ELIMINATE SET-UP TIME FOR RESETTING MACHINE CNC BY USING PALLET SYSTEM OF FMS IN PT.XYZ

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# LIST OF TERMONOLOGIES

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
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</thead>
<tbody>
<tr>
<td>CNC machine</td>
<td>A machine which used to produce the mold automatically</td>
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<tr>
<td>Efficiency</td>
<td>The comparison time, affort, cost is well-used for the intended achieve the purpose with consumption of resources.</td>
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<tr>
<td>Erowa tools</td>
<td>Name of pallet tools on this resources.</td>
</tr>
<tr>
<td>Flow process</td>
<td>Time and action are needed for the attain production cycle.</td>
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<td>Effective production time</td>
<td>Total of all observed time in production process</td>
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<tr>
<td>Inspection</td>
<td>Process of checking the product is quality after finishing a kind of production process.</td>
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<tr>
<td>Machine Downtime</td>
<td>Excessive use of time on a production machine that is not effectively used for production</td>
</tr>
<tr>
<td>Machine hour</td>
<td>The time is needed by CNC machine in production activity</td>
</tr>
<tr>
<td>Manufacturing process</td>
<td>Process to produce molds from beginning until the end.</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
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<td>---------------------------</td>
<td>---------------------------------------------------------------------------</td>
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<tr>
<td>Pallet system</td>
<td>Systems which is involve to use by CNC machine such as equipment which will</td>
</tr>
<tr>
<td></td>
<td>completed flexible manufacturing system based.</td>
</tr>
<tr>
<td>Payback</td>
<td>Total cost of asset divided by total saving per month or per year</td>
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<tr>
<td>Productivity</td>
<td>Amount of product that can be produced by operator and hour</td>
</tr>
<tr>
<td>Setup time</td>
<td>Time for setup the CNC machine before machine operated</td>
</tr>
<tr>
<td>Standard operational</td>
<td>A set of instructions that have the power as a hint or a directive that</td>
</tr>
<tr>
<td>procedure</td>
<td>must be to know how to start the CNC machine and equipment.</td>
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<tr>
<td>PT. XYZ department tools</td>
<td>A manufacturing company that produces molds of dolls</td>
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<tr>
<td>Estimated scrap prevented</td>
<td>The estimate of minimal cost on prevention</td>
</tr>
<tr>
<td>SMED</td>
<td>The system used of set-up time can be eliminate the cost of production</td>
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ABSTRACT

This thesis is mainly focused on eliminate set-up time for resetting machine CNC using Pallet System in CNC area. Existing project is focused on the time resetting the CNC machine so that the quantity, quality, and costs in order to achieve maximum production. The time of production, costs of production, quality in production, and earn profits in a company is of fundamental importance that the goals can be obtained. PT.XYZ department tools have a problem at the time of production, quantity, and cost. The existence of this thesis discusses how to Eliminate set-up time for resetting CNC machines or downtime on the machine using a pallet system in flexible manufacturing system. The pallet systems can improve the capacity, can reduce production costs, and gain satisfaction from customers. By implement the pallet systems the company can be saving cost per month. Payback has accepted that pallet invested by company is 16.4 months and Incresing Total Saving Cost per year until $17'000 US$ or $1'400 US$ per month. Thus, payback has obtained from calculation that the company attained profit for the next month.

Keywords: productivity, CNC machine, eliminate setup time, pallet system, Flexible manufacturing system
CHAPTER I
INTRODUCTION

1.1 Problem background
Performance of producing in each indusrtty and the analysis done through the performance influence the development of technology machine. Thus, it can be concluded that industry has progress. Due to the developed system of production, the industry tries to minimize the wasted cost of production in order to maximize the quality and quantity by eliminating set-up time in the system of production. One of methods can be done to develop the production system is by building the connection with universities, to study the case and have research of the production system in order to have developed system. Based on Kienzle, 1970, International Institution for Production Engineering Research (CIRP) shared about production techniques, which is:

- Cutting (machining),
- Abrasive Processes (Grinding, Lapping, Polishing, Mirror finishing),
- Surfaces (surfaces Engineering, Surfaces Integrity, Roughness, Residual Stresses, Head affected Zone),
- Forming (Bending, Extrusion, Drawing, Rolling, Sheet Metal Forming, etc.),
- Assembly (Flexible automated Assembly Process, Planning, Design),
- Dimensional Metrology & Quality Assurance,
- Optimization (Production System, Information System, Data bases, Planning, Scheduling, Expert System, etc.)
- Design (CAD/CAM, Production Modeling, and Simulation).

High efficiency is important for the company could get many benefits. A company will be producing more output with fewer resources. Having high efficiency is important for PT.XYZ department tools produces mold of dolls. The process of making tools of doll can be classified into 2 major processes which are
tools of Body process and Accessories doll Process. That is all include for manufacturing process. Manufacturing is a process from the beginning until finish products. Body and accessories tools process started from Implementation Process (IP), CNC Rough-finish, CMM, EDM, Polishing, and benching injection molding. All of that process purpose to create mold of dolls as well.

IP is a begin process to make holds of mold used to give doll pin. Next process is being by machines CNC (Control Numerical Control) is controlling NC machines (Numerical Control) which fused with computer. CMM area process used to measure the molds to find the directions on that area is pas or not. This process is checking dimension on a part. Next step is EDM Machine, it process to repairing and creating the suitable of CAD, CAM and Design as same as measurement on EDM processes. The Polishing and Bench injection molding area is to polishing the surface of mold becomes smooth and neat that even every mold was injected and incorporated that achieve the good result.

