DESIGN AND DEVELOPMENT AN ERGONOMIC SMED’S EXTERNAL PREPARATION FOR SMALL PRESS DIE AT FKP LAB

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ABSTRACT

Single Minute Exchange of Dies (SMED) mainly focuses on recognition of internal and external activities. It is concerned particularly with transferring internal activities into external ones in as many numbers as possible, by also minimizing the internal ones. The major problem when operating a press machine is when the process of changing a die to a new one in order to produce other products. The die changing process is too long to be completed. Much energy is used through the process of changing of die includes human and machine. The objective of this project is to design and fabricate good external preparation equipment (prototype) for small press dies as a reflection to the next semester students who will continue this project in order to produce the actual product. The major step through this project is to study current condition of press machine. After studying the current condition, went to PHN Industry Sdn Bhd for a pilot visit to get the related information of the project. Then the design idea is come out through the visit after seeing the condition at stamping department at PHN Industry Sdn Bhd. Two conceptual designs are produced using CAD Software which is Catia V5 and the design that fits the condition at Fakulti Kejuruteraan Pembuatan (FKP) laboratory was selected and validated by the supervisor. The selected design stimulated into rapid prototyping machine and fabricated. A prototype of external preparation equipment for small press dies (Die T-Table) is produced using rapid prototyping machine. This project will bring the idea for the next semester final year student who will continue this project and will assist them in order to produce the actual Die T-Table to be attached at stamping machine in FKP Laboratory.
ABSTRAK

Single Minute Exchange of Die (SMED) menumpukan kepada pengiktirafan aktiviti dalaman dan luaran. Ia adalah berkenaan dengan memindahkan aktiviti-aktiviti dalaman ke aktiviti luaran seberapa banyak yang mungkin, dengan juga mengurangkan aktiviti dalaman. Masalah utama apabila mengendalikan mesin hentakan adalah apabila proses menukar acuan yang lama kepada yang baru untuk menghasilkan produk-produk lain. Proses untuk menukar acuan mengambil masa terlalu lama untuk disiapkan. Banyak tenaga digunakan melalui proses menukar acuan termasuk tenaga manusia dan mesin. Objektif projek ini adalah untuk merekabentuk dan menghasilkan peralatan penyediaan luaran yang baik (prototaip) untuk mesin hentakan kecil sebagai gambaran kepada pelajar-pelajar semester seterusnya yang akan meneruskan projek ini bagi menghasilkan produk yang sebenar. Langkah utama melalui projek ini adalah untuk mengkaji keadaan semasa mesin hentakan. Selepas mengkaji keadaan semasa, pergi ke PHN Industry Sdn Bhd sebagai lawatan perintis untuk mendapatkan maklumat yang berkaitan dengan projek. Kemudian, idea reka bentuk terhasil selepas melihat keadaan di kawasan mesin hentakan kecil di PHN Industry Sdn Bhd. Dua reka bentuk konsep dihasilkan menggunakan perisian CAD yang Catia V5 dan reka bentuk yang sesuai dengan keadaan di Fakulti Kejuruteraan Pembuatan (FKP) makmal telah dipilih dan disahkan oleh penyelia. Reka bentuk yang dipilih disalur ke mesin prototaip pantas dan terus dibina. Satu prototaip peralatan penyediaan luar untuk mesin hentakan kecil (Die T-Table) dihasilkan menggunakan mesin prototaip pantas. Projek ini akan mengutarakan idea untuk pelajar yang akan mengambil subjek projek tahun akhir pada semester akan datang yang akan meneruskan projek ini dan akan membantu mereka untuk menghasilkan Die T-Table yang sebenar yang akan dipasang pada mesin hentakan kecil di Makmal FKP.
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CHAPTER 1

INTRODUCTION

1.1 PROJECT BACKGROUND

The industrial manufacturing industry is responsible for the fabrication of products intended for industrial use from raw materials; it is the output of this industry which has made further mass manufacturing possible in most other industries. It is responsible for producing a variety of different machinery, from huge industrial to simple household machines, as well as other industrial-use products such as hardware, paper and packaging materials, glass, and other fixtures. However, in spite of the huge range of products, they all have a common function: to eliminate or reduce the amount of human energy expenditure, or manpower, needed to complete the job. No matter what type of machinery is employed, it is crucial in producing many of the goods and services vital to any economy in a timely and cost-efficient manner.

