STUDY OF PRODUCTIVITY IMPROVEMENT IN A DIE CASTING UNIT

Thesis submitted in partial fulfillment of the requirements
for the award of the degree of

**MASTER OF ENGINEERING IN MECHANICAL ENGINEERING
(INDUSTRIAL ENGINEERING)**
of BHARATHIAR UNIVERSITY

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This is to certify that this thesis work entitled **"STUDY OF PRODUCTIVITY IMPROVEMENT IN A DIE CASTING UNIT"** being submitted by K.VENKADESHWARAN (REG. No. 0137H0017) for the award of degree of MASTER OF ENGINEERING IN MECHANICAL ENGINEERING (INDUSTRIAL ENGINEERING) is a bonafide work carried under my guidance. The results embodied in this thesis have not been submitted to any other university or institute for the award of any Degree or Diploma.

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ROOTS CAST PRIVATE LIMITED

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PROJECT WORK CERTIFICATE

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SYNOPSIS

Downtime is non-productive time. Whenever time that is designated to be used in the active production of a product or the delivery of a service is used for something else, down time occurs. Simply stated, downtime is any time that is used for some other activity other than accomplishing a goal. Down time occurs for different reasons but can be generally be traced back to people, machine problems and material problems. These problems result from poor planning, ineffective communication or lack of follow up and confrontation.

Downtime prevents managers from meeting their goals. Down time increases the cost of the product, and has a negative effect on the profit that manager is expected to 'earn' for the company.

In this work, an effort is made to identify and reduce the downtime in a die casting unit at ROOTS CAST Pvt. Ltd., Coimbatore. This is one of the premier organisations engaged in the production of Aluminium and Zinc castings of various sizes ranging from 12g to 1250g. The analysis of the previous months data of production gave a clear picture of the downtime loss in terms of hours and monetary value suffered by the company. The reasons behind the various downtimes were studied thoroughly. In this process of analysis of reasons, powerful tools such as Pareto analysis, Cause and Effect Diagrams, etc. are used. After studying the reasons, appropriate recommendations are suggested to reduce or nullify the down time.

An attempt is made to improve the production efficiency of the operators through the use of Trend Chart indicating the hourly production rate. A generalised software is developed using Visual Basic as front end and Microsoft Access as the back end to handle the downtime data and generate periodical report.

CONTENTS

1.INTRODUCTION

1.1 Productivity And Its Improvement:

Productivity has now become an everyday watchword. It is crucial to the welfare of industrial firm as for the economy progress of the country. High productivity refers to the work in a shortest possible time with least expenditure on inputs without sacrificing quality and with minimum wastage of resources.

Today the term productivity has acquired a wider meaning. Originally, it was used only to rate the workers according to the skills. The persons who produced more either faster or harder were said to have higher productivity. Subsequently, emphasis was laid to improve the hourly output by analyzing and improving upon the techniques applied by different workers. A system of measurement was then evolved, to compare the improvement made in relation to the rate of output and in order to improve productivity further, machines were introduced. Manufacturers of machines started incorporating new features with the help of latest technological developments. Today we have machines that are completely controlled by computers. Computers have now become powerful tools towards improving productivity.

Concept

Productivity is the quantitative relation between what we produce and what we use as a resource to produce them, i.e., arithmetic ratio of amount produced (output) to the amount of resources (input).

Productivity can be expressed as:

$$\text{Productivity} = \frac{\text{Output}}{\text{Input}}$$

Productivity refers to the efficiency of the production system. It is the concept that guides the management of production system. It is an indicator of how well the factors of production (land, labour, material, energy) are utilized.

Definitions Of Productivity

- Productivity is a function of providing more and more of everything to more and more people with less and less consumption of resources.
- The volume of output attained in a given period of time in relation to the sum of the direct and indirect efforts expended in its production.
- Productivity is the measure of how well the resources are brought together in an organisation and utilized for accomplishing a set of objectives.
- Productivity is concerned with establishing congruency between organizational goals with societal aspirations through input-output relationship.
- Productivity is the multiplier effect of efficiency and effectiveness.

Production And Productivity:

Production is defined as a process or procedure to transform a set of input into output having the desired utility and quality. Production is a value adding process. Production system is an organized process of conversion of raw materials into useful finished products.

The concept of production and productivity are totally different. Production refers to output whereas productivity is relative term where in the output is always expressed in terms of inputs. Increase in production may or may not be an indicator of increase in productivity. If the production is increased for the same output, then there is an increase in productivity.

Productivity can be increased

When production is increased without increase in inputs.

The same production with decrease in inputs.

The rate of increase in output is more compared to rate of increase in input.

Benefits From Productivity

Always there is a misunderstanding about the productivity in the mind of workforce. To the workers, higher productivity means higher work, higher efforts, more profit to owners and unemployment.

Productivity integrates the objectives of owners and workers. Productivity contributes towards increase in production through efficient utilization of resources and inputs rather than making workers to work hard. Productivity strives to minimize the human hazards and human efforts with a view to utilize them to those where they can contribute maximum to the output.

Dynamics Of Productivity Change

Productivity results in lower cost per unit by effective utilization of all the resources and reducing wastages. Lower cost per unit contributes to increased profit levels so that company can reinvest the surplus in new technology, equipments and machines. This will result in further productivity increase and also there is a greater employment generation due to new investments. The productivity increase results in higher wages thereby increasing purchasing power of workers. The productivity increase sets in a chain reaction as shown in fig.1.1