Although the CNC machine has advantages can be fused with the engine computer but still need to use the measurement settings to find the center point of a point deduction. When making repeated measurements on each mold to find the center point is not very time efficient. This situation results such as consequences low productivity and high cost of production time. The process can work well to get the high productivity and low cost of production by using the FMC systems (Feasible Manufacturing Cell) concentrate on the equipment which is pallet systems which define the addition of pallets on each work piece and appealed APC (Automatic Pallet Changer) system in PT.XYZ in keeping with standardization and organization. CNC machine process still has several problem such as highest downtime for machine which make complained from customers. The initial observation shows that the operation for CNC machine still has 33% idle time. this situation results to consequences such as high cost of production and low productivity. The complains are about the standardization such as is needed most of times to produce one mold per day. Production is very slowly. Moreover, the company can reduce waste times to increase the productivity of
operations. Therefore, some study need to be held to see this opportunity to improve condition and this situation.

1.2 Problem Statement
The background of the problem leads into the statement below. How to reject long set-up time of presetting center point for machine CNC in order to increase productivity and low cost production?

1.3 Objectives
The main objective of this research is finding the way to eliminate set-up time for presetting measurement center point on process CNC machines by making or buy the pallet system.

1.4 Scope
Due to limited time and resources in doing this research, there will be some scope in this observation:

1. The Observation focus on CNC machine area
2. The observation is done in December 1\textsuperscript{st} – January 28\textsuperscript{th} 2014

1.5 Assumption
The assumption as follows:

1. No machine breakdown during the process
2. The CNC machine performance is assumed to be the same
3. The skill operator is the same
4. There will be no defect the midst of CNC machine process

1.6 Research Outline
The project can be finished if the all of chapter is done. Process on this project finished from chapter 1 until chapter 5.

Chapter I Introduction Outline

This Chapter Explains of the background of research, problem statement, objective, scope, and assumption of the study.
Chapter II  Literature Study

For this chapter explain all related concepts and theories are given that this research can supported from theoretically.

Chapter III  Research Methodology

In this chapter explained the flow of research.

Chapter IV  Data Collection and Analysis

Data and analysis from observation are processed in this chapter.

Chapter V  Conclusion and Recommendation

The conclusion result of this research can viewed in this chapter and also recommendation for future research

The problem and objectives of research have been clearly explained in this chapter. The scope and assumption have also stated. Start this research must have direction that needed to know how to solve this project until achieved the objectives. Therefore, the next chapter will be delivered by previous studies who related about the subject.
CHAPTER II
LITERATURE STUDY

2.1. Numerical Control
Based on Daniel 2009, Numerical Control is programming automatically where the machine controlled by computer. Information from computer is controlled direct by program computer too. The program is determined for many machines which are milling machine, drilling machine, turning etc. The technology has been advantages are comparing instead of manual operation. Advantages of this technology have a high accuracy and speed more than manual system. Manual system have code program to process data component from another computer so that it printed on paper tape and finally put on the reading tape of that machine. NC machines more sophisticated have been computer related with machine. The system is called CNC (Computer Numerical Control). The photos as can be seen in the attachment.

2.1.1. Computer Numerical Control (CNC)
Based on Daniel 2009, CNC stems from 1952, developed by John Pearseon from Massachusetts Institute of Technology, United States. In 1975 the production of CNC machine began growing rapidly. The advantage of CNC system is all program can be modified the process although machine still running. Another advantage on this system will be saving the data modifications so that don’t worry if the data in paper tape is lost. Thus, do not need to read paper tape on the process. One computer would be handle one machine. CNC Machining center is one kind of CNC machines are widely used in the manufacturing process, in said machining centers for this one machine can do any machining process. There are process of drilling, Milling, boring, tapping. Type machining center there are 2 kinds, namely vertical and horizontal machining center. Vertical types process direction from top to bottom. Whereas horizontal machining center process horizontal direction, can move forward or backward depending on the engine design and program.
2.1.2. **Parts of CNC**

The photos of CNC machine and the part are saved in attachment. CNC machine have point parts are useful to know more about the system and machine of CNC. Parts of CNC System which are,

- **Linear Axis** is the axis moves in a linear fashion. CNC machining center machines generally have 3 linear axes, i.e. X, Y and Z axis. The movement of the 3 axes are orthogonal.
- **Rotation Axis** is moving in a rotary axis (spin). Rotary movement can be done 1°, for a new type of machine Machining center could move 0.1°. Whereas precision rotary axis movement generally 0.001°.
- **APC** is Automatic Pallet change. This means that the replacement pallet done automatically. For the APC process, there should be 2 pallets. 1 pallet is in the machine and the other is outside the machine. For pallets that are outside the machine in use for setting work pieces yet in the process, while the pallet is in the machine used to process the work pieces. If the finished work pieces pallet in a setting in which there is outside and the work pieces in the machine already in process, the APC can be done. This means that existing pallet outside the engine into the engine and the pallet is in the machine off automatically.
- **Cutting tool** is a tool that is used to form the machining process.
- **Magazine** is a parking lot cutting tool. So that cutting tools used in the process are stored in the magazine.
- **Spindle** is a cutting tool holder for the process. Spindle can be played according to the desired but the maximum speed of rotation in accordance with the specification of the spindle motor’s used.
- **ARM ATC** serves to turn the tool where ARM took a cutting tool in the magazine to the spindle in place. Tool replacement process can be done manually, MDI (Manual Data Input) and automatically called by the term ATC (Automatic Tool Change).
- **ATC** is a simple process as follows the magazine prepared a tool that will be transferred to the spindle area that ARM ATC took the tool.
from magazine and put into the spindle. If there is a tool in the spindle before than the tool in the pot to move to the magazine according to previous address

- CNC machining center machines require lubrication because the movement is very fast and accurate. Sideway lubrication is to place or flow path axis X, Y, Z axis, spindle gearbox axis, and gearbox lubricant table
- Coolant is used from cooling and lubricating the cutting tool during the process
- CNC controller is controller device that complicated and device. CNC Controller serves to control all that machine can be done automatically and manually
- CNC Program Is a program that is made to order work processes sequentially. When XYZ axis moves, when the spindle rotate is fast, medium, or slow and then when coolant on. It is set by program that has been created and stored in the CNC controller CPU

The great system of CNC machine is all part can be applied as well that could be production process has not waste.

