sleeve from bed and hook it to the crane | Internal | | **1.1** |
| | 10 | Carry the sleeve from M F | Internal | | **1.45** |
| | 11 | Operator went take screw to remove the block | External | | **1.29** |
| | 12 | Operator went take screw to remove the block | External | | **0.57** |
| | 13 | Insert the screw to block and remove the bolts | Internal | | **1.4** |
| | 14 | Hook the blocko to the crane | Internal | | **1.02** |
| | 15 | Remove the block from the bed | Internal | | **1.05** |
| | 16 | Carry the block from M F by operator | Internal | | **3.41** |
| | | Screw of the plunger bed and height is adjusted by the shift chief | Internal | | |
| | 17 | Hook the new block to the crane and carry it from F M | Internal | | **5.06** |
| | 18 | Operator helps the chief in adjusting the height of the plunger bed | Internal | | **1.1** |
| | 19 | Insert the block into the bed | Internal | | **6.46** |
| | 20 | Clean the block and bed to remove the settled dust and grease | External | | **1.53** |
| | 21 | Insert the blocko to the bed | Internal | | **0.45** |
| | 22 | Insert the bolts and mount the block to bed by tightening it | Internal | | **1.11** |
| | 23 | Break (9-9.15am) | Internal | External | **18.48** |
| | 24 | Clean the camisa | External | | **2.39** |
| | 25 | Operator went to take the grease | External | | **0.29** |
| | 26 | Apply the grease to block | Internal | | **0.5** |
| | 27 | Hook the crane to the camisa | Internal | | **2.46** |
| | 28 | Remove the plunger from bed | Internal | | **1.19** |
| | 29 | Operator went to keep the grease and to bring the wooden blocks | External | | **5.11** |
| | 30 | Insert the sleeve into the block | Internal | | **2.38** |
| | 31 | Operator went to keep the wooden blocks | External | | **5.46** |

| | | | | | |
|---|---|---|---|---|---|
| | | **INSERT FIXED PART OF DIE** | | | |
| D | 32 | Carry the crane M F | Internal | | 1.05 |
| | 33 | Operator went to take the screw | External | | 0.37 |
| | 34 | Hook the fixed die to the crane | Internal | | 0.56 |
| | 35 | Carry the die from F M | Internal | | 2.32 |
| | 36 | Insert the die to the bed | Internal | | 4.01 |
| | 37 | Insert and tighten the clamps | Internal | | 8.51 |
| | 38 | Operator went to keep the measuring tape | External | | 2.06 |
| | 39 | Tightening the clamps | Internal | | 13.51 |
| | 40 | Operator takes break | External | | 6.17 |
| | | | | | |
| | | | | | |
| | | **INSERT MOVABLE PART OF DIE** | | | |
| E | 41 | Unhook the crane from die | Internal | | 0.47 |
| | 42 | Carry the crane from M F | Internal | | 1.03 |
| | 43 | Remove the oil that was present inside the die | External | | 7.31 |
| | 44 | Hook the movable die to the crane and carry it from F M | Internal | | 2.21 |
| | 45 | Machine problem maintanence | External | | 195 |
| | | Placing the die parallel to the fixed part of die | Internal | | |
| | | Waiting time for themachine to attain pressure | External | | |
| | | Insert the movable into the fixed part of die | Internal | | |
| | | Insert and tighten the rods on the back of movable | Internal | | |
| | | Insert and tighten the back screws | Internal | | |
| | 46 | Unhook the die from crane | Internal | | 2.56 |
| | 47 | Carry the crane from M F | Internal | | 0.36 |
| | 48 | Operator went to take the hosepipes | External | | 5.41 |
| | 49 | Connect hosepipes | Internal | | 45.16 |
| | | | | | |
| | | | | | |
| | | **PREHEATING THE DIE** | | | |
| F | 50 | Preheat | Internal | | 68 |
| | | | | | |
| | | | | | |
| | | **FIRST GOOD PIECE** | | | |
| G | 51 | Production Approval | | External | 44.05 |
| | 52 | Quality Approval | | External | 35 |
| | | TOTAL HOURS | | | 9 hrs 15 min |

Annex 2 - IP 1000 data with change of sleeve

## 6.2 IP 1000 data without change of sleeve

| | | ASSEMBLY OF DIE | | | |
|---|---|---|---|---|---|
| | Machine No | **IP 1000** | Date | **23-06-17** | |
| | Part No | **4751 TO 4753** | Start Time | **7.40 AM** | |
| | Part Name | **COMPIN** | End Time | **12.50 PM** | |
| | S.NO | Activity Description | Internal | External | Time(MIN) |
| **A** | | **REMOVAL OF FIXED PART OF DIE** | | | |
| **B** | | **REMOVE THE MOVABLE PART OF DIE** | | | |
| | 1 | Remove the die from the bed | Internal | | **0.52** |
| | 2 | Operator went to search tools | External | | **2.19** |
| | 3 | Remove the rods | Internal | | **2.59** |
| | 4 | Carry the die from M F | Internal | | **4.03** |
| | 5 | Unhook the die from crane | Internal | | **0.48** |
| **C** | | **REMOVAL AND INSERT SLEEVE & BLOCK & PLUNGER** | | | **No Change** |
| | | **INSERT FIXED PART OF DIE** | | | |
| **D** | 8 | Waiting time for the die | External | | **1.5** |
| | 9 | Hook the clamp to the new die | Internal | | **2.01** |
| | 10 | Carry the fixed part from F M | Internal | | **7.13** |
| | 11 | Insert the die to the bed | Internal | | **3.45** |
| | 12 | Search for the clamps | External | | **0.49** |
| | 13 | Insert the clamps on both sides | Internal | | **1.15** |
| | 14 | Checking the placement of die | Internal | | **0.47** |
| | 15 | Tight the clamps on both sides | Internal | | **2.27** |
| | 16 | Remove crane from the die | Internal | | **0.35** |
| | 17 | Tighten the clamps | Internal | | **0.46** |
| | | **INSERT MOVABLE PART OF DIE** | | | |
| **E** | 18 | Break | | External | **25.34** |
| | 19 | Carry the crane from M F | Internal | | **1.58** |
| | 20 | Hook the movable part to the crane | Internal | | **1.2** |
| | 21 | Carry the die from F M | Internal | | **6.23** |
| | 22 | Place the die paralle to the fixed part of the die | Internal | | **3.07** |
| | 23 | Insert the movbale into the fixed part of the die | Internal | | **7.01** |
| | 24 | Break taken by operator | External | | **1.28** |
| | 25 | Insert and tightening the rods | Internal | | **4.39** |
| | 26 | Operator identifies problem in thread of rod | External | | **12.39** |
| | 27 | Operator rectify the problem | External | | **3.22** |
| | 28 | Remove all the rods | Internal | | **2.02** |
| | 29 | Fix the movable to the bed | Internal | | **2** |
| | 30 | Removed the die from bed and also the rods | Internal | | **3.4** |
| | 31 | Insert and again tighten the rods | Internal | | **4.19** |
| | 32 | Insert and tighten the back rods | Internal | | **6.16** |
| | 33 | Remove the crane from the die | Internal | | **0.4** |
| | 34 | Move the crane from M F | Internal | | **0.3** |
| | 35 | Break taken by operator | External | | **1.25** |
| | 36 | Insert and tighten the clamps | Internal | | **1.52** |
| | 37 | Hosepipes | | | **13.54** |
| | | **PREHEATING THE DIE** | | | |
| **F** | 38 | Pre heat | Internal | | **59.45** |
| | | **FIRST GOOD PIECE** | | | |
| **G** | 39 | Production Approval | | External | **36.21** |
| | 40 | Quality Approval | | External | **35** |
| | | TOTAL HOURS | | | 5 Hr 10 min |