In the past a lot of effort has been put to reducing the cycle time and speeding up the output rate whilst totally ignoring the change overtime from one product to another. This has lead to the Economic batch quantity Concept and has resulted in small batches appearing to be Uneconomical to run. Reducing Setup times can give the equivalent of huge increase in process speed. This is all achieved without detriment to the quality of the Product. The idea of a setup time reduction Plan is move towards SMED (Single Minute Exchange Die) or OTED (One Touch Exchange of Dies).
1.2 PROBLEM STATEMENT

Lean Production System is about constantly finding the most convenient solutions possible. It concerns everything from reducing or eliminating unnecessary waste to giving customers exactly what they want. The concept was introduced in Japan by Toyota. That is also where it was refined and tested. Today, decades later, the thoughts and ideas have spread all over the world to thousands of companies.

The major problem when operating a press machine is when the process of changing a die to a new one in order to produce other products. Now, the die changing process is taking too long to be completed. Much energy is used through the process of changing of die includes human and machine. Forklift is used to remove existing die on the machine and then lift the other die to put back into the press machine. Manpower then used to make sure the mold is in the right position. The workers had to use a lot of energy to move the mold to make sure it is in the required position. Here, too much time and energy has been wasted to complete the conversion process mold.

As such, a necessary tool to save time and labor during the conversion process of the dies. The main purpose of this project is to reduce the changeover time at a small press machine located at Manufacturing Engineering Laboratory by reducing or eliminating activities that do not provide benefits. So in this stage of project, a prototype of external preparation activities at small press machine will be produced before it goes to the next stage which is to produce the actual equipment.
1.3 PROJECT OBJECTIVE

The objective of this project is to design and fabricate good external preparation equipment for small press dies. Stamping machines that available in the FKP laboratory serve as inspiration to create a suitable table design so that the resulting design will be appropriate and to the machine and its environment in terms of size and dimensions. The size of the resulting prototype will be scaled down to a scale of 1:5. The design of Die T-Table will be drawn using CAD Software which is Catia V5 and the prototype will be produced using the Rapid Prototyping machine. Rapid prototyping is a group of techniques used to quickly fabricate a scale model of a physical part or assembly using three-dimensional computer aided design (CAD) data. Construction of the part or assembly is usually done using 3D printing technology. The first techniques for rapid prototyping became available in the late 1980s and were used to produce models and prototype parts. Today, they are used for a wide range of applications and are used to manufacture production-quality parts in relatively small numbers if desired without the typical unfavorable short-run economics.

1.4 PROJECT SCOPE

i. The small press machine 60 tonnes that are located at Manufacturing Engineering Laboratory.

ii. The project will be focused only on external preparation activities during the changing process of the dies.

iii. The main target of this project is designing and producing a prototype of external preparation equipment for small press dies.

1.5 OUTPUT EXPECTED FROM THE RESULT

i. Able to design the Die T-Table using CAD Software.

ii. Able to fabricate the prototype of Die T-Table
1.6 Definition of Term

**Changeover**: In manufacturing, changeover is the process of converting a line or machine from running one product to another. Changeover times can last from a few minutes to as much as several weeks in the case of automobile manufacturers retooling for new models. The terms set-up and changeover are sometimes used interchangeably however this usage is incorrect. Set-up is only one component of changeover.

**Internal setup**: Operations that only can be performed when the machine is stopped. For example, mounting or removing dies.

**External setup**: Operations that can be conducted while the machine is operating. For example, transportation of tools and parts to where they are needed.

**Setup time**: Period required preparing a device, machine, process, or system for it to be ready to function or accept a job. It is a subset of cycle time.

**Single Minute Exchange of Die (SMED)**: One of the many lean production methods for reducing waste in a manufacturing process. It provides a rapid and efficient way of converting a manufacturing process from running the current product to running the next product.

**Quick Changeover**: On the base of Single Minutes Exchange of Dies (SMED) helps operator to reduce setup time, improve the effective machine running time, and surely increase the quality.