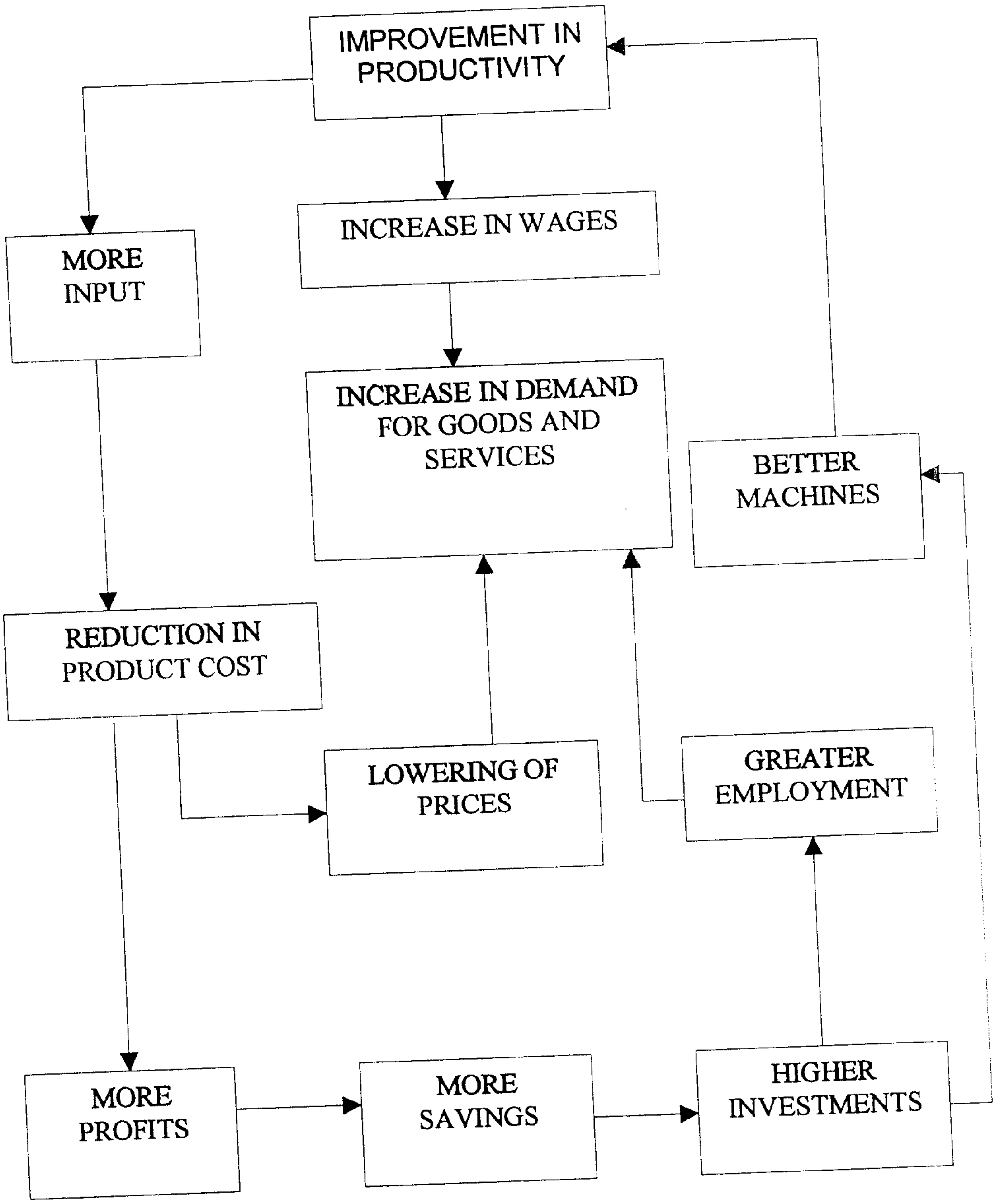


Fig 1.1 Dynamics Of Productivity Change

1.2 Company Profile

ef History about the Company	Established in 1984, with one machine, now equipped with 10 machines Initially manufacturing only Horn components and gradually developed other components in Automobiles, Textile, Pneumatic, Electrical components Growth Rate 1984 - 10 tons 2002 – 1000 tons
uality Policy	Providing world-class products and services with due concern for the environment and safety of the society. This will be achieved through ➢ Continuous improvement in quality. ➢ Technology up gradation. ➢ Cost reduction. ➢ Total employee involvement
Quality Systems	ISO 9002 by TUV.
Products & Range	• Auto Electric Parts 50 to 500 g • Fuel Injection Pump Parts 70 to 750 g • Ring & Speed Frame parts 10 to 800 g • Engine Parts 20 to 200 g • Electric Iron Parts 200 to 400 g • Electro Mechanical parts 50 to 250 g • FRL – Pneumatic Parts 50 to 300 g
Major Products, Volumes and Annual Capacity	Manufacturers of Precision Aluminum and Zinc Pressure Die Cast components. a) Textile Machinery components: 190 tons

	b) Automobile components : 450 tons c) Pneumatic components : 215 tons d) Electrical components : 145 tons Total Annual capacity : 1000 tons
oys used: Aluminium alloy Zinc alloy	DIN: GD AL Si 9 Cu3 GD AL Si12 (Cu) GD AL Si 7 Mg GD AL Si 10 Cu 2 Fe JIS ADC6 ADC12 GDZn AL 4, GDZn AL 4 Cu 1
Annual Sales for last Three years	1999- 2000 - 2.40 USD in millions 2000 -2001 - 2.98 USD in millions 2001- 2002 - 3.74 USD in millions
Forecast for next year	2002 -2003 - 4. 14 USD in millions
Facility Area	Unit – I - 42000 Sq. ft. (Built up area – 12000 sq f Unit – II - 25000 Sq. ft. (Built up area - 13000 sq
Production Equipments	Pressure Die Casting Cold Chamber Machine DC 60T - 3 Nos HMT Buhler DC 120T - 3 " " DC 180T - 2 " " H 250 T - 1 " " 250 JT - 1 " Toshiba, Japan CNC Fully Automatic

. of Employees	189
cal Customers	• Lakshmi Machine Works Ltd and its group of Companies. • Roots Industries Ltd and its group of companies • Premier Instruments and controls Ltd. • Philips India Ltd. • Lucas TVS Ltd. • Motor Industries Co. Ltd. • Wipro Information Technology Ltd. • Instrumentation Limited. Astra Microwave Limited.
Overseas Customers	Marzoli, Italy (1996 – 1998). Suessen Ltd, Germany. Zinser Textilmaschinen GmbH, Germany. Trico Products (through Tata International Ltd). GE Industrial Systems, USA.
Major Facilities	Roots Group is equipped with a modern in-house Tool Room with state of the art facilities like • CAD - Pro/Engineer, SDRC, I-DEAS, AutoCAD • CAM- Micron 3 Axis Milling Machine supported by MasterCAM Software • CAE - 3 Axis CMM Well equipped in-house Metrology Lab for Calibration requirements of our group and other leading industries.
Working pattern	Three shifts of 8 hours for six days a week.

2. SYSTEM STUDY

2.1 Die Casting Process

Die-casting is a manufacturing process for producing accurately dimensioned, sharply defined, smooth or textured surface metal parts. It is accomplished by forcing molten metal under high pressure into reusable metal dies. The process is often described as the shortest distance between raw material and finished product. The term die-casting is also used to describe the finished part.

There are two basic die casting processes: the hot-chamber and the cold chamber processes. The hot chamber process is used for die casting metals that melt at lower temperatures, such as Zinc and lead. The cold-chamber process is used for die casting metals that melt at higher temperatures, such as aluminium, magnesium and brass.

Hot Chamber Process:

In the hot-chamber process, the plunger and cylinder are submerged in the molten metal in the holding furnace. The power to pump zinc into the die cavity is provided by a hydraulic accumulator. Oil is supplied to the accumulator pressures up to the desired operating level each time a casting (shot) is to be made.

When a shot is made, the control valve opens causing the shot cylinder to force the plunger down and force molten metal through the nozzle, past the sprue pin, through the runners and gates, and into the die cavity. The gases that were in the system and some of the molten metal flow through the die cavity and out through vents and/or into over-flows. After the cavity is filled, the metal is allowed to solidify, the casting is ejected, and the cycle is repeated. Since the gooseneck and plunger are submerged in the molten metal, the system refills automatically when the plunger is withdrawn.