2.2. Manufacturing Operations

2.2.1. Traditional Manufacturing (TM) Versus Contemporary Manufacturing (CM)

Based on Tompkins 1996, Traditional manufacturing is the way manufacturing organization were designed, managed, and operated in 1970s. The characteristics of TM are long setup, many vendors, noncertified vendors, centralized storage systems, corrective quality control, quality control department in charge of quality assurance, lot size, top-down decision making, centralized rework department, centralized offices for support personnel, process layout, vertical organizational structure, inflexible material handling systems, sequential product process design corrective maintenance, a minimum number of receiving shipping point. Consequently, TM organizations are operate with large inventories, long production lead times, high manufacturing cost, poor customer service, poor
quality, long delivery times, high space and storage requirement, high handling requirements and also low productivity. The progression from traditional manufacturing to contemporary manufacturing is shown in figure 2.1

![Figure 2.1 stage of progression from traditional manufacturing to contemporary manufacturing](image)

Utilize Contemporary manufacturing is tend to follow strategy that begin with the development of long term and short term objectives and goal that correlate with corporate, marketing, and product development strategies. The objective and goal that means are tactical and operational strategies. It is implemented by terms following an integrated and organized reengineering and continues improvement process. Figure 2.2 shows a relationships among the contemporary manufacturing areas by technique and concepts between Just in Time, Total Quality Maintenance, Total Employee Involvement, and Computer Integrated Manufacturing Systems.
Figure 2.2: Relationships among the contemporary manufacturing areas

Technique and concepts related with Just in Time (JIT), Total Quality maintenance (TQM), Total Employee Involvement (TEI) and Computer integrated manufacturing Systems (CIMS).

2.2.2. Just in Time (JIT)

Based on Kindersley, 2006, Just in Time manufacturing concept was founded in part due to the contribution of Dr Chango Shigo and Taichii Ohno of Toyota Motor Corporation more than 20 years ago. Just in Time production system has been defined by the American Production and Inventory Control Society (APICS) based on the pursuit of the planned elimination of all waste and consistent to improve productivity and quality. JIT applies to all of forms manufacturing, process, job shop, and repetitive manufacturing. To eliminate waste from a philosophy respect for people gives recognize to employee using visibility, simplicity, flexibility, organization, and standardization (Tompkins 1996).

- Visibility is obtain with the following techniques such as electronic boards for quick feedback, decentralized storage systems, tools, dedicate area for inventory etc.
Simplicity can be achieved with a simple machine, small lot size, simple setup changes, certified processes, leveled production, teamwork, simple material handling etc.

Flexibility can be achieved with short production times, short setup times, flexible material handling equipment, multi-functional and flexible employees etc.

Organization is required for setup times, for work areas, for kanban system, for the storage areas, tools, team work activity etc.

Standardization of tools, pallets, methods, containers, materials, boxes, equipment, and processes.

Eliminate waste is important to recognize first so that would be find the common sources of waste in organization are equipment, time, inventory, space, labor, handling, transportation, and paperwork.

### 2.2.3. Total Employee Involvement (TEI)

Based on Tompkins 1996, Empowerment is needed to revise the traditional decision making and problem-solving approach. TIE is to involve the experts from different departments to improve decision making of complicated issues or involve the experts from the specific department, area, or line to continuously improve their operations. Empowered individual needs to change from dependency to interdependency such as administrative, human-related, development of operational, technical, skills,and knowledge, for the manager is need to change from bosses to a leader, develop all themselves through training, education, and involve to direct, coach, participate and delegate authority and responsibility. All of those interdependency is very needed to improvement with creating the new system in the area manufacturing to develop as more better then before.

### 2.2.4. Total Quality Maintenance (TQM)

Based on Tompkins 1996, Total quality maintenance is continuous process improvement. To continuous every process improvement have ultimate focus to increase customer satisfactions.
TQM is applied to quality management system so all practitioners will be involvement of all functions, all employees, strong customer orientation and a philosophy of continuous improvement. It must improve the processes to comply with and, when possible, exceed their expectations. For the CNC machine have intensive of quality of source is achieved through in process verification. The product can be built if monitoring of process is close. Reduction in quality problem helps shorten the lead time of manufacturing.

The quality of product and on time delivery can bring happier customers that is the opportunity business in the future. World class manufacturing environment will allow to reduction of the quality of cost which is reduction time needed most cost to resetting up CNC machine. Education and training employees can be standardization and organization into team to carry on improvement opportunities.

Pareto chart is a graph presented in the hours lost by problematic machine focus on the actual problems. A corrective action plan is developed to specific identified to solving the problem will be achieve the goal. For example is the specific problem about machine downtime which influence for machine breakdown. The pareto chart of breakdown on the machine can see from figure 2.3 to explain views of higher problem not yet reached the target goals.

![Figure 2.3: Machine breakdown between actual and goal](image)

From this figure can do the conclusion to find how much the problem machine breakdown by the pareto chart source. How much the percentage of the problem which shows the higher response to accomplish that problem.
Detail pareto chart of Breakdown per machine shows in figure 2.4. choose the highest source of problem by machines.