Annex 3 - IP 1000 data without change of sleeve

# ASSEMBLY OF DIE

| | | | | | |
|---|---|---|---|---|---|
| | Machine No | **IP 1000** | Date | **27-07-17** | |
| | Part No | **4843 TO 4553** | Start Time | **7.30 AM** | |
| | Part Name | **SUNVIAUTO TO BORGWARNER** | End Time | **1.45 PM** | |
| | S.NO | Activity Description | Internal | External | Time(MIN) |
| **A** | | **REMOVAL OF FIXED PART OF DIE** | | | **40** |
| | | **REMOVE THE MOVABLE PART OF DIE** | | | |
| **B** | 1 | Hook the die to crane and remove clamps | Internal | | **2.55** |
| | 2 | Remove the die from bed | Internal | | **4.07** |
| | 3 | Remove the rods | Internal | | **3.02** |
| | 4 | Carry die from M F | Internal | | **6.36** |
| | | Waiting for the forklift to take the old die | External | | |
| **C** | | **REMOVAL AND INSERT SLEEVE & BLOCK & PLUNGER** | | | **No Change** |
| | | **INSERT FIXED PART OF DIE** | | | |
| **D** | 5 | Hook the fixed part of die to the crane | Internal | | **2.17** |
| | 6 | Carry the die from F M | Internal | | **1.34** |
| | 7 | Insert the die to the bed | Internal | | **3.26** |
| | 8 | Adjusting the die position | Internal | | **3.07** |
| | 9 | Insert and tighten the clamps on one side | Internal | | **2.4** |
| | 10 | Operator takes break | External | | **1.57** |
| | 11 | Insert and tighten the clamps on other side | Internal | | **18.19** |
| | 12 | Unhook the crane and carry itfrom M F | Internal | | **1.59** |
| | 13 | Hook the die to the crane | Internal | | **1.16** |
| | 14 | Operator went to take hosepipes | Internal | | **4.32** |
| | 15 | Break | | External | **17.4** |
| | 16 | Operator connects hosepipes | Internal | | **3.01** |
| | | **INSERT MOVABLE PART OF DIE** | | | |
| **E** | 17 | Carry die from F M | Internal | | **2.34** |
| | 18 | Postioning the movable parallel to fixed part of die | Internal | | **0.57** |
| | 19 | Adjust the ramp of the machine | Internal | | **4.54** |
| | 20 | Waiting time for the bed to attain pressure | Internal | | **2.55** |
| | 21 | Insert the movable into fixed | Internal | | **5.5** |
| | 22 | Insert and tighten the rods | Internal | | **8.02** |
| | 23 | Insert and tighten the clamps by chief | Internal | | **15.15** |
| | | Operator inserts and tighten the backscrew | Internal | | |
| | 24 | Unhook the crane and carry it from M F | Internal | | **2.49** |
| | 25 | Break taken by operator | External | | **3.05** |
| | 26 | Connect the hosepipes | Internal | | **26.27** |
| | 27 | Operator went to help another operator | External | | **3.26** |
| | 28 | Continue connecting hosepipes | Internal | | **14.51** |
| | 29 | Chief instructs operator about the connection of hosepipes | External | | **2.39** |
| | 30 | Connect the oil hoses from thermoregulator | | | **37.25** |
| | | **PREHEATING THE DIE** | | | |
| **F** | 31 | Preheat | Internal | | **1hr09min** |
| | | **FIRST GOOD PIECE** | | | |
| **G** | 32 | Production Approval | | External | **40.23** |
| | 33 | Quality Approval | | External | **35** |
| | | TOTAL HOURS | | | 5 hr 10 min |

Annex 4 - IP 1000 Data without change of sleeve

## 6.3 C 1000 data without change of sleeve

| | | ASSEMBLY OF DIE | | | |
|---|---|---|---|---|---|
| | Machine No | C 1000 | Date | 11-07-17 | |
| | Part No | 4874 TO 4898 | Start Time | 7.40 AM | |
| | Part Name | BWI TO DEVIALET | End Time | 4.02 PM | |
| | S.NO | Activity Description | Internal | External | Time(MIN) |
| A | | REMOVAL OF FIXED PART OF DIE | | | 24 |
| B | | REMOVAL OF MOVABLE PART OF DIE | | | 35 |
| C | | REMOVAL AND FIXING OF SLEEVE & BLOCK | | | No change |
| | | INSERT FIXED PART OF DIE | | | |
| D | 1 | Cleaning the bed | External | | 4.11 |
| | 2 | Hook and carry the fixed part of die to the bed | Internal | | 2.26 |
| | 3 | Position the die parallel to the bed | Internal | | 2.15 |
| | 4 | Fixing the die into the bed | Internal | | 1.07 |
| | 5 | Checking the position of the die | Internal | | 4.41 |
| | 6 | Insert the clamps on one side and check the position of die | Internal | | 6.01 |
| | 7 | Break | | External | 9.38 |
| | | Simultaneously the shift chief continuous the work | Internal | | |
| | 8 | Insert and tightening the clamps | Internal | | 8.04 |
| | | TOTAL | | | 38.23 |
| | | INSERT MOVABLE PART OF DIE | | | |
| E | 9 | Carry the crane from M F | Internal | | 0.41 |
| | 10 | Operator takes break | External | | 3.38 |
| | 11 | Connect the hosepipes | Internal | | 5.51 |
| | 12 | Hook the die to the crane | Internal | | 0.31 |
| | 13 | Carry the die from F M | Internal | | 2.57 |
| | 14 | Postion the die parallel to the fixed | Internal | | 6.47 |
| | 15 | Waiting time for machine to attain the pressure | Internal | | 3.58 |
| | 16 | Insert the die to the fixed | Internal | | 5.43 |
| | 17 | Insert and tighten the rods | Internal | | 4.27 |
| | 18 | Fix the backscrews(Automatic) | Internal | | 3.18 |
| | 19 | Remove and carry the crane from M F | Internal | | 1.04 |
| | 20 | Insert and tightening the clamps | Internal | | 18.42 |
| | 21 | Connect the hosepipes | Internal | | 39.29 |
| | 22 | Keep the tools back in its place | External | | 4.43 |
| | 23 | | | | |
| | | TOTAL | | | 101.49 |
| | | PREHEATING THE DIE | | | |
| F | 24 | Preheat | Internal | | 195 |
| | | Sprayer repair | External | | |
| | 25 | Cycle start | External | | 13.32 |
| | 26 | Reconnecting hosepipes | Internal | | 43.01 |
| | | TOTAL | | | 251.38 |
| | | FIRST GOOD PIECE | | | |
| G | 27 | Production Approval | | External | 50.16 |
| | 28 | Quality Approval | | External | 45 |
| | | TOTAL | | | 95 |
| | | TOTAL HOURS | | | 8hr 22 min |