Cold Chamber Process:

The casting sequence for the cold-chamber process in illustrated in the fig 2.1.1. In this process, molten metal is ladled into the cold chamber and then the plunger advances to force the metal into the die. Except for the manner in which molten metal is fed into the shot system and injected into the die, the casting sequence for the two processes are similar.

Clamping Mechanism:

Because of the tremendous pressures used to inject the molten metal into the die, many tons of forces are required to hold the two die halves together. This holding force is accomplished with the tie bar-platen-toggle type machine construction. The construction arrangement not only achieves the required holding (clamping force), but it also opens and closes the die rapidly. This speed helps to achieve the high production rates of the die casting process.

Die Casting Dies:

Die-casting dies consist of two sections: the cover half and the ejector half, which meet at the parting line. The die cavity, which forms the part being cast, is machined into both halves of the die block or into inserts that are installed in the die blocks. The die designed so that the casting remains in the ejector pins that come through holes in the die and are actuated by the ejector plate, which is powered by the machine. Guide pins extending from one die half enter holes in the other die half as the die closes to insure alignment between the two halves.

Dies that produce castings with complex shapes may contain stationary and movable cores. The movable cores are moved by cam pins or hydraulic cylinders and are locked in place when the die is closed.

Since die casting machines operate at high rates, heat must be removed from the die at a high rate. Heat is removed from the die by circulating water or other coolant through channels drilled in the die blocks. Heat sometimes is added to the die by electric or gas heaters for warm-up or making thin sections, which transmit insufficient heat to maintain the die at the proper operating temperature.

Operating sequence of the cold chamber die casting process:

1. Die is closed and molten metal is poured into the cold chamber
2. Plunger pushes molten metal into die cavity. The metal is held under pressure until it solidifies.
3. Die opens and plunger advances to insure casting stays in ejector die. Cores, if any, retract.
4. Ejector pins push casting out of ejector die and plunger returns to original position

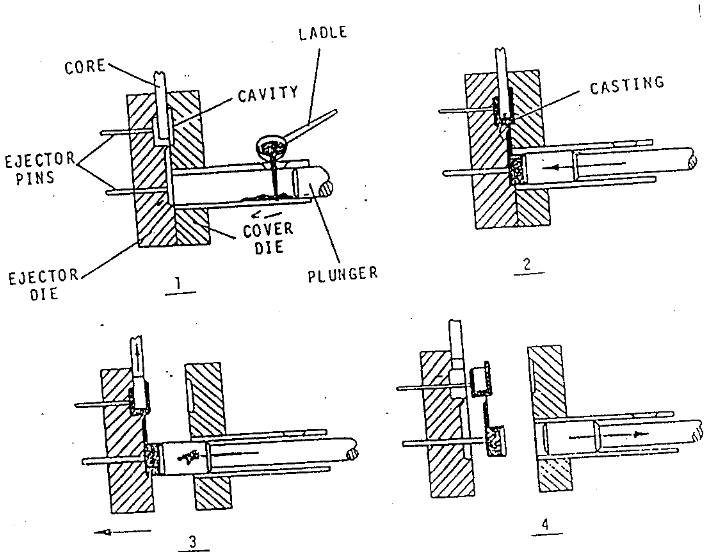


Fig.2.1 Casting Sequence for the Cold Chamber Process

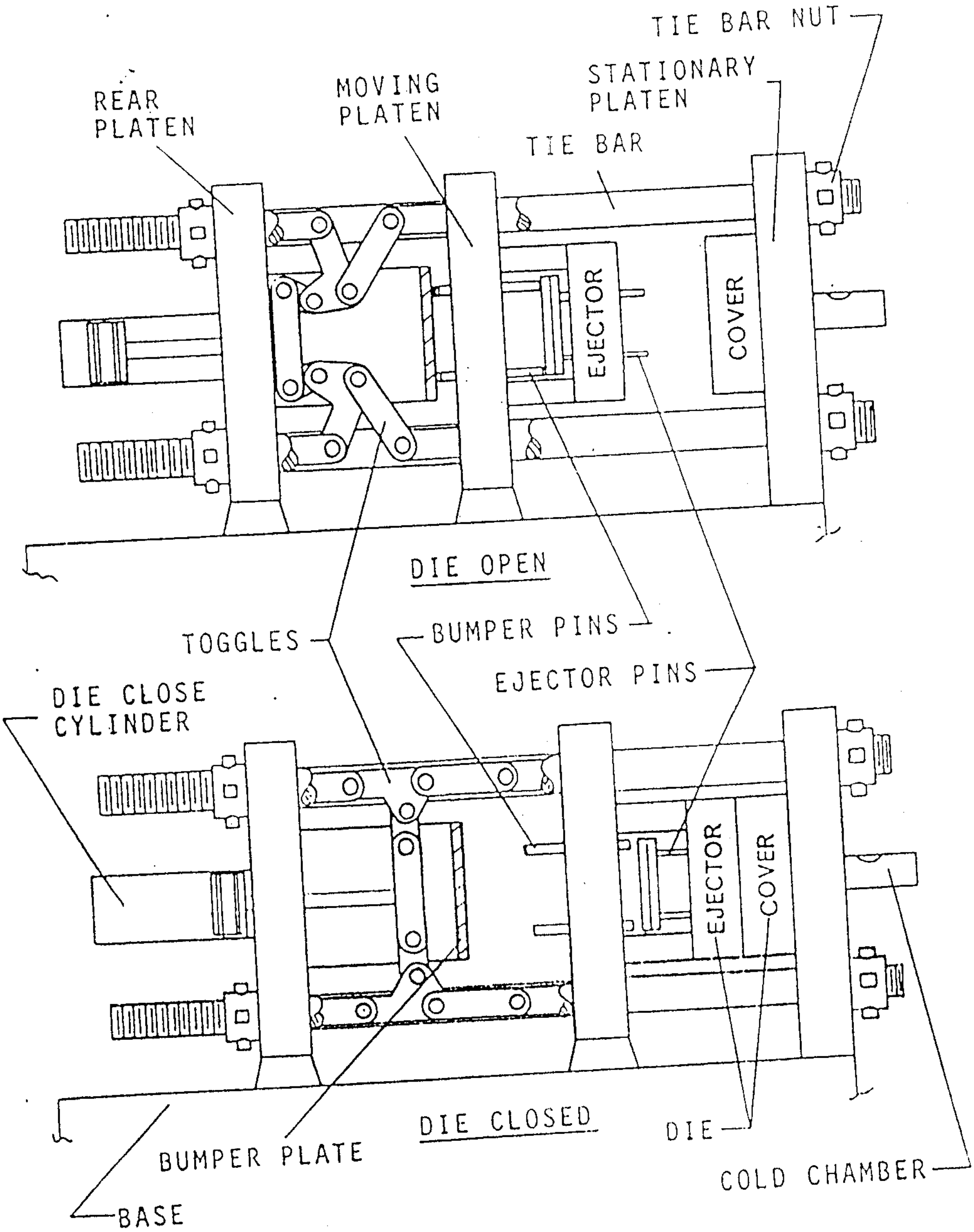


Fig.2.2 Typical Diecasting machine construction. The hydraulic die closing cylinder straightens the toggle links to close the die. This arrangement achieves high die clamping force and rapid die opening and closing action.