![Pareto Chart]

**Figure 2.4 : Breakdown per machine**

### 2.2.5. Computer Integrated manufacturing Systems (CIMS)

The term computer integrated manufacturing systems (CIMS) was coined by Joseph Harrington, written in 1973. CIMS brings people, technology, products, and processes to a single integrated system. (Tompkins 1996)

CIMS futures are enable to improve and control the plant and manufacture good quality products. Production Process in CIMS must be related with the FMS system, assembly systems based on manufacturing processes. Automation from CIM system can being the processes is more quickly than before no using CIM. Figure 2.5 shows about CIM production process.
The equipment, material handling equipment, quality and the process control devices are automatic should be under computer control integrate those the whole system and interface to other components of the CIM system. The automated material handling is most important rule for this kind of integration. For example are CNC machine, grinding machine, and CNC electrod are integrated with one the central measurement’s EDM machine with purpose the manual handling to reduce work in process between workstations.

2.3. Pallet System for CNC Machine

Based on Niebel & Freivalds, 2009, The adaptation of machine to automatic tool changer and the automatic pallet changer was primary to development of Flexible Manufacturing Systems. Purpose of Pallet System is to improve the machine utilization, improve the output of the machine, and boost the productivity of manufacturing by eliminating nonproductive idle time and optimizing use of manpower in producing part. Set up the fixtures that hold the jobs on pallets. By installing the pallet system, the operational time of the system can be extended to run for long periods completely unattended.

The storage of pallets to kept those equipment of pallets is saving in pallet stand. When the manufacturing schedule of the pallet to be made, the mold is entered in the cell controller schedule, the pallet arrives at the setup station where the mold or material is loaded, and the pallet is moved to a machine. After finished, the mold and pallet is bring to pallet stand to save them.
2.3.1. Setup and tools

Based on Niebel and Freivalds, 2009, Setup time is closely with tooling because tooling invariably determines the setup in tear downtime. Setup operations are especially important in the job shop where production runs tend to be small. Even if this type of shop has modern facilities that may still have difficulty meeting the competition if setup is too long. It caused inefficient tooling and poor planning. The ratio of setup time to production is high so that a methods analyst can develop several possibilities for setup and tools improvement. That is approach with standardization on JIT techniques.

\[
\text{Setup Time} = \text{Cost per machine hour} \times \text{Gain with tooling} \quad (2-1)
\]

2.3.2. Reduce Setup Time

The SMED (single minute exchange of die) System of Toyota Production System (Chingo, 1981) is a good example that setup time can often be eliminated by ensuring raw materials. The smaller lots in production can often prove the cost of effective. When time in the work can be pressed become more efficient it could be work with using presetting tools for machine numerical control (NC) is done. When we talk about time in manufacturing which often difficult to control would be reduce the downtime in processing that needs the new systems to improve the resetting of machines.

2.3.2. Flexible Manufacturing Systems (FMS)

Flexible Manufacturing System is reprogrammable manufacturing system capable of producing a variety of products automatically. Numerical control machines and incorporation of robots provides reprogramming capabilities at the machine level with minimum setup time (Tompkins, 1996). The equipment for Flexible manufacturing systems to completed the rules going on production flows.

The Figure 2.6 shows a rectangular layout of pallet using flexible manufacturing systems.
This figure shows from begin is loading, machine operation, unloading molds or workparts and the last is mold is complete. Load man is the operator who will assembled the workparts and pallet becomes into a single unit. Unload man is area unloadig where the operator will be seperating the pallet and mold are already finish operated by machine and then the pallet put on the conveyor line will be come back to loading area again. This is the cycle of pallet system on production molds.

The studies about CNC machine, manufacturing operations, pallets systems, setup time and other tool that support this research has been delivered in this chapter. Thus, the steps to eliminate wasting time for resetting machine CNC using pallet systems are starting to be revealed. Next, defining the methodology in research has to be done in order to obtain clear steps in achieving the objectives. The research methodology is defined in the next chapter.
CHAPTER III
RESEARCH METHODOLOGY

Initial Observation
- Direct observation in PT XYZ

Problem Identification
- Analyze CNC machine in manufacturing process
- Problem and objective identification
- Determine scopes and assumption

Literature Study
- Analysis machine CNC and setting up tools
- Quantitative tools and machine relationship
- Pallet systems
- Comparison of alternative cost

Data Collection and Calculation
- Observation by using Pallet systems
- Comparison of alternative cost
- Set-up time analysis
- Reduce setup times

Analysis and Development
- Analyze current condition
- Propose a new system
- Counting cost current
- Comparison current versus propose system

Conclusion and recommendation
3.1. Initial Observation
The initial observation is done by observing Computer Numerical Control (CNC) machine process area directly. CNC machine was being observed because this area has several problem issues that can not solved until now. After observation that will be interview Supervisors, Team and Project Leaders, Quality Coordinators, and operators to knows about CNC machine, setup machine. The long times to produce one mold in one day, flow process, and the management manufacturing so can be taught and advised on developing new knowledge and skills about CNC machine and manufacturing areas.

3.2. Problem Identification
After observation in CNC machines process is conducted several problems happened inside area. One of problem in CNC machine is higher downtime for set-up tools. This observation is having problem that could be conducted with some improvement in this area. The scopes and assumption are made to limit the project due the limitation of resources and time.

3.3. Literature Study
The literature should be conducted to find any relevant references related to the problem. It needed when doing problem identification, data collection and calculation, and data analysis. This activity will provide in term of theory and concept as guidance in accomplishing this project. Theories and concept are the one related with problem identification and problem solving. This project consist to approach Feasible manufacturing system, reducing setup time and got the most efficient term to find the problem solving.

3.4. Data collection and calculation
After the problem, theories, and problem solving are got it, next step is collected the data and calculating with using theories and concept from educated to find the solving of literature ways.
3.5. **Analysis and Development**

After finish to collected and calculated the data until analyzing is done. Create some new system in the machine area and than created a new tool which exaited to help the operator has presetting up the raw material and machine will be running. Analyze set-up time on machine CNC , analyze productivity or input which produce per week, analyze equipment and maintenance cost, purchase cost. After all the analysis is done will be propose the system new tool work arrangement for productivity in CNC machine. Since final project has not been implemented, the new work arrangement for efficient result by the productivity and setup time cost after finish calculating the data.