**Downtime**: Period during which an equipment or machine is not functional or cannot work. It may be due to technical failure, machine adjustment, maintenance, or non-availability of inputs such as materials, labor,
power. Average downtime is usually built into the price of goods produced, to recover its cost from the sales revenue. It is also called waiting time.
CHAPTER 2

LITERATURE REVIEW

2.1 THE HISTORY OF LEAN

After World War II Japanese manufactures were faced with dilemma of vast shortage of material, financial and human resources. The problems that Japanese manufactures were faced with differed from those of their western counterparts. These conditions resulted in the birth of the “lean” manufacturing concept. Toyota Motor Company, led by its president Toyota recognized that American automakers of that era were out-producing their Japanese counterparts, in the mid-1940’s. American companies were outperforming their Japanese counterparts by a factor of ten. In order to make a move toward improvement early Japanese leaders such as Toyoda Kiichiro, Shigeo Shingo and Taiichi Ohno devised a new disciplined, process oriented system, which is known today as a “Toyota Production System” or “Lean Manufacturing”.

Taiichi Ohno, who was given the task of developing a system that would enhance productivity at Toyota is generally considered to be the primary force behind this system. Ohno drew upon some ideas from the west and particularly from Henry Ford’s books “Today and Tomorrow”. Ford’s moving the assembly line of continuously flowing material formed the basis for the Toyota Production System. After some experimentation, the Toyota Production System was developed and refined between 1945 and 1970, and it is still growing today all over the world. The basic underlying idea of this system is to minimize the consumption of resources that add no value to the product. In order to compete in today’s fiercely competitive market, US manufactures
have come to realize that the traditional mass production concept has to be adapted to the new ideas of lean manufacturing.

2.2 WHAT IS LEAN?

Lean manufacturing, lean enterprise, or lean production, often simply, "Lean", is a production practice that considers the expenditure of resources for any goal other than the creation of value for the end customer to be wasteful, and thus a target for elimination. Working from the perspective of the customer who consumes a product or service, "value" is defined as any action or process that a customer would be willing to pay for.

Essentially, lean is centered on preserving value with less work. Lean manufacturing is a management philosophy derived mostly from the Toyota Production System (TPS) (hence the term Toyotism is also prevalent) and identified as "Lean" only in the 1990s (Womack e.t al, 1990). TPS is renowned for its focus on reduction of the original Toyota seven wastes to improve overall customer value, but there are varying perspectives on how this is best achieved. The steady growth of Toyota, from a small company to the world's largest automaker has focused attention on how it has achieved this success (Bailey e.t al, 2007).

The lean manufacturing (LM) or Toyota Production System (TPS) was pioneered by a Japanese automotive company, Toyota, during 1950’s. Due to its global superiority in cost, quality, flexibility and quick respond. LM was transferred across countries and industries (Schonberger, 2007).LM has become a widely acceptable and adoptable best manufacturing practice across countries and industries (Holweg, 2007). The primary goals of LM were to reduce the cost of product and improve productivity by eliminating wastes or non-value added activities (Womack e.t al, 1990).

The success of LM implementation depends on several factors and approaches. Prior study has identified four critical success factors: leadership and management,
financial, skills and expertise, and supportive organizational culture of the organization (Achanga et al., 2006). Other researchers also suggested that applying the full set of lean principles and tools also contribute to the successful LM transformation (Herron et al., 2007). However, in reality not many companies in the world are successful to implement this system (Balle, 2005). Furthermore, previous researchers insist that there is no “cookbook” to explain step by step of the LM process and how exactly to apply the tools and techniques (Allen, 2000). Many manufacturing companies have implemented LM in many different ways and names in order to suit with their environment and needs. Therefore, it is important to conduct the research in order to identify the approaches and processes in LM implementation.

Lean focuses on abolishing or reducing waste (“muda” the Japanese word for waste) and on maximizing or fully utilizing activities that add value from the customer’s perspective. From the customer’s perspective, value is equivalent to anything that the customer is willing to pay for in a product or the services that follows. So the elimination of waste is the basic principle of lean manufacturing.

2.3 CHANGOVER

In manufacturing, changeover is the process of converting a line or machine from running one product to another. Changeover times can last from a few minutes to as much as several weeks in the case of automobile manufacturers retooling for new models. The terms set-up and changeover are sometimes used interchangeably however this usage is incorrect. Set-up is only one component of changeover. Example: A soft drink bottler may run 16oz glass bottles one day perform a changeover on the line and then run 20oz plastic bottles the next day.