2.2 DOWNTIMES IN A DIE CASTING UNIT

The inefficient time during which the production is hindered because of breakdown, maintenance activity, setting up operation or any other reason can be considered as downtime. The most commonly encountered downtimes in a die casting unit are as follows,

2.2.1 Die Changing Time:

In a die casting unit, a variety of components are manufactured. This means a number of dies are to be used. When the production of a particular component is over the die has to be unloaded and another die has to be loaded for casting the next component. This time is naturally an inefficient time.

2.2.2 Melt Treatment:

The aluminium in molten state is to be treated with chemicals prior to pouring into the die. It plays an important role towards the quality of the casting in terms of microstructure, strength, machinability, freedom from porosity, etc..

2.2.3 Die Breakdown Maintenance:

The ejection pins, used to eject the die-castings out of the die and the core pins used to have cavity or hole in the casting often breaks, bringing the production to halt.

2.2.4. Die Regular Maintenance Time:

Though it does not require unloading the die from the machine, the frequency of its occurrence makes it a concern. Soldering or sticking of a small quantity of aluminium to the die requires time to get it scratched. Flashing or dimensional inaccuracy also stops the production.

2.2.5. Electrical Breakdown:

The machines being semi-automatic have cards and circuits. These cards and circuits are liable to failure. Also the accessories such as burners, furnaces may also face electrical problems.

2.2.6. Metal Changing Time:

In the unit concerned Zinc as well as aluminium castings are made and same crucible is used for both. Hence it takes time to change the metal in the crucible.

2.2.7. Crucible Changing Time:

Due to a variety of reasons, the crucible in which the metal is kept breaks or leaks requiring a change of it.

2.2.8.Initial Melting:

The metal has to be heated to melt it. For quality castings the aluminium is heated around 670°C and it takes time to reach that temperature.

3. PROBLEM DEFINITION

In any industry, the downtime or lost time is the causing one for them to attain the maximum productivity. Downtime is non-productive time. It prevents managers from meeting their goals. Downtime increases the cost of the product and also has an impact on the profit that the manager is expected to earn for the company.

The chosen company is interested to improve the productivity by reducing the non-productive times.

The problem is to analyse the various reasons causing the downtime in the various stages of manufacturing using the tools such as Cause and Effect diagram, Pareto analysis, Method study etc. Based on the reasons obtained, appropriate recommendations are to be suggested. The recommendations are to be implemented to the possible extend and the improvement is to be studied. In addition to it, generalised software is to be developed to handle the downtime data so that the periodical review can be done easily and the improvements can be monitored effectively.

4. METHODOLOGY

The tools used for this study are as follows,

Pareto Analysis,

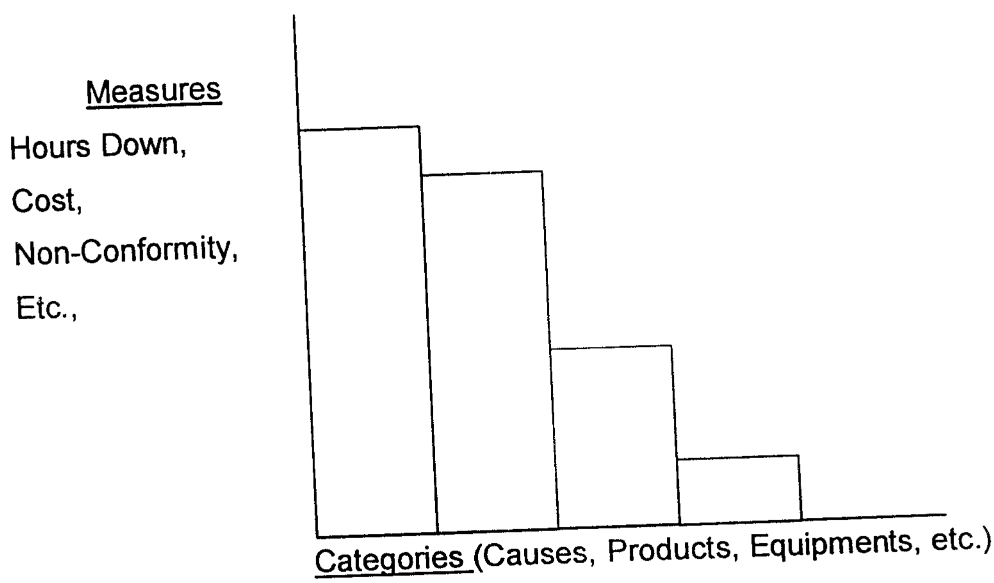
Cause and Effect Diagram and

Workstudy.

4.1 Pareto Analysis:

Pareto was an Italian economist, who studied the distributions of wealth and quantified the extent of inequality or non-uniformity or its misdistribution in the society. His concepts are now been generalized as they hold true in many other fields.

This is also known as 80-20 principles i.e. 80% of the problems in downtimes are due to 20% of the causes. Thus if the 'vital few' causes are identified, major rejections can be eliminated by concentrating on these particular cause leading aside the other 'trivial many' causes. Pareto diagram is used to identify the vital few causes.



The Pareto diagram is plotted by taking various measures in Y-axis and by taking various categories in X-axis. The measures may denote hours down, cost etc., the categories may denote causes, operators, products, equipments, etc. The categories are arranged in descending order. A bar is drawn against each category, the height of the bar is equal the percentage contribution of category.

4.2 Cause And Effect Diagram (Fishbone Diagram)

A cause and Effect Diagram is a simple yet powerful tool of visually recording possible causes affecting a problem and relating to the effects.

- Helps breakdown a seemingly large problems into smaller elements.
- Helps individuals and groups to generate ideas.
- Provides a means to record ideas
- Reveal hidden relationships
- Helps to identify the root of the problem
- Highlights important relations for investigation

An effect means the result of any work or activity that is physically seen or behavior that is observed and therefore could be used in any situations.

Cause means any element or source, which has influence directly or indirectly on the effect noticed. For every effect, there must be a cause associated with the environment in which the work or activity is done.
In 1953 Prof.Ishikawa while working in the university of Tokyo designed this form of diagram known as Dr. Ishikawa's diagram. Since the final form of the diagram looks like a fish, it is also called as " Fishbone Diagram".