3.6. **Conclusion and Recommendation**

This is the last phase of this research. Conclution the improvements and effects resulted from the solution implementation achieve the objectives or not. In this phase also included by the recommendation. The recommendation comes for both the readers and the company.

Next after the research methodology for this research is explained in chapter three, on chapter four will be analysis from the data collection and the developing the new system is the pallets in CNC machine.
CHAPTER IV
DATA COLLECTION AND ANALYSIS

4.1.  Current Condition in Manufacturing Area especially CNC Machine process area

Manufacturing floor area is place of all process area machines make to be a flow is called flow process. CNC process area is a great innovation that has successfully made by PT.XYZ. With CNC machine, the operator does not need to roughting mold manually. The operator need to load molds to the machine and than presetting up masure of zero point and prepare equipment of setting before loading and the machine will run automatically. Manufacturing flow process detail shows at figure 4.1.

The detail process of CNC machine shows at figure 4.3 currently the CNC machine needs set-up mold on machine before machine is run which needed more times. Currently, there are two CNC machines which still usage in PT. XYZ.

This Figure 4.1 is about flow process in manufacturing area. Every processess have relationship from one process area with another. The first process is product development, tool making stage and until debuging’s finish. But this important area of this research to specific release in number 6 is CNC Steel. CNC Steel is area of this research would be explanation. Methods in general of operated CNC machine by entering commands via tail numeric buttons are available on the instrument panel in each machine.
Figure 4.1: Manufacturing Flow Process in PT. XYZ

The specific release directly to this research is CNC steel. Computer Numerical Control have a PC, machine, and equipments supported. PC (Personal Computer) to CNC machine as an input device for CNC machines very important role to obtain the performance of CNC machine. Therefore, every factory that manufactures CNC machines also produce or recommended PC specifications are used as inputs for the production of CNC machining. Standard code CNC
machine can only read of standards agreed upon by industry that makes CNC machines. The standard code PT.XYZ can be used as a Personal Operation input produced or recommended. CNC machine area can be shown in figure 4.2.

![CNC Machine Area](image)

**Figure 4.2: CNC machine Area**

CNC Machine in PT. XYZ is a new generation with advances in the field of computer technology, it has developed software application contains technical drawings with CAD (Computer Aided Design) who already may be asked to show the program to work with CNC machine.

The application has used by PT.XYZ is CAM (Computer Aided Manufacturing). This software generally made the aim to optimize the performance of CNC machine produced. By using CAM, an operator simply work to drawings of objects that will be made with CNC machines on PC. The result of working drawings can be executed in a simulation to see how the work of the workpiece on the CNC machine through the monitor screen. If there is a deficiency or error, it can be repaired without loss of material. If the result of the simulation execution has been as expected then the program continues with program execution engine.

Engine program can be directly sent to the CNC machine over a network or cable or transferred through the recording media. The possible inputs CNC machines can be derived from the image of manual labor that is read through the scan then interpreted by PC connected to the CNC machine. The scan will readings can be processed by the software on the PC into the simulation
program such CAD or CAM. On machine must having shrink fit or cutting, magnetic based plate, insert, coolant liquid. All of those supporting the production process. The simulation to be execute into a program that is ready to be executed CNC machine to make the workpiece. A CNC machine needs around 5 hours to produce mold.

- Start
  - Load mold to resetting tools: 5 minutes
  - Setting Program to machine: 15–30 minutes
  - Load mold to machine: 30–45 minutes
  - Unload mold from machine: Around 240 minutes
  - Inspection: 10 minutes
  - End: 15–20 minutes

Figure 4.3: CNC Machine Process (set-up)
The process is using Standard Operational Procedure for CNC machine. The beginning is the start, next is load molds to resetting tools, next the load mold to machine CNC, next the unload mold from machine CNC, and then Inspection the mold, and the last is end of that machine process. The set-up procedure can be divided into four basic elements which are preparation, jaw/cutter change, tool change and the first part machining. Table 4.1 explaining about operations category per mold. The categories have internal and external operations. Internal operation talk about set-up time inside machine whereas external operations is outside set-up machine.

**Table 4.1 Operation category per mold using SMED Shigeo Shingo**

<table>
<thead>
<tr>
<th>No</th>
<th>Operations Internal</th>
<th>Time (min)</th>
<th>Operations External</th>
<th>Time (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Tool preparation and coolant</td>
<td>15</td>
<td>Raw material preparation</td>
<td>15</td>
</tr>
<tr>
<td>2</td>
<td>Measuring center point (set-up)</td>
<td>15 – 30</td>
<td>Jaw preparation</td>
<td>15</td>
</tr>
<tr>
<td>3</td>
<td>Insert change</td>
<td>10</td>
<td>Inspection</td>
<td>20</td>
</tr>
<tr>
<td>4</td>
<td>Holder change</td>
<td>10</td>
<td>Load mold from machine</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Insert numeric program</td>
<td>30-45</td>
</tr>
<tr>
<td>5</td>
<td>TOTAL</td>
<td>65</td>
<td>TOTAL</td>
<td>105</td>
</tr>
</tbody>
</table>

Operator needs 15-30 minutes to set-up the load mold with tools and for the next process needs 30-45 minutes of setting program to machine. After that, around 4 hours more the molds would be process on machine. Reduce set-up time is using SMED (Single Minute Exchange of Die). The set-up time can be often be eliminated by ensuring raw materials. The current condition of the table machine as shown in figure 4.4.
Load mold to resetting tools is the characteristics of how to operate the CNC machine in PT.XYZ department tools can be done is the absolute system. This system, the starting point of the replacement of the cutting tool which is used as a reference in set a reference point remains valid during engine operation takes place. Machine CNC lathes the reference point is placed on the axis (center) of the workpiece to be done at the end need 15-30 minutes for that. Dial of machine CNC is used to searching flatness and straightness of the workpiece on the machine table as shows at figure 4.5:

Load mold to machine is meaning of the machine’s running to produce mold with tool’s equipment which operated by PC. After producing the finished mold, the mold is brought to the table in the inspection to check whether there is a defect or incorrect cutting. Unload mold from machine means that the mold are not manufactured by CNC machines.
Inspection is the place of inspected and corrected all the mold is finished produce. Inspection place is a place to correction the result after process producing the mold.