The key to success in many manufacturing businesses is a move toward a leaner, more flexible, more responsive manufacturing environment. The ability of a company to change over rapidly from one product to another is essential if this move is to be achieved. There is a significant amount of information in the literature on specific
ideas that have been used to reduce changeover times, but in the vast majority of cases this rich source of data is ignored by companies undertaking changeover reduction programmed. Change over time that is illustrated in Figure 2 is defined as a method of analyzing and reducing the time needed to change a process from producing one good part to producing the next good part.

![Figure 2.1: Representation of change over time](image)

Source: Paudzi Abdullah module 2013

### 2.4 REDUCING CHANGEOVER

The need to reduce changeover times, or set-up reduction (SUR), was first realized by Shingo’. This arose from Toyota’s development of their Just-In-Time based production system. Shingo’s contribution was the development of SMED (Single Minute Exchange of Dies), which gained improvements mainly by adopting improved working methods, and which was based on the concept of moving internal to external work.
Other practitioners followed, notably Hay and Mather from the United States, who again concentrated on the improved method aspects of SUR.

In more recent years, companies have become increasingly focused on market and customer responsiveness. The problem has been to achieve this while at the same time reducing stocks throughout the whole process of manufacture. This has led, particularly in the automotive industry, to the adoption of a series of techniques that are collectively termed lean manufacture. Again, it has been recognized that the ability to rapidly and accurately changeover machines and equipment from manufacturing one product to another is a key requirements.

The SMED approach is defined as the period between the last good product from previous production order leaving the machine and the first good product coming out from the following production order (Gest e.t al, 1995). Most initiatives for set-up reduction time have been associated with Shigeo Shingo’s “Single Minute Exchange of Die” (SMED) methodology (Shingo, 1985). SMED was proposed as a workshop improvement tool focusing on low cost proposals with a kaizen improvement basis, involving shop floor teams (McIntosh e.t al, 2001). Later on, the evolution of Toyota Production System contributed to the spreading of the methodology around the world (Liker e.t al, 2006). Shingo claimed that SMED is a “scientific approach” to set-up time reduction that can be applied in any factory to any machine. With regards this statement, many studies are focusing in its applicability to other types of factories and machines (McIntosh e.t al, 2000).

Shingo (Shingo, 1985) bases his method on categorizing all setup activities into internal and external ones. With internal activities being the ones that can be performed only when the machine is shut down, and external being those that can be conducted during the normal operation of machine, when it is still running. These internal and external set-up activities involve different operations, such as preparation, after-process adjustment, checking of materials, mounting and removing tools, settings and calibrations, measurements, trial runs, adjustments, etc. SMED methodology is formed by four single stages (Shingo, 1985); a preliminary stage where the internal and external
set-up conditions are not distinguished; the first stage were separating internal and external set-up takes place; the second stage where internal activities are converted to external ones; and finally the third stage focusing on streamlining all aspects of the set-up operation.

The application of Shingo’s methodology usually results into two main benefits: increasing manufacturing capacity and improving the equipment flexibility (Coimbra, 2009). That allows working with smaller batch sizes, creating a flow of materials by eliminating waiting.

2.5 SINGLE-MINUTE EXCHANGE OF DIE (SMED)

Single Minute Exchange of Die (SMED) is one of the many lean production methods for reducing waste in a manufacturing process. It forms one of the key factors behind the success of the Just – in – Time (JIT) concept. It provides a rapid and efficient way of converting a manufacturing process from running the current product to running the next product. It is based on the concept of the Seven Wastes. Reducing time in changing over from one die to another is considered a saving in non-value adding process time. As reducing the change over time also results reduced inventories due to shorter runs, it is also considered a saving in the inventory. It is also often referred to as Quick Changeover (QCO). Closely associated is a yet more challenging concept of One-Touch Exchange of Die, (OTED), which says changeovers can and should take less than 100 seconds.