4.3 WORKSTUDY:

Workstudy succeeds because it is systematic both in investigation of the problem being considered and in the development of the solution. Some aspects of the nature of Workstudy and why it is such a valuable 'tool' of management are listed below

- It is a means of raising productivity of a plant or repeating unit by the reorganization of work, a method that normally involves little or no capital expenditure on facilities and equipment.
- It is systematic. This ensures that no factor affecting the efficiency of an operation is overlooked; whether in analyzing the original practices or in developing the new, and that all the facts that operation are available.
- It is the most means yet evolved of setting standards of performance, on which the effective planning and control of production depends.
- It can contribute to the improvement of safety and working conditions at work by exposing hazardous operations and developing safer methods of performing operations.
- The savings resulting from properly applied work study start at once and continue as long as the operation continues in the improved form.
- It is a 'tool', which can be, applied everywhere. It can be used with success wherever work is done or plant is operated, not only in manufacturing shops but also in offices, stores, laboratories and service industries such as wholesale and retail distribution and restaurants, and on farms.
- It is relatively cheap and easy to apply.

Techniques in Workstudy:

The term 'workstudy' embraces several techniques, but in particular method study and work measurement.

Method study is the systematic recording and critical examination of ways of doing things in order to make improvements.

Work measurement is the application of techniques designed to establish the time for a qualified worker to carry out a task at a defined rate or working.

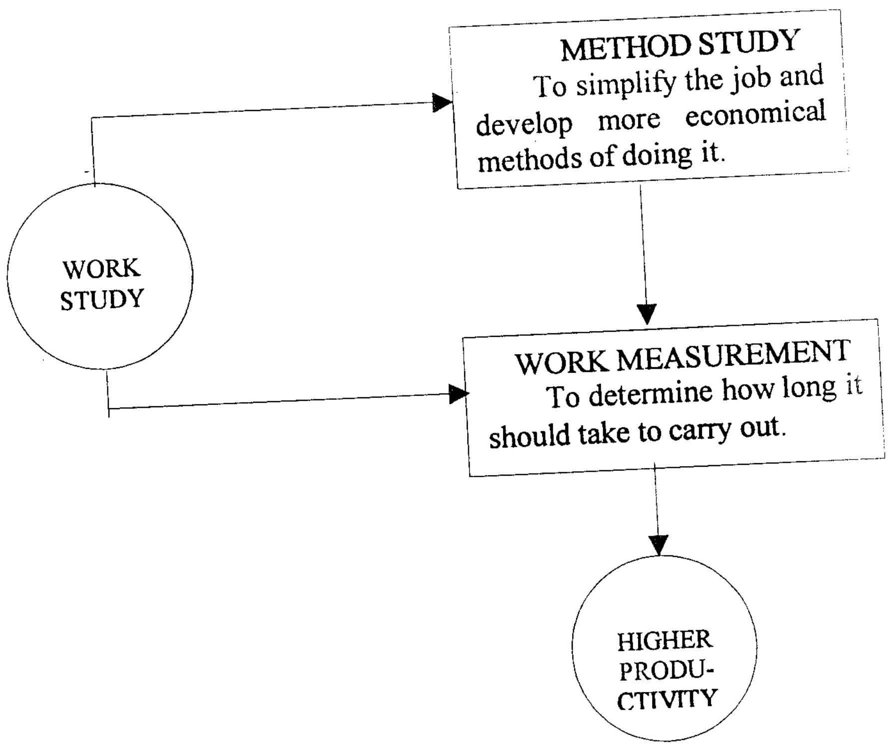


FIG 4.3.1 Techniques of Workstudy

Basic Procedure For Method Study:

- Selecting the job or process to be studied.
- Recording or collect all relevant data about the job or process using the most suitable data collection techniques, so that the data will be in the most convenient form to be analysed.
- Examining the recorded facts critically and challenge everything that is done, considering in turn: the purpose of the activity; the place where it is performed; the sequence in which it is done; the person who is doing it; the means by which it is done.
- Developing the most economic method, taking into account all the circumstances and drawings as appropriate on various production management techniques, as well as on the contributions of managers, supervisors, workers, and other specialists with whom new approaches should be explored and discussed.
- Evaluating the results attained by the improved method compared with the quantity of work involved and calculate a standard time for it.
- Defining the new method and related time and present it to all those concerned, either verbally or in writing, using demonstrations.
- Installing the new method, training those involved, as an agreed practice with the allotted time of operation.
- Maintaining the new standard practice by monitoring the results and comparing them with the original targets.

Time Study:

Time study is a work measurement technique for recording the times of performing a certain specific job or its elements carried out under specified conditions, and for analyzing the data so as to obtain the time necessary for an operator to do it at a defined rate of performance.

Steps in making a Time study:

When the work to be measured has been selected, the making of a time study usually consists of eight steps.

- Obtaining and recording all the information available about the job, the operative and the surrounding conditions, which is likely to affect the carrying out of the work.
- Recording a complete description of the method, breaking down the operatioj into elements.
- Examining the detailed breakdown to ensure that ethe most effective method and motions are being used, and determining the sample size.
- Measuring with a timing device (usually a stop-watch) and recording the time taken by the operative to perform each 'element' of the operation.
- At the same time, assessing the effective speed of working of the operative relative to the observer's concept of the rate corresponding to standard rating.
- Extending the observed times to 'basic time'.
- Determining the allowances to be made over and above the basic time for the operation.
- Determining the standard time of the operation.

Breaking the job into elements:

Once the study person has recorded all the information about the operation and the operative needed for proper identification in the future, and is satisfied that the method being used is the correct one or the best possible in the prevailing circumstances, it must be broken down into elements.

An element is a distinct part of a specified job selected for convenience of observation, measurement and analysis.

A detailed breakdown into element is necessary

- To ensure that productive work (or effective time) is separated from the unproductive activity (or ineffective time).
- To permit the rate of working to be assessed more accurately than would be possible if the assessment were made over a complete cycle.
- To enable the different types of element to be identified and distinguished, so that each may be accorded the treatment appropriate to its type.
- To enable elements involving a high degree of fatigue to be isolated and to make the allocation of fatigue allowances more accurate.
- To facilitate checking the method so that the subsequent omission or insertion of elements may be detected quickly. This may become necessary if at e future date the time standard for the job is queried.