4.1.1. *CNC Machine and Man Performance potential*

Machine must be utilized to the greatest possible extant. The work of machine in the working time is 1800 hours per years output of leisures, weekends, and holidays.

On this current condition have a bigest down time for the machine. comparing the times of the effective production and the downtime machine per year is shown in table 4.2

<table>
<thead>
<tr>
<th>Effective Production Time</th>
<th>800 hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Down time machine</td>
<td>1000 hours</td>
</tr>
</tbody>
</table>

The productivity is increased though the elimination of setting up work from the machines but the current condition in PT.XYZ will not using flexibility in production planning. In this case, the downtime for the machine have a highest hours. Effective production has 800 hours and downtime has 1000 hours.

4.1.2. *Production Hour Presumed*

In Indonesian factory have three fully manned shifts @ 8 hours per day.

4.1.3. *Machine Costs per Hour*

<table>
<thead>
<tr>
<th>Table 4.3 : Machine cost without tooling and several component</th>
</tr>
</thead>
<tbody>
<tr>
<td>Investment on EDM machine and equipment</td>
</tr>
<tr>
<td>Lifetime of machine</td>
</tr>
<tr>
<td>Payback of Credit</td>
</tr>
<tr>
<td>Machine Costs per year</td>
</tr>
<tr>
<td>Production hours per years (3 shifts per 8 hours)</td>
</tr>
<tr>
<td>----------------------------------------------</td>
</tr>
<tr>
<td>Gain with tooling</td>
</tr>
<tr>
<td>Costs per machine hour</td>
</tr>
</tbody>
</table>

Pallet holder, plate-based pallets, EDM machine and another equipment was invest with 10 years lifetimes in the factory.

4.1.4. Setup Time in Current Conditions

Gain with tooling searched by total production hours per year within By using equation 2-1, setup time of machine to be assigned can calculated as follow

\[ \text{Gain with tooling : Total production hours per years (3 shifts per 8 hours) – production hours without tooling} \]

\[ 3600 – 2400 = 1200 \]

\[ \text{Setup time = Cost per machine hour x gain with tooling} \]

\[ 10 \text{ US$ x 1200} = 12,000 \text{ US$ per years} \]

4.2. Purpose Scenario 1: Investment for Tooling per machine

Setting up for CNC machine will be simple if there is having component for reset up workpiece on the machine. No resetting in the actual sense of the word any more. Replenishment pallet holder and baseed for workpiece expected the work is efficient.

This system will be the base on all machines allowing the product will be moved from one workstep to the next without removing from the pallet, even it is a different kind of machining (hard milling to the EDM to the Grinding and to next process)

Invested the tooling of machines which are pallet holder, 2D presetting machine, and based plates needed cost is not cheap but with this case helped process is quickly.
**Table 4.4: machine cost with tooling and several component**

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Investment on EDM machine and equipment with pallets, 2d preset</td>
<td>260,000 US$</td>
</tr>
<tr>
<td>Lifetime of machine</td>
<td>10 years</td>
</tr>
<tr>
<td>Payback of Credit</td>
<td>5 years</td>
</tr>
<tr>
<td>Machine Costs per year</td>
<td>26,000</td>
</tr>
<tr>
<td>Production hours per year (3 shifts at 8 hours)</td>
<td>3,600 hours</td>
</tr>
<tr>
<td>Gain with tooling</td>
<td>1,200 hours</td>
</tr>
<tr>
<td>Costs per machines hour</td>
<td>7 US$</td>
</tr>
</tbody>
</table>

Scenario one is no require setup time 1200 hours output in years. Totally 3600 hours/year used by production output if using pallet. Eliminate set-up time for production create the minimize downtime and get the costs of target. Eliminating set-up time will be described in the table 4.5 below.

**Table 4.5 Eliminating set-up time per day if using pallet and plate-based.**

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gain with tooling per year</td>
<td>1,200 hours</td>
</tr>
<tr>
<td>Gain with tooling on minutes per year</td>
<td>1200 hours x 60 min = 72,000 minutes</td>
</tr>
<tr>
<td>Gain with tooling per month</td>
<td>6,000 min / month</td>
</tr>
<tr>
<td>Using pallet system (3 shift)</td>
<td>5 days / week</td>
</tr>
<tr>
<td>Eliminate downtime is</td>
<td>5 hours / day</td>
</tr>
</tbody>
</table>

The detail explanations from Table 4.5 will be explained from Table 4.6. Pallet system is usage of CNC machine can be eliminate the wasting time of operations category. Using Pallet can eliminates tools preparation 15 minutes, set-up time is 30 minutes, insert change is 10 minutes, holder change is 10 minutes, inspection
mold is 20 minutes, unload mold from machine is 10 minutes. Therefore, partially from operations internal and external can eliminated. Total eliminate operations when using pallet is around 95 minutes per mold. Therefore, eliminate time already can be used entirely on load mold on machine. So that, total output of production can be increase.