Annex 5 - C1000 Data without change of sleeve

## 6.4 C1000 data with change of sleeve

| | | ASSEMBLY OF DIE | | | |
|---|---|---|---|---|---|
| | Machine No | C 1000 | Date | 13-07-17 | |
| | Part No | 4898 TO 4827 | Start Time | 3.30 PM | |
| | Part Name | DEVIALET TO HUTCHINSON | End Time | 9.30PM | |
| | S.NO | Activity Description | Internal | External | Time(MIN) |
| A | | REMOVAL OF FIXED PART OF DIE | | | |
| | | REMOVAL OF MOVABLE PART OF DIE | | | |
| B | 1 | Carry the crane from F M | Internal | | 0.54 |
| | 2 | Operator went to take the wooden blocks | External | | 0.59 |
| | 3 | Hook the crane to the die | Internal | | 1.03 |
| | 4 | Went Back to keep the wooden board | External | | 0.43 |
| | 5 | Checking the machine | Internal | | 4.43 |
| | 6 | | Internal | | |
| | 7 | Remove the clamps | Internal | | 3.5 |
| | 8 | Remove the die from the bed | Internal | | 1.21 |
| | 9 | Remove the rods | Internal | | 3.48 |
| | | REMOVAL AND FIXING OF SLEEVE & BLOCK | | | |
| C | 10 | Carry the die from M F | Internal | | 3.29 |
| | 11 | Break taken by the operator | | External | 6.1 |
| | 12 | Bring crane from F M | Internal | | 1.14 |
| | 13 | Hook the sleeve to the crane and remove it from bed | Internal | | 0.52 |
| | 14 | Carry sleeve from M F | Internal | | 2.1 |
| | 15 | Carry crane from F M | Internal | | 2.25 |
| | 16 | Hook the crane and remove the block from the bed | Internal | | 2.37 |
| | 17 | Carry the block from M F | Internal | | 3 |
| | 18 | Hook the new block to the crane | Internal | | 1.54 |
| | 19 | Carry the block from F M | Internal | | 2.45 |
| | 20 | Insert the block into the die | Internal | | 12.05 |
| | 21 | Carry thr crane from M F | Internal | | 1.08 |
| | 22 | Hook the new sleeve to the crane | Internal | | 0.56 |
| | 23 | Carry the sleeve from F M | Internal | | 2.12 |
| | 24 | Insert the camisa into the block | Internal | | 4.02 |
| | 25 | Operator went to take the wooden blocks | External | | 4.28 |
| | 26 | Insert the camisa into the block using the wooden blocks | Internal | | 1.23 |
| | 27 | Carry the crane from M F | Internal | | 1.32 |

| | | | | | |
|---|---|---|---|---|---|
| | | | | | |
| | | **INSERT FIXED PART OF DIE** | | | |
| **D** | 28 | Waiting for the new die | External | | **37.26** |
| | | Plunger is changed during this waiting time | External | | |
| | 29 | Insert the die into the bed | Internal | | **8.17** |
| | 30 | Waiting for the chief | External | | **2.06** |
| | 31 | Insert and tighten the clamps | Internal | | **4.59** |
| | 32 | Unhook the die from the crane and carry crane from M F | Internal | | **2.14** |
| | | | | | |
| | | | | | |
| | | **INSERT MOVABLE PART OF DIE** | | | |
| **E** | 33 | Hook the movable part of die to the crane and connect hosepipes | Internal | | **7.04** |
| | 34 | Carry the crane from F M | Internal | | **2.18** |
| | 35 | Position the die parallel to the fixed part | Internal | | **1.17** |
| | 36 | Insert the movable part into the fixed | Internal | | **0.54** |
| | 37 | Waiting for the machine to attain pressure | Internal | | **5.38** |
| | 38 | Insert and tighten the rods | Internal | | **3.39** |
| | 39 | Remove the crane from die and carry it to the floor | Internal | | **0.5** |
| | 40 | Insert and tighten the clamps | Internal | | **6.14** |
| | 41 | No work done by the operator | External | | **2.4** |
| | 42 | Connect the hosepipes | Internal | | **6.3** |
| | 43 | Break by operator due to that he didn't know to connect the correct tube | External | | **5.39** |
| | 44 | Antonio helps in connecting the hosepipes | Internal | | **11.36** |
| | 45 | conntinue to connect hosepipes | Internal | | **20.29** |
| | | | | | |
| | | | | | |
| **F** | | **PREHEATING THE DIE** | | | |
| | | Preheat | Internal | | |
| | | | | | |
| | | **FIRST GOOD PIECE** | | | |
| **G** | | Production Approval | | External | |
| | | Quality Approval | | External | |
| | | | | | |
| | | TOTAL HOURS | | | **6 hrs** |