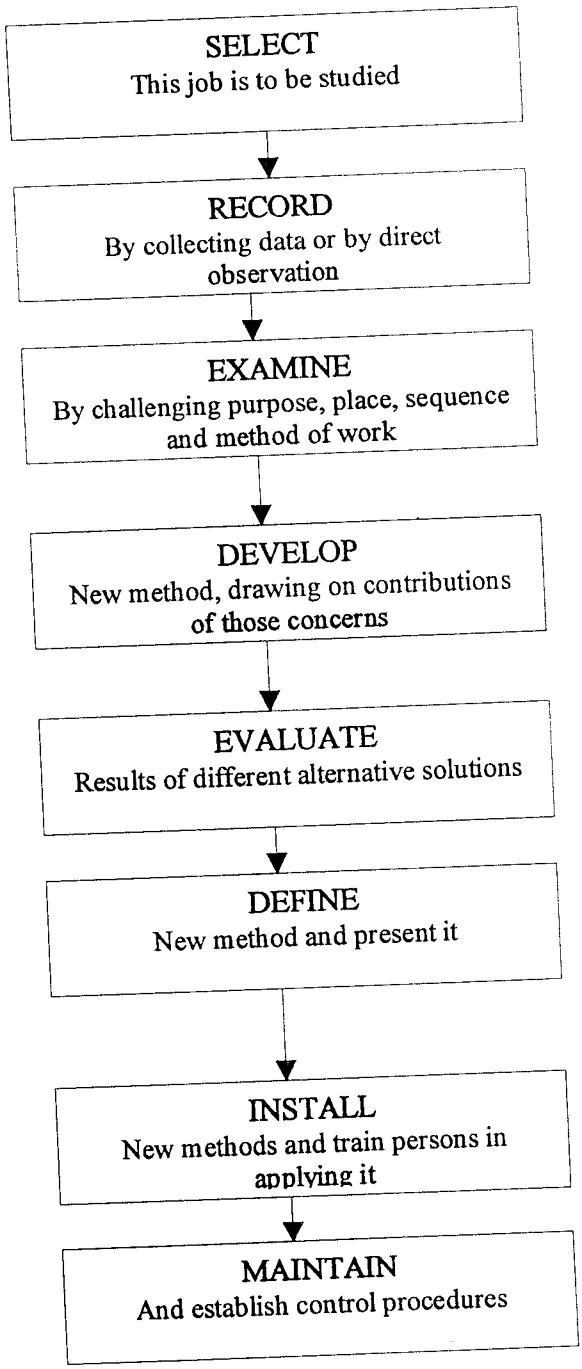


FIG:4.3.2 The approach for work-study

5. PROBLEM SOLVING

5.1 Die Changing Time:

In a die casting unit, a variety of components are manufactured. This means a number of dies are to be used. When the production of a particular component is over the die has to be unloaded and another die has to be loaded for casting the next component. This time is naturally an inefficient time. Moreover, if the die insert experiences any problem, it has to be unloaded, set right and reloaded to the machine.

Though this Die changing time could be considered in setting time, the inefficient time within it has to be reduced.

The operation is done about 50 times a month, and hence any reduction or elimination in any of the elements would have its impact on the total downtime per month.

As can be seen from data collected, the die changing time alone contributes 56 hours towards monthly downtime.

Objective:

- Study the operation in detail.
- Breakdown the operation into elements
- Conduct time study
- Identify bottlenecks
- Provide recommendations to reduce this downtime.

Die Changing Operation:

The die changing operation in brief has the following steps

1. It is to be ensured that the die has completely undergone the regular maintenance.
2. The die is taken from the die maintenance room to the machine using a wheeled table.
3. The die already in the machine is to be unloaded.
4. New die is loaded.
5. Set the Process parameter conditions.
6. Check whether the operation is smooth and error free.

Elements in die changing operation:

The operation is studied in detail and it is broken down to smaller elements. An element is a distinct part of a specified job selected for convenience of observation, measurement and analysis.

The elements identified in the die changing operation are

1.Removing of Mechanical/Hydraulic Core	8.Shot sleeve, Plunger, Plunger rod changing
2.Return rod nut and moving die unclamping	9.New fixed die loading
3.Return rod and Bumper rod removing	10.New fixed die parallel setting
4.Tie bar removing	11.New moving die loading
5. Moving die clamping and unloading	12.Die height setting
6. Fixed die unclamping	13..return rod and bumper rod providing
7.Removing of fixed die	14.New moving die clamping

15.Return rod tightening and lock setting	17.Die heating
16.Mech./Hyd. Core providing	18.Attribute free first shot

5.1.1 Existing Condition:

Time study is conducted expecting to reveal the bottlenecks as well as the efficient time. It is found that the operation takes around 60 minutes, which is much higher than the fixed target of 25 minutes.

5.1.2 Problems Identified:

The bottlenecks in the Die changing operation are

1. Inefficient material handling.
2. Improper display of tools
3. Time taken for die heating

The problems identified are not alien and are as follows. The operators were found searching for tools and accessories such as Return rods, Ejection rods, etc. Only after stopping the machine, the new die to be loaded is brought to the machine. The die is loaded from the machine manually which resulted in more time taken. The parallel setting and die heating were found as most time taking elements. Often the operators have to wait for die heater. The Cover die and Ejection die are loaded separately. The loading and unloading of the dies are done using chain block.

5.1.3 Recommendations to reduce Die Changing Time:

Based on the investigations done on the operations the following recommendations are provided in order to improve the efficiency of the operation as well as reduce the inefficient time.

1. Set the die to be loaded closer to the machine before the production with the older die/ previous die is stopped.
2. Ensure that the proper die is taken from the Die Maintenance Department since the label on the die and insert may vary.
3. Ensure that the accessories such as ejection rods, return rods etc., relevant to the new die are ready.
4. Avoid the time consumed in searching of these accessories by providing each die with a set of ejection rods, return rods etc.
5. Ensure that the tools required are previously set and hence avoid the delay in searching. Provide each machine with a set of tools.
6. Use electrical hoist to load and unload the dies rather than doing it manually. It would save a considerable time.
7. The die is heated to around 125 °C before starting the production. The time taken for this is about 15 minutes. This time must be reduced to a possible minimum. In order to do this, the die heater may be provided with two nozzles, so that both the fixed die and the ejection die can be heated simultaneously.
8. The cover die and Ejection die may be set as close as possible while heating to reduce the heat loss and to ensure faster heating.
9. Providing an additional die heater could do much to the cause most of the time operators are found waiting for the die heater. This extra die heater may also be used for simultaneous heating of the dies.

10. Parallel setting of the die is one of the elements taking more time. Hence markings may be engraved or pasted on the machine to enhance the speed of this element.
11. While heating the die, ensure that the plunger tip also is heated, so that the initial products may not lack in quality and surface finish.

5.2 Melt Treatment:

5.2.1 Need for Melt Treatment:

Liquid metal treatment is nothing but the process of adding some fluxes in order to remove the impurities in it and also to improve the quality and strength of the die-casting. It plays an important role towards the quality of the castings in terms of microstructure, strength, machinability, Freedom from porosity etc[7].

5.2.2 Troublesome Characteristics of Aluminium:

The melting technology of Aluminium alloy is different from other metals. Some of the inherent but troublesome characteristics of Aluminium from the melting angle.

1. Aluminium has low specific gravity.
2. Liquid aluminium has high affinity to Oxygen and hence rapidly forms oxide film, whenever the surface is freshly exposed. Now the difficulty is the aluminium oxide formed has same specific gravity as that of aluminium. Hence oxide particles remain suspended in the molten metal as inclusions. It does not float on molten metal like other heavier metals. Another problem is, this oxide is porous in nature, hence catches large amount of liquid metal, increasing the melting losses.
3. Aluminium has low melting temperature (660 – 750 °C). It is difficult to control this temperature and operator always has tendency to superheat the melt.
4. Specific heat of aluminium more, so more amount of heat is required to raise the temperature. (The amount of heat required to raise the temperature and melt aluminium is about twice as much per Kg as is needed for copper alloy).
5. Another important characteristic is aluminium melt readily dissolve gas (particularly hydrogen) and the solubility increases with increase in temperature. At 660C the solubility increases 20 times.