**Table 4.6 operations category will be reduce the set-up time using pallet system.**

<table>
<thead>
<tr>
<th>No</th>
<th>Operations Internal</th>
<th>Time (min)</th>
<th>Operations External</th>
<th>Time (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Tools preparation</td>
<td>15</td>
<td>Raw material preparation</td>
<td>15</td>
</tr>
<tr>
<td>2</td>
<td>Measuring center point (set-up)</td>
<td>15 – 30</td>
<td>Jaw preparation</td>
<td>15</td>
</tr>
<tr>
<td>3</td>
<td>Insert change</td>
<td>10</td>
<td>Inspection</td>
<td>20</td>
</tr>
<tr>
<td>4</td>
<td>Holder change</td>
<td>10</td>
<td>unload mold from machine</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Insert numeric program to PC</td>
<td>30-45</td>
</tr>
<tr>
<td>5</td>
<td>TOTAL</td>
<td><strong>65</strong></td>
<td>TOTAL</td>
<td><strong>105</strong></td>
</tr>
</tbody>
</table>

Total Internal and external operations in one CNC machine is 170 minutes where are the opearations included the inspection time, unload a mold in machine, insert numeric program from work book to personal computer owned by the engine, jaw preperation, holder change, insert change, set-up tool preperation (jig) and the raw material preparation.

**4.2.1. Pallet Holder and Based plates for CNC machine**

Using Pallets as mentioned will reduce machine down times to almost zero for the work. work that has been done once can be reproduced by other operators without any errors at any time. Using universal tooling system the workpieces can be checked, measured and re-machined in reference position before the operators clamped into the system. The pallet holder is shown in figure 4.6. and base plates is shown in figure 4.7.
Pallet system create the machining times of the manufacturing batches can be reduced several times over. Investment costs will pay off within a short period of time.

4.2.2. Changes in the Shapes of the Mold after Using Pallet

Changes in the shape of a mold design that has not been put on a pallet into a mold that has been designed by using a pallet can be seen from figure 4.8 and figure 4.9 are listed below.
In figure 4.8 it can be seen that the holes in the mold dowel pin looks less than the mold that use pallets. Perencangan manufacture of pins in each mold is done by part design consisting of CAD and CAM, and mold design. Each dowel pin hole in the mold serves as the glue that combines workpiece mold and other tools. Dowel Pin were made in the mold has a different size. There is a great dowel pin for mold hole too large and there are small for small holes. All depends on measuring and describing the design section. Setting the zero position on the insert before the drill and then make a hole for the dowel pin Ø 8H7 with 0:02 to distance 100. tolerance after the screw hole jig plate M10 using the existing two dowel pin holes, which had previously been made so no need to position the longer direction x and y her. After complete screw holes and dowel pin holes, insert subsequently fitted with pallet Erowa.
using pallet more than have screw holes for fitting with pin pallet use to united a mold with pallet so that assembling from twice can not missed. The bond between these two may be closely or stronger and can not be displaced from a position that is already in the assembly.

4.2.3. Incorporation pallet with mold

Invest palette for CNC machines have the advantage for the company. Installation tool pallet with mold can be seen in this figure 4.10. As for advantages in investing pallet is as follows:

Reproducibility, optimization of production, flexible planning of manufacturing processes, and reduction of manufacturing costs. The reproducibility is work that has been done once can be reproduced by other operators without any errors at any time. the pallet system introduces standardized procedures into operations. Molds can be checked, measured and if necessary, re-machined in reference position before they are clamped into the system. Optimization of production talk about the use of automation, unmanned night and weekend shifts are transformed into lucrative production time so the machining time can be reduced several times over. Investment costs will pay off within a short period of time. Flexible planning of manufacturing processes talk about resetting for another molds is simple because there is no resetting in the actual sense of the word any more. If a sufficient number of tools and the program are in place, the machine can be reset of a new workpiece. Even long term programs can be interrupted to accommodate urgent jobs, and then resumed at a later stage. Just in Time becomes a purely
organizational issue. Reduction of manufacturing costs speak about manufactuting costs can be cut drastically. In proportion, the greated investment costs are only slight.

**Figure 4.10: mold has assembled by pallet**

Insert from the figure means mold which will be in production. The below of insert is a pallet from investement and the bottom is based of plates of pallet. It can see from figure 4.11 shown as mold incorporate with a pallet.

**Figure 4.11: the example of mold and pallet is already assembly**

Based plates and pallet are one unit can not be seperated because both of complementary and interconnected.
4.3. Scenario 2: pallets produced

In this matter, producing pallet and plate-based requires a lot of time, workers were not a few, and also the high cost of raw materials. PT.XYZ department tools can be actually produce pallets itself but requires time, effort, and cost a bit too by following process flow where the manufacture of pallets that have previously been made in advance. The process flow can be seen in figure 4.12

4.3.1. Pallet manufacturing Process Flow

Flow process pallet produced shown in figure 4.12.

![Flow process pallet produced](figure4.12)

**Figure 4.12: Flow process pallets produced**

Figure 4.12 is about flow process to produced pallet by factory. From the beginning is the start, blocking face of raw material, Griding the raw material,
and the next presetting on self centering, next is drilling by CNC machine, and the next 2D presetting on pallet, roughting work pallet by CNC machine, and check finished work pallets. After that, the pallet will be tested in Quality Control on CMM machine and CMM machine that to obtain more accurate results, the quality control of pallets it tested again. If that result is accurate so that the pallet will be fitting and assembled.

Make pallets requires no fewer workers and has been providing raw materials, design, machine and equipment that require a lot of time to create maximum results

**4.3.2. Cost of Minimum Salary has produced pallet**

Estimate of calculation minimum salary for worker on pallets production / month

Recruit workers

@ shift1 : Rp. 1.700.000

- 1 worker for supervisor pallets
- 1 worker for design
- 2 workers for running CNC, EDM and 2D machine
- 1 worker for assembly pallet on molds

\[ \text{Needed} \quad 5 \text{ Workers} \times \text{Rp. 1.700.000} = 8.500.000 \]

(output raw material, equipment and cost of machine, And Time Production Cost)

include the costs of raw materials, equipment, and the cost of machine, the costs involved will be more than invest pallet. Where is the time to produce pallets are also very much so do not achieve the desired targets. so then pallet production time employee time-consuming to operate and produce mold.