Annex 6 - C 1000 data with change of sleeve

# ASSEMBLY OF DIE

| | | | | | |
|---|---|---|---|---|---|
| | Machine No | **C 1000** | Date | **25-07-17** | |
| | Part No | **4827 TO 4824** | Start Time | **7.20 AM** | |
| | Part Name | **HUTCHINSON** | End Time | **5.10 PM** | |
| | S.NO | Activity Description | Internal | External | Time(MIN) |
| | | **REMOVAL OF FIXED PART OF DIE** | | | |
| **A** | | Fixed part removed by 7.53 AM | | | |
| | 1 | Fix stand to keep down the die | External | | **3.09** |
| | | **REMOVAL OF MOVABLE PART OF DIE** | | | |
| **B** | 2 | Unhook the crane from die and carry the die from F M | Internal | | **3.01** |
| | 3 | | Internal | | |
| | 4 | Hook the movable part to the crane | Internal | | **1.36** |
| | 5 | Checking the machine | Internal | | **4.13** |
| | 6 | Went to help the other operator | External | | **3.29** |
| | 7 | Problem in machine | Internal | | **3.59** |
| | 8 | Problem in machine | Internal | | **4.22** |
| | 9 | Operator removes the hosepipes | Internal | | **6.49** |
| | 10 | Operator went to bring back the tools taken by other operator | External | | **1.41** |
| | 11 | Remove the clamps | Internal | | **5.21** |
| | 12 | Remove the movable die from the bed | Internal | | **3.44** |
| | 13 | Remove the rods | Internal | | **3.1** |
| | 14 | Remove the hosepipes | Internal | | **5.11** |
| | 15 | Carry the die from M F | Internal | | **2.48** |
| | 16 | Fix stand to keep the die down | Internal | | **8.33** |
| | 17 | Operator went to take missing stand | Internal | | **1.1** |
| | 18 | Fix thestand to keep it down | External | | **4.03** |
| | 19 | Break (9-9.15) | | External | **30.38** |
| | | **REMOVAL AND FIXING OF SLEEVE & BLOCK** | | | |
| **C** | 20 | Remove the Sleeve | Internal | | **4.41** |
| | 21 | Carry the Sleeve from M F | Internal | | **2.41** |
| | 22 | Unhook the sleeve | Internal | | **1.21** |
| | 23 | Hook and carry the new sleeve from F M | Internal | | **1.53** |
| | 24 | Removw the bolts and insert screw to the block | Internal | | **2.57** |
| | 25 | Hook the crane to the block and remove it from bed | Internal | | **3.3** |
| | 26 | Clean the block and bed | Internal | | **2.05** |
| | 27 | Carry the block from M F | Internal | | **2.49** |
| | 28 | Time taken to clean by operator to clean himself | External | | **1.19** |
| | 29 | Operator went to take correct screw to hook the new block | External | | **1.31** |
| | 30 | Keeping the old sleeve and block into its position | External | | **2.06** |
| | 31 | Clean the new block | External | | **3.18** |
| | 32 | Carry the block F M | Internal | | **3.17** |
| | 33 | Operator went to drink water | External | | **2.09** |
| | 34 | Place the block into bed | Internal | | **2.08** |
| | 35 | Operator went to take tool to insert the block into the bed | External | | **0.4** |
| | 36 | Insert the block into the bed using the tool | Internal | | **1.08** |
| | 37 | Insert bolt into block and tighten it | Internal | | **2.34** |
| | 38 | Carry crane from M F | Internal | | **1.27** |
| | 39 | Search for tool to remove plunger | External | | **1.16** |
| | 40 | Searching tools to use the suitable tool | External | | **8.13** |
| | 41 | Remove the plunger and carry it to the floor | Internal | | **1.51** |
| | 42 | Clean the plunger | External | | **2.23** |
| | 43 | Tie the rope around sleeve and hook it to the crane | Internal | | **1.01** |
| | 44 | Clean the camisa | External | | **2.59** |
| | 45 | Carry the camisa from F M | Internal | | **1.46** |
| | | Wooden blocks are taken by other operator | External | | **2.5** |
| | 46 | Insert camisa into the bed | Internal | | **1.17** |
| | 47 | Went to take wooden tool | External | | **5.48** |
| | 48 | Problem in machine | Internal | | **2.44** |
| | 49 | Insert camisa into the bed | Internal | | **3.04** |
| | 50 | Operator went to keep the wooden tools back | External | | **4.34** |
| | 51 | Clean the bed | External | | |

| | | | | | |
|---|---|---|---|---|---|
| | | **INSERT FIXED PART OF DIE** | | | |
| **D** | 52 | Hook the fixed part of die and carry from F M | Internal | | **2.11** |
| | 53 | Insert the fixed part of die into the bed | Internal | | **4.02** |
| | 54 | Insert and tighten the clamps | Internal | | **15.06** |
| | 55 | Unhook the crane and carry it from M F | Internal | | **2.27** |
| | 56 | Break taken by operator | External | | **3.03** |
| | | | | | |
| | | | | | |
| | | **INSERT MOVABLE PART OF DIE** | | | |
| **E** | 57 | Hook the movable and carry it from F M | Internal | | **5.09** |
| | 58 | Positioning the die paralle to the fixed part of die | Internal | | **9.48** |
| | 59 | Waiting time for the machine to attain pressure | Internal | | **3.05** |
| | 60 | Insert the movable into the fixed part of die | Internal | | **7.37** |
| | 61 | Lunch | | External | **31.41** |
| | 62 | Insert and tighten the rods | Internal | | **4.3** |
| | 63 | Insert and tighten the clamps | Internal | | **11.15** |
| | 64 | Unhook the crane from the die | Internal | | **2.54** |
| | 65 | Connecting the hosepipes | Internal | | **1hr24min** |
| | | | | | |
| | | | | | |
| | | **PREHEATING THE DIE** | | | |
| **F** | 66 | Preheat of the die | Internal | | **55.29** |
| | 67 | Shift change (3- to 3.30 ) | External | | **1hr01min** |
| | 68 | Problem in machine | External | | **26.45** |
| | 69 | Check the machine | External | | **7.04** |
| | | | | | |
| | | | | | |
| | | **FIRST GOOD PIECE** | | | |
| **G** | 70 | Production Approval | | External | **33.27** |
| | 71 | Quality Approval | | External | **30** |
| | | | | | |
| | | TOTAL HOURS | | | **9 hr 50 min** |
| | | | | | |

Annex 7 - C 1000 data with change of sleeve

## 6.5 Pareto for IP 1000 data with change of sleeve

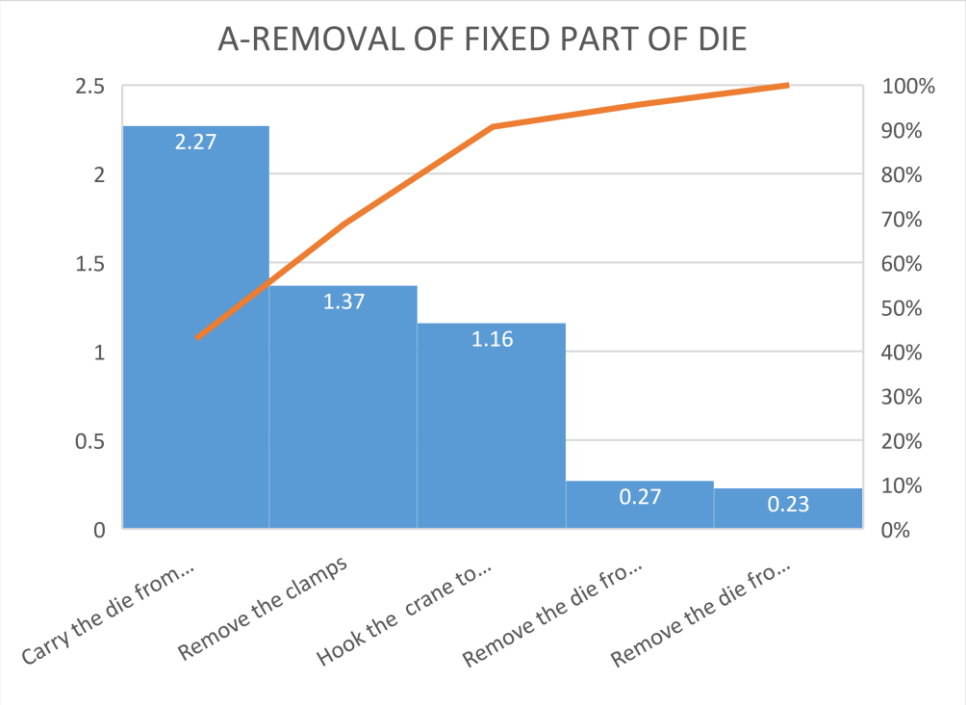


Figure 23: Removal of fixed part (Annex 1)