6. Easy contamination of iron in the liquid aluminium. Excessive Fe in aluminium alloy result into grain coarsening, brittleness, and internal shrinkage problems.
7. Loss of volatile metal element during melting.

Out of all the above characteristics, two major properties, which are more troublesome & difficult to control, are Oxidation and gas pickup. Oxidation or dross formation means more & more melting losses, Gas pickup results into porosity and consequently heavy rejection. Therefore, care must be taken at every stage in melting process, if high quality castings are to be produced.

5.2.3 Melt Treatment Process:

a. When the melt is at 690 +- 20C, 500g of coverall-11 powder is mixed with the molten metal and stirred well.
b. The slag is removed using the skimmer.
c. 100g of Degasser 190 is kept deep into the crucible.
d. Waited till the bubbling ends.
e. For Pressure tight castings alone, 100g of Nucleant 20 is added deep in the furnace and waited till bubbling ends.
f. For Pressure tight castings alone, 250g of coveral36 is spread on the surface of the melt and stirred well.

After the removal of slag, the melt is ready for production.

5.2.4 Uses of Fluxes:

The melt treatment comprises of

a. Slag /dross coagulation and the removal using cover fluxes/drossing fluxes.
b. Degassing using tablets or Nitrogen gas
c. Grain Refining
d. Grain Modification

Usage of Cover flux for dross removal:

Aluminium foundries normally use suitable cover fluxes to minimize loss of metal due to oxidation and to clean the metal. Many foundries use the basic cover flux (equivalent to Foseco's coverall-11) without actually looking into the composition requirements of the alloys being cast. Coverall-11 is recommended for regular use only in alloys that do not contain Mg as an element above 1.3%. for alloys containing 1.3% or more of Mg, a suitable covering flux free from Na salt only to be used. The reason is that the Mg in the alloy gets depleted due to reaction of Na salts containing chlorides with the basic metal. All these cover fluxes are to be used in two stages before the melt is ready for casting[2].

Usage of covering flux can also form build up on the furnace walls thereby increasing the possibility of the hard silicon carbide/graphite flakes peeling out and getting into the metal. These hard flakes when they get lodged in a casting can cause damage to the crucibles as well as extending melting time due to the build up. One must thus ensure that these scales or build-up are removed periodically, so that the life of the crucibles can be improved[2].

Usage of degassers:

The liquid Al contains dissolved Hydrogen. If it is not removed it appears as pinhole defect in machined castings and hence the next stage of treatment will be degassing the metal using suitable degassers. The foundry industry in India has so far been using conventional degassing tablets containing hexachloroethane. These tablets when immersed in the metal liberate chlorine gas, which reacts with the Hydrogen present in the melt and serves to flush it out. However this emission of chlorine is environmentally quite harmful affecting the health of the operators. Secondly, the chorine in addition to removing the H also reduces the Mg content of 4.5% is found to loose Mg to the extent of nearly 1.5% after the degassing operation using Cl. The contents of such degassing tablets also contribute to the wear of the crucible.

Grain Refiners:

The next aspect of metal treatment is grain refining. Grain refiners are added to Al-Si alloys to improve the size of the primary Al grains which otherwise will lead to subsequent leakage and failure when pressure test is carried out. Grain refinement also ensures improved mechanical properties and reduces surface porosity, brings down scrap rates and improves the consistency and reliability of the casting. All this translated to improved quality and increased productivity. It has been found that additions of Titanium and Boron either singly or in combination in very small quantities so as not to alter the base composition of the melt significantly, do the job remarkable well. In general 0.05% to 0.15% Ti plus 0.03% B in the melt is the recommended range of additions for satisfactory grain refining for most applications. Grain refiners can be classified as chemical grain refiners in the form of tablets containing suitable salts of Ti and B in various proportions or metallic grain refiners. Usage of chemical grain refiners in the form of tablets has significant disadvantages:

1. Chemicals are not environmentally friendly.
2. The life of the crucible or the furnace is reduced.
3. The effects of such chemical grain refinement is uncertain and also fades out within 1-1.5 hours of introduction as against the Ti B metallic grain refinement which does not fade out for 2-4 hours after melting.

Modification of Hypoeutectic alloys:

The subject of modification deals with solid solubility of Si in Al alloy. Because of very low solid solubility of Si in Al, during solidification, in alloys containing Si below the eutectic level of 11% the Si in the alloy tends to solidify in the form of plates or needles in the angular form. This will lead to brittleness, lower mechanical properties and poor machinability. This problem is overcome by modifying the Si particles to have a more rounded or spherical shape resulting in tremendous improvement in properties. Modification of hypoeutectic alloys has so far been done by using suitable Na salts/Na metal. There are limitations in handling Na metal, which is combustible and explode when it comes into contact with moisture. The Na salts are mainly fluorides, which are harmful to the environment. These salts also adversely affect furnace walls. The other main draw back in using metallic Na/chemical modifiers is retention of modification effect in the melt will at best be for a duration of 40 minutes only which means that modification will have to be carried out in an hour. In order to achieve permanent modification metallic modifier containing Strontium /Antimony can be comfortably used. The percentage of addition of Strontium into the melt can be between 0.02% - 0.07% to achieve ideal modification. This can be done by addition of suitable Strontium Aluminium Master alloy containing Strontium 4-6 %, which can be used to the extent of 1% of the melt weight.

5.2.5 Problem:

The study of downtime data of previous months revealed that the time taken for metal treatment is one of the most influencing causes for the downtime. It is because of its frequency (normally 4 times a day on one machine) the process posts a bigger downtime. As it occurs in higher number of time any small reduction in it could accumulate to a major reduction in total downtime.

The problem could be approached by two means. First is to identify fluxes that could work efficiently as well as quicker than the presently used ones. Second is to completely eliminate the process of purification opting for Pre-Treated melt.

Methodology:

2. Study the basics of melt treatment such as the reason behind doing it and fluxes used and the time taken for it.
3. Study the chemistry behind the treatment such as the fuctions of various fluxes used.
4. Identify the fluxes, which could work efficiently as well as quickly.
5. Else search for means to eliminate the process itself without affecting the quality of the product.

5.2.6 Recommendations:

1. Using the system of rotary degassing [7], which can produce well-dispersed bubbles of Nitrogen to purge into the molten metal. These bubbles will ensure that practically all the hydrogen is flushed out.

Figure5.2.6.1 shows the schematic representation of the rotary degassing. The Mobile Degassing Unit is ideally suited where large numbers of small melting/ holding furnaces exit. It can easily be maneuvered around the foundry to each treatment station. The graphite rotor is thrust into the liquid metal and rotated; Nitrogen from the cylinder is passed through the central longitudinal base of the graphite shaft. The rotating speed decides the size and the dispersal of bubbles in the melt.