**4.4. Compared between the current condition, Scenario 1, and Scenario 2**

Current condition, scenario 1 and scenario 2 should be compared in order to get a decent propose. If the existence of a new enterprise system change
PT.XYZ get better conditions change then one such scenario, a reference to the increase in the manufacturing process.

4.4.1. **Comparison between Current Condition with Scenario 1**

Comparison between the current condition and the scenario 1 can be seen in figure 14:13 which describes the effective production machinery equipment on time and down time machine.

Standardization in scenario 1 explains that the performance potential of machine further reduce down time and increase the effective production system in working time. This is increases the production but not wasting time of work.

![Figure 4.13: Comparison Machine Performance Potential Between Current and Proposed](image)

In figure 4.13, it explained about the differences of effective production time and machine downtime between the time of CNC machine with using tooling and current condition just on the working time. On this figure catch up only 800 hours are obtained by no tooling and 1200 hours are obtained using tooling after that can be the some conclusion. Comparison between effective production and machine downtime is 400 hours. It obtained from reset another company which using Erowa pallet. The conclusion is downtime from using tooling can be reduce.
Comparison between CNC Machine no tooling with CNC Machine with tooling (Pallet) Standardization.

Table 4.7 : Comparison Current and Proposed System

<table>
<thead>
<tr>
<th>Description</th>
<th>CNC Machine no tooling</th>
<th>CNC Machine with PALLLET Standardization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Investment on EDM machine and equipment</td>
<td>237’000 US$</td>
<td>260’000 US$</td>
</tr>
<tr>
<td>Lifetime of machine</td>
<td>10 years</td>
<td>10 years</td>
</tr>
<tr>
<td>Payback of credit</td>
<td>5 years</td>
<td>5 years</td>
</tr>
<tr>
<td>Machine Costs per year</td>
<td>23’700.-</td>
<td>26’000.-</td>
</tr>
<tr>
<td>Production hours per year (3 shifts at 8 hrs)</td>
<td>2400 hours</td>
<td>3600 hours</td>
</tr>
<tr>
<td>Gain with tooling</td>
<td>1200 hours</td>
<td></td>
</tr>
<tr>
<td>Costs per machine hour</td>
<td>10 US$</td>
<td>7 US$</td>
</tr>
</tbody>
</table>

Table 4.7 explains about comparison between CNC machines no tooling dan CNC machine with using tooling pallet of standardization. Investment EDM machine and equipment for the machines are needed highest costs than before is no tooling, but there is the strategy to improving all current condition becomes to real of the future component and got the goals. Production hours per machine not into working time and leisure time on night, weekend and holiday not included for the production time. CNC machine with tooling standardization have production hours per year is completed so that totality working time for worker in production flow is increasing with compared with CNC machine without tooling. Production hours per year is the output hours per year. Production hours per year from CNC no tooling in PT.XYZ department tools obtained is 2400 hours per year. Gain for tooling would be explained on Table 4.5 and 4.6 about setup time and tools. Pallet investment to the company establish costs of machine hour is diminish.
### 4.4.2. Return of Investment

**Table 4.8: Return of investment per machine**

<table>
<thead>
<tr>
<th>Description</th>
<th>Components</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>One EDM machine</strong></td>
<td><strong>23’000.- US$</strong></td>
</tr>
<tr>
<td>Investment for Tooling US$</td>
<td>1200 h/yr x 10 US$</td>
</tr>
<tr>
<td>Chuck, Pallets, share of PreSet 2D+C</td>
<td></td>
</tr>
</tbody>
</table>

| Savings in one year because of: | |
| Setup time | 12’000.- US$ |
| Estimated scrap prevented | 5’000.- US$ |
| **Total savings per year** | **17’000.-US$** |
| **Total savings per month** | **1’400.- US$** |

| Payback time | |
| Total investment Tooling (23’000$) | **16.4 Months** |
| Total savings per month (1’400$) | |

The calculation process of saving in one year about setup time can be found on pages 26 and 27.

Through this comparison can be conclude that the new system on manufacturing floor is pallet system give the eliminate set-up time on CNC machine so as the obtain return of investment. Therefore, conclusion and recommendation to the company will be explained in the last chapter.
CHAPTER V
CONCLUSION AND RECOMMENDATION

5.1. Conclusion

The objective of this final project already in chapter 1. The conclusion of this research:

1. Using Pallet System for CNC machine reduce cost per machine hour and increasing the productivity.
2. Increasing Total Saving Cost per year until 17’000 US$ or 1’400 US$ per month.
3. Payback of investment tooling is 16,4 month if buying the pallet in order to eliminate 1200 hours, the calculation above is not consider the interest rate.

5.2. Recommendation

5.2.1. For the company

The recommendation for the company such as:

1. Conduct some research to solve the quality issue in CNC machine process area. The suggestion to make some improvement in CNC machine. The machine already consistence, the output of result will be the same so that the inspection process can be deleted. Therefore, eliminate downtime of setting up CNC machine can increase the effectiveness of production time.
2. Focus on training and motivating the operators in the manufacturing area in order to improve the quality of the operators to operate the machine, to develop the new skill so that the operators are capable to operate that machine.

5.2.2. For future research

For the future research is suggested to focus on work station layout of CNC machine process area because at the previous, there has not been done any
research yet in CNC machine. Thus, to improve system work station layout by WSAD, Work System Analysis Design.
REFFERENCES