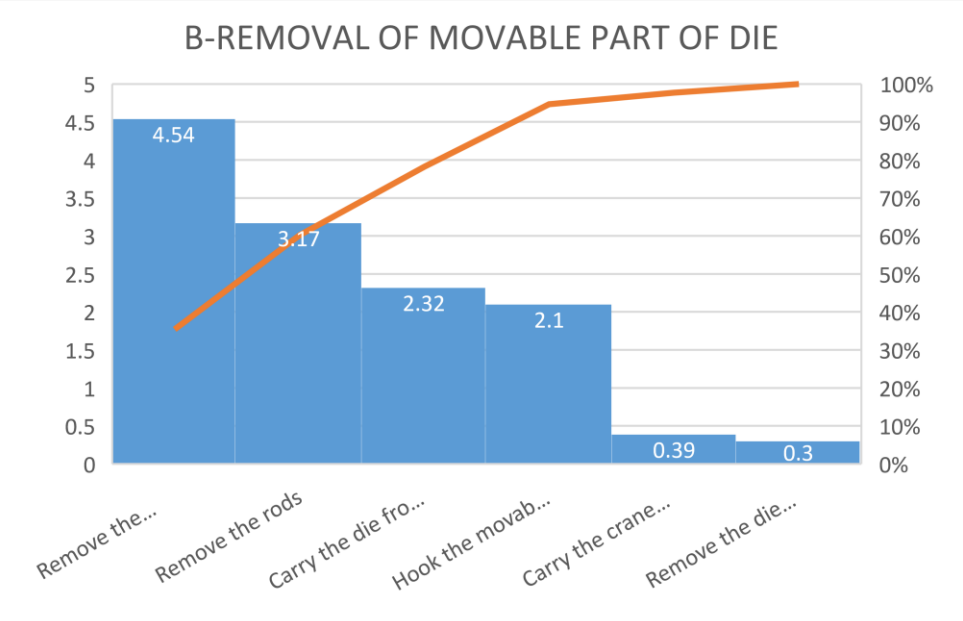


Figure 24: Remove movable (Annex 1)

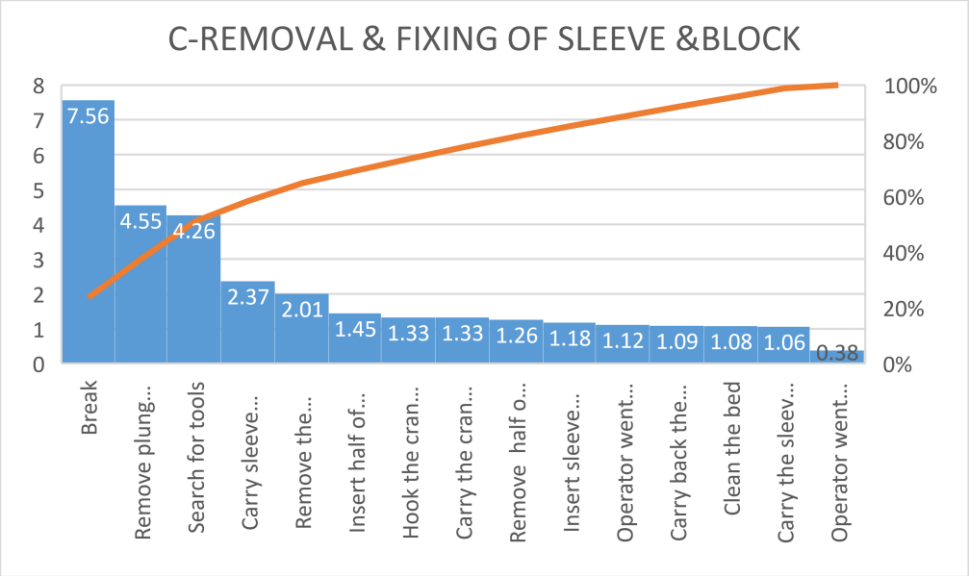


Figure 25:Remove&fix Sleeve&block(Data 3)

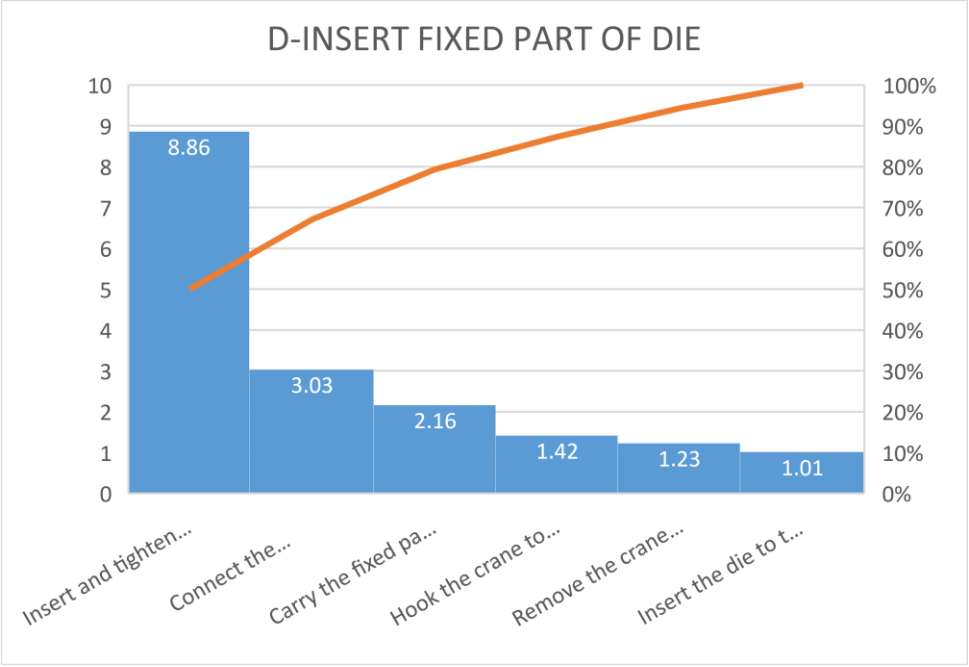


Figure 26: Insert fixed part(Annex 1)