Working in any kind of manufacturing environment one of the unfortunate characteristics is waste. Waste can extend from unused raw material to damaged products, and it can carry quite of a financial loss for the company if not treated in an efficient manner. In order to reduce waste, there are several numbers of methods and strategies that companies can use depending on the desired results. One of the most popular methods is Single Minute Exchange of Die or SMED. SMED was developed by Shigeo Shingo in 1950s Japan in response to the emerging needs of increasingly smaller
production lot sizes required to meet the required flexibility for customer demand. The SMED technique is used as an element of Total Productivity Maintenance (TPM) and “continuous improvement process”. It is one of the methods of a reducing wastage in a manufacturing Process. The phrase "single minute" does not mean that all changeovers and startups should take only one minute, but that they should take less than 10 minutes (in other words, "single-digit minute").

At Toyota, Shingo developed the concept of Single Minute Exchange of Dies (SMED) to reduce setup times (Shingo, 1985); for instance, setup time in large punch press could be reduced from hours to less than ten minutes. This has a big effect on reducing lot sizes. Another way to reduce the inventory is by trying to minimize machine down time (Shingo, 1985). This can be done by preventive maintenance. It is clear that when inventory is reduced, other sources of waste are reduced too. For example, space that was used to keep inventory can be utilized for the other things such as to increase facility capacity. Also, reduction in setup times as a means to reduce inventory simultaneously saves times, thus reduces time as a source of waste.

Ohno at Toyota developed SMED in 1950. Ohno’s idea was to develop a system that could exchanges dies in a more speedy way. By the late 1950s’s Ohno was able to reduce the time that was required to change dies from a day to three minutes (Womack et al, 1990). The basic idea of SMED is to reduce the setup time on a machine. There are two types of setup: internal and external. Internal setup activities are those that can be carried out only while the machine is stopped while the external setup activities are those can be done while the machine is running. The idea is to move as many activities as possible from internal to external.

Single-Minute Exchange of Die (SMED) refers to the theory and techniques used for the reduction of equipment setup times. SMED has as its objective to accomplish setup times in less than ten minutes, i.e. a number of minutes expressed by a single digit. Although not all setups can be literally reduced to this time, between one and nine minutes, this is the goal of the SMED methodology (Shingo, 1985).
SMED, also known as Quick Changeover of Tools, was developed by Shingo (1985), who characterized it as a scientific approach for the reduction of setup times, and which can be applied in any industrial unit and for any machine. SMED is defined as the minimum amount of time necessary to change the type of production activity taking into consideration the moment in which the last piece of a previous lot was produced vis-à-vis the first piece produced by the subsequent lot (Shingo, 1985). His pioneering work led to documented reductions in changeover times averaging 94% (e.g. from 90 minutes to less than 5 minutes) across a wide range of companies. Changeover times that improve by a factor of 20 may be hard to imagine, but consider the simple example of changing a tire:

- For many people, changing a single tire can easily take 15 minutes.
- For a NASCAR pit crew, changing four tires takes less than 15 seconds.

Many techniques used by NASCAR pit crews (performing as many steps as possible before the pit stop begins; using a coordinated team to perform multiple steps in parallel; creating a standardized and highly optimized process) are also used in SMED. In fact the journey from a 15 minute tire changeover to a 15 second tire changeover can be considered a SMED journey. In SMED, changeovers are made up of steps that are termed “elements”. There are two types of elements:

- Internal Elements (elements that must be completed while the equipment is stopped)
- External Elements (elements that can be completed while the equipment is running)
2.6 STAGES OF SMED

2.6.1 Current Setup Study

This first stage consists of studying the current setup process because simply put “what is unknown cannot be improved”. It is necessary to know the process, the variability and the cause(s) that produce this variability.
2.6.2 Separating Internal and External Setup

The first stage consists of separating the operations that should be carried out when the machine is still processing the previous lot (external setup) and those where it is necessary to carry out setup with the machine stopped (internal setup). The goal for this stage is to separate/classify setup operations according to the given definition of external and internal setup. This classification takes into account the same operations and duration included in the current method, that is to say, without improving any particular operation. Also, in this stage it is necessary to assure that the operations that are defined as external setup can all be carried out with the machine running.
2.6.3 Converting Internal Setup to External Setup

The setup process time reduction from the first stage can be very significant but is not where SMED ends. To reduce setup time as far as possible (or economical), it is necessary to study the possibility of converting some internal setup operations into external setup, so that they could be carried out while the machine is running.