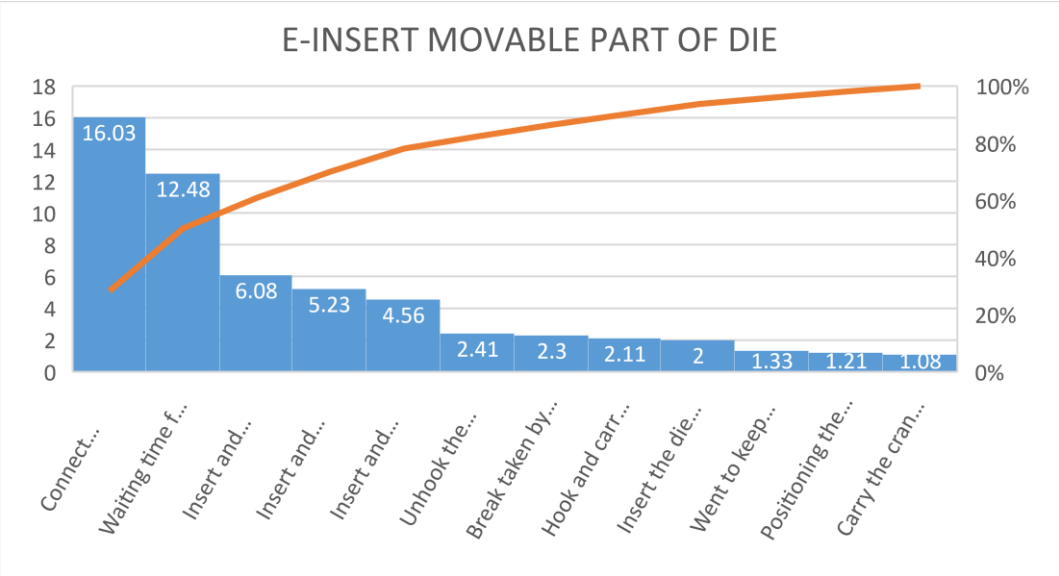


Figure 27: Insert movable(Annex 1)

## 6.6 Pareto of IP 1000 without change of sleeve

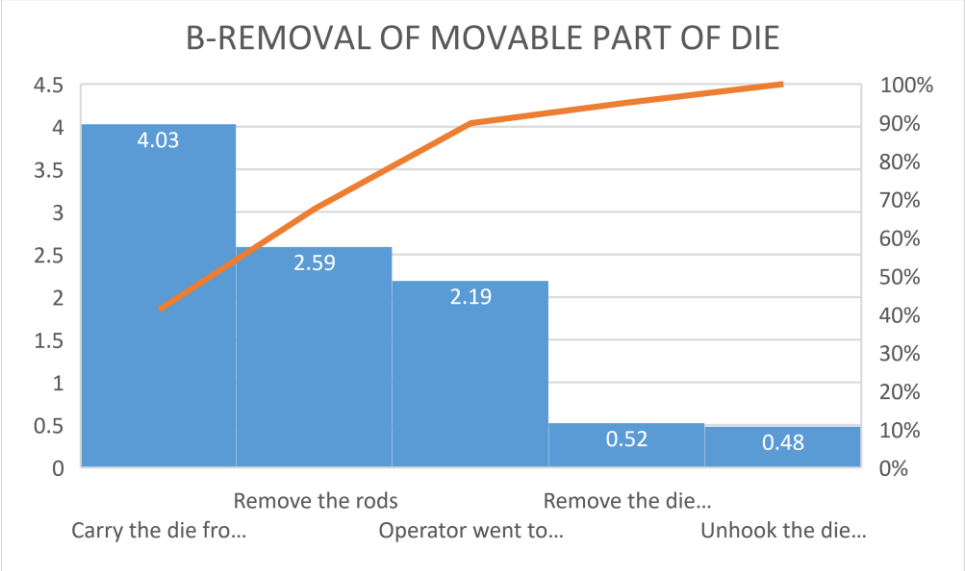


Figure 28: Remove movable (Annex 3)

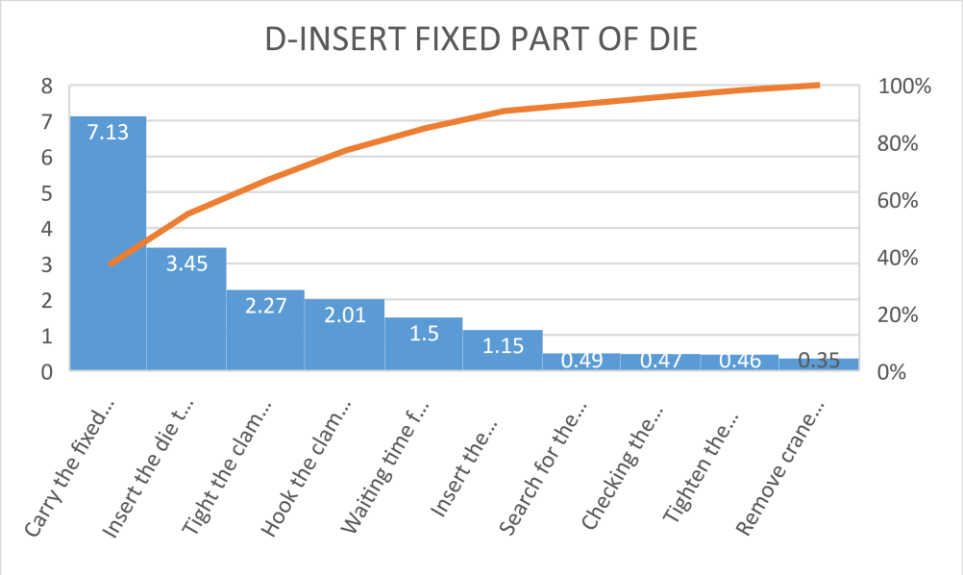


Figure 29: Insert fixed part(Annex 3)

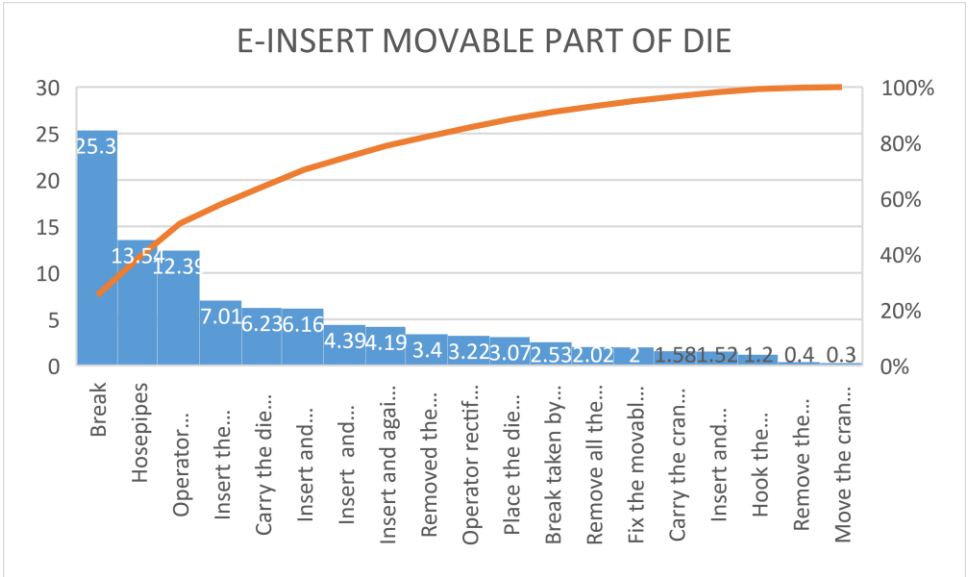


Figure 30: Insert movable part in Ip 1000(Annex 3)

## 6.7 Pareto for C1000 with change of sleeve

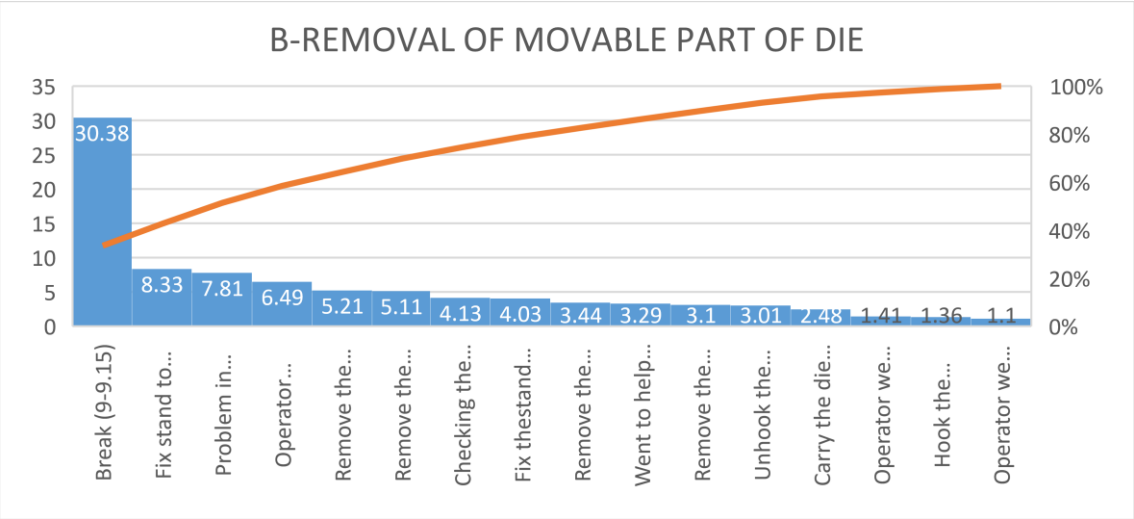


Figure 31- Remove movable part(Annex 5)

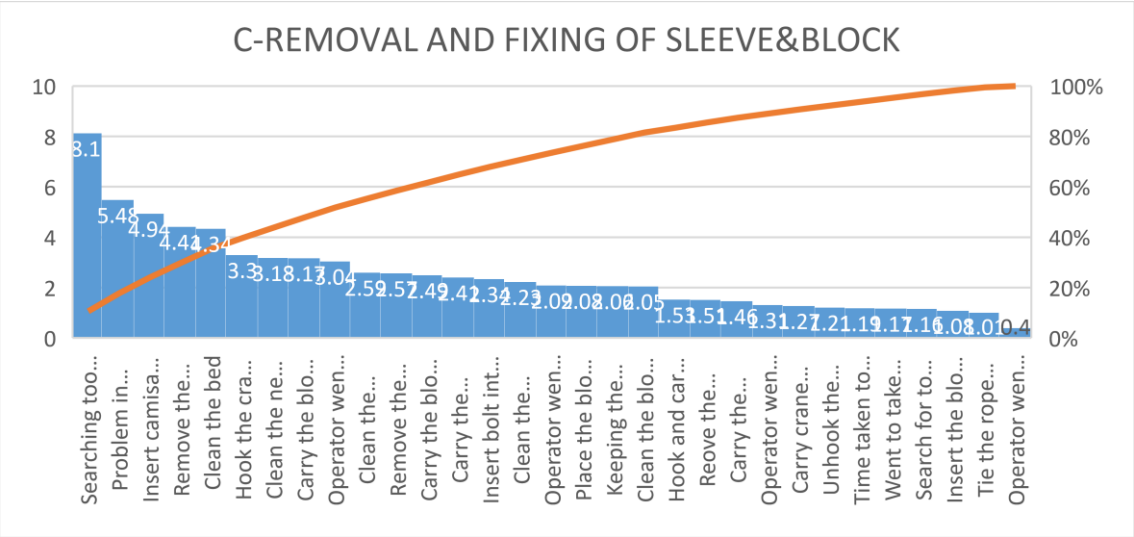


Figure 32:Remove&fix Sleeve& block(Annex 5)

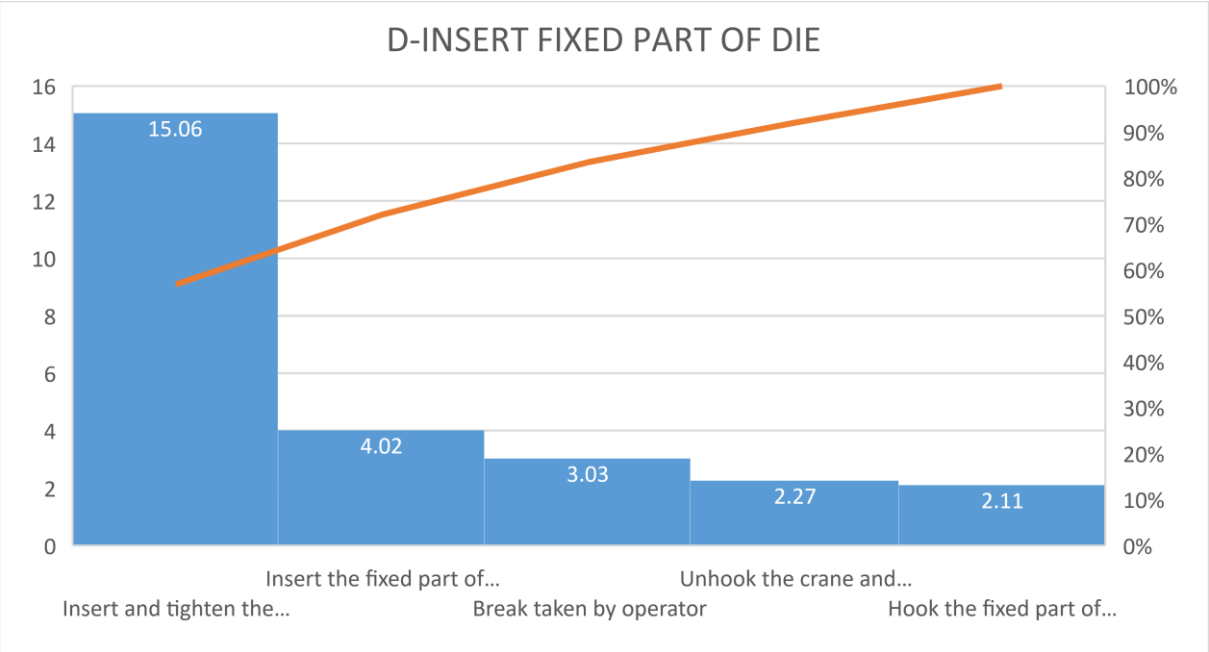


Figure 33-Insert fixed part(Annex 5)

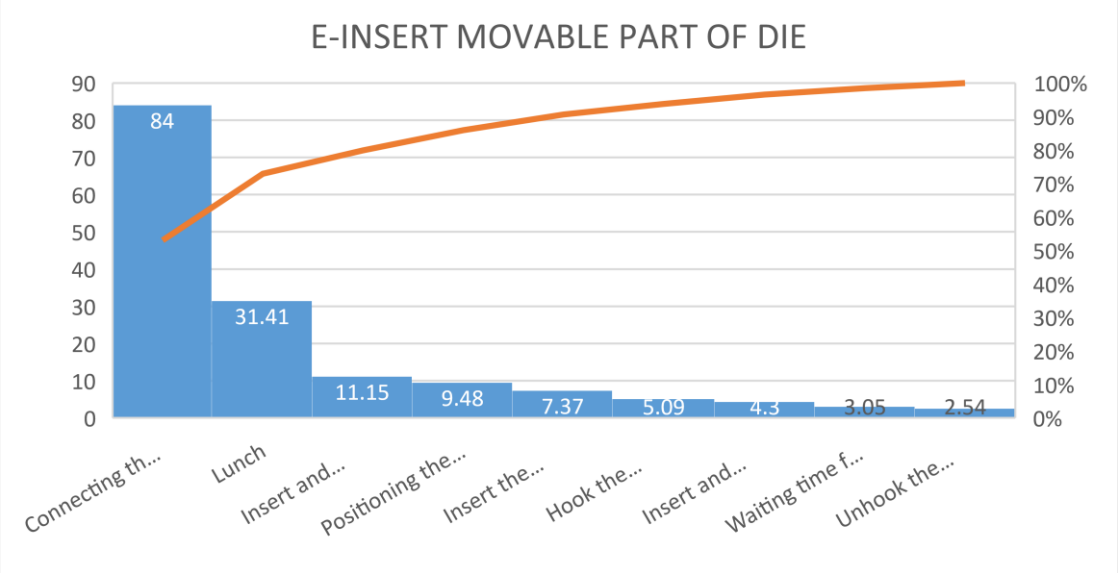


Figure 34:Insert movable (Annex 5)

## 6.8 Pareto for C 1000 without change of sleeve

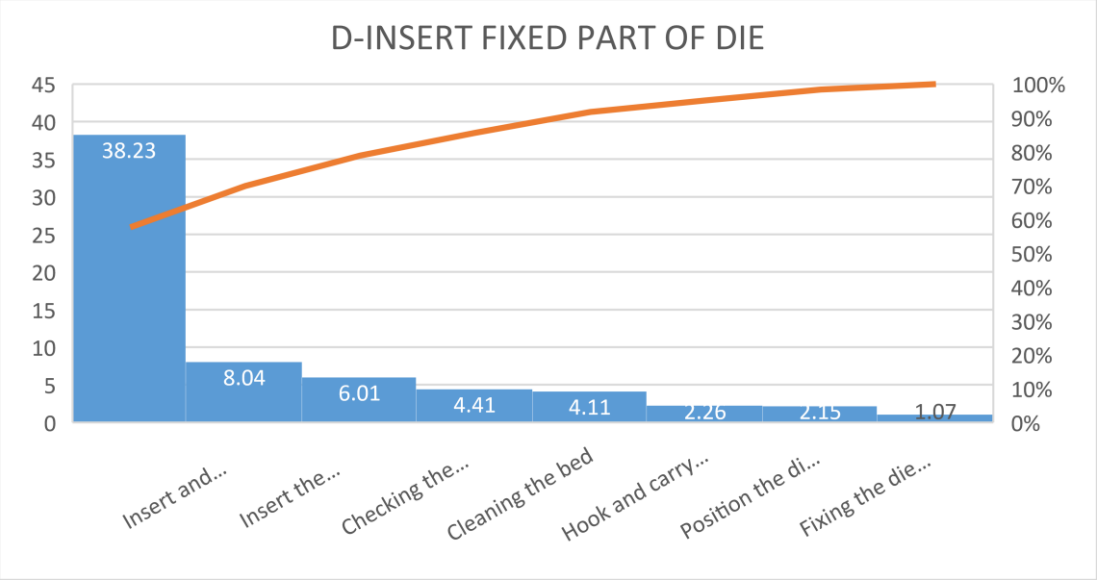


Figure 35- Insert fixed part (Annex 6)

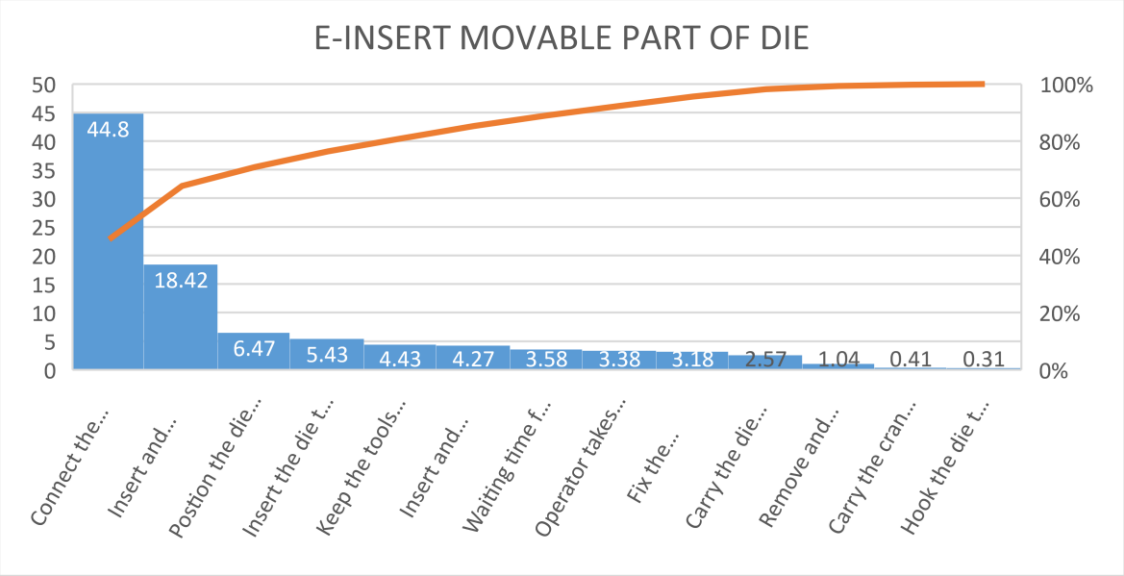


Figure 36- Insert movable(Annex 6)

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