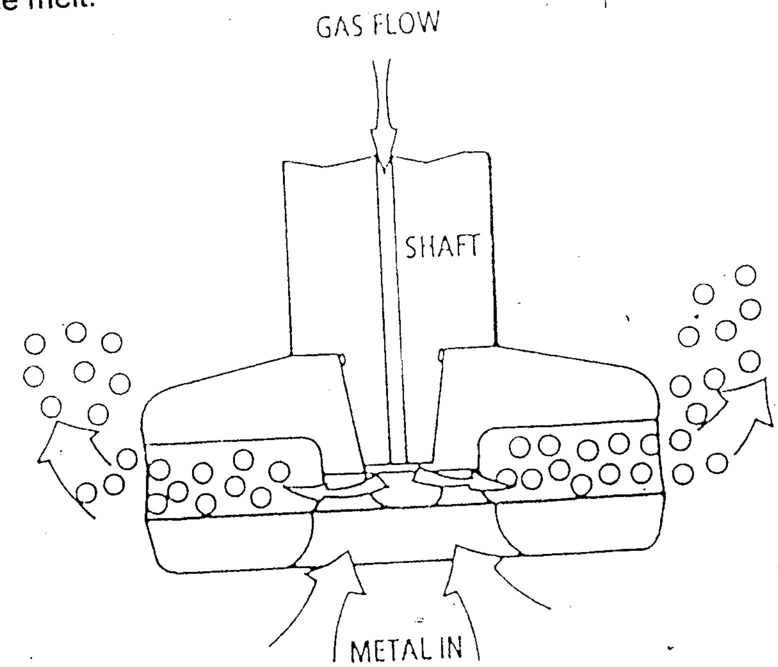


Fig 5.2.6.1 Schematic Representation Of Rotary Degassing

2. The grain refiners and modifiers need not be added to the Pressure Diecasting, since the melt is at a high temperature and the molecules move with high velocity.

3.This suggestion attempts to completely eliminate the melt treatment downtime. Melt treatment downtime possess a heavy loss of monetary value as shown below:

Average metal treatment downtime	= 140 hours
Machine hour rate	= Rs. 550

Therefore,

Financial loss due to melt treatment down time = Rs. 550 * 140

= Rs. 77,000

The time taken for melt treatment can be reduced by providing the crucibles with 'Pre-Treated melt' i.e. providing two extra furnaces for Aluminium and Zinc melting and carrying out the melt treatment in these furnaces only, so that the furnaces with the machines can be supplied with the melt that does not require any further treatment.

Financial backup for this suggestion:

As the suggestion involves heavy investment, it has to be justified on the basis of monetary values and is done as follows.

Cost of furnace = Rs. 60,000

Cost of Burner = Rs. 20,000

Therefore,

For 2 furnaces investment = Rs. 1,60,000

Cost of melt treatment downtime = Rs. 77,000 per month

Pay back period = 2 months 2 days or

290 hours of melt treatment

The payback period is only around 2 months. After two months, a savings of about Rs.75000 can be benefited, which accounts for the additional fuel consumption of the added furnaces.

5.3 Die Maintenance

The die maintenance activity is broadly classified as die breakdown maintenance and die regular maintenance. The die breakdown maintenance includes the failure of ejection pins and core pins whereas regular maintenance covers flashing and soldering. The Cause and Effect Diagram of the die failure is shown below.

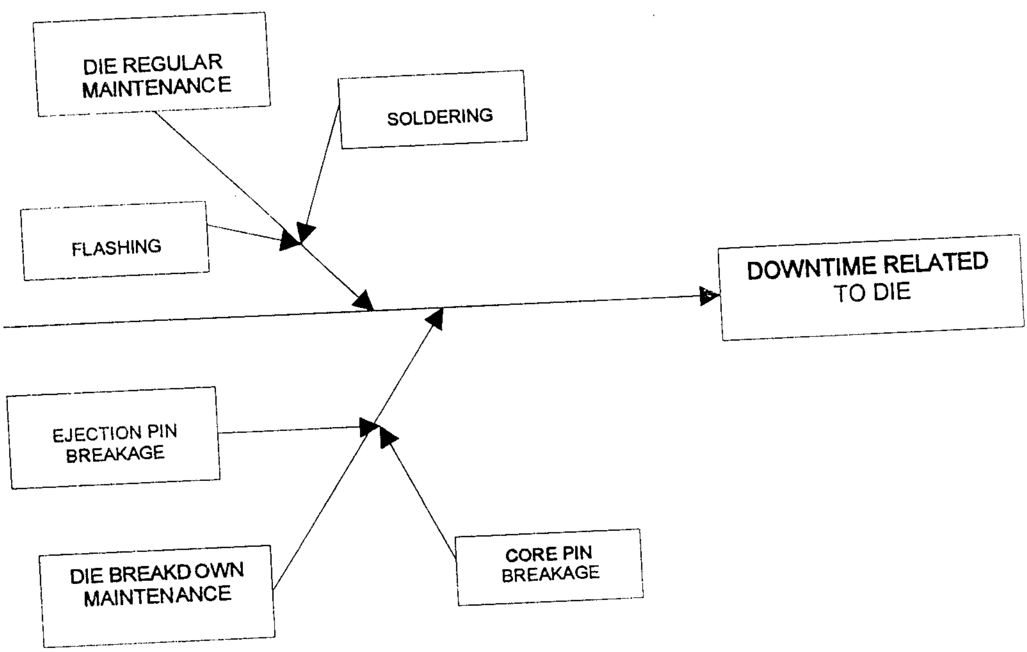


Fig 5.3.1 Cause and Effect Diagram for Die Failure

5.3.1 Soldering:

Soldering of metal to die cast components such as core pins, slides, and inserts results in costly downtime and die wear. Soldering causes increased friction, which can affect the ejection force of the die casting operation. When not enough ejection force is available, the casting has a difficult time releasing. On the other hand, increasing the release force excessively can bend ejector pins, cause casting marks, and make castings bend or loose tolerance. This all results in unnecessary scrap. It is critical that lubricant sprayed on the surface of the die and any coating applied to the dies surface, be maintained. This forms the protective layer between the die and cast metal (aluminium) that prevents molten metal from sticking to the die's surface and minimizes the ejection force for casting release[4].

Causes for soldering:

1. Hot spots on the die's surface can eventually cause a loss of lubricant by burn off.
2. Since aluminium (Al) and iron (Fe) have a natural affinity for each other, the loss of lubricant adhering leads to aluminium adhering to the die's surface.

Over the time the aluminium and iron interact to form an intermetallic covalent bond.

Solutions for soldering:

- It is important to maintain good die lube retention by spraying. The spray wetting of the surface can, as long as present help to maintain a barrier between the aluminium and iron[4].
- It is best to apply a diffusion process to create a compound layer at the surface that generates a non-contributing barrier that will not allow aluminium to interact with the iron. This will protect areas that receive inadequate wetting[4].
- Increase the surface finish of the mould.
- Increase the frequency of nitriding.

Surface Engineered Coatings:

Three most important performance criteria for die coatings are wear resistance, non-sticking, and corrosion resistance. No single coating provides an optimum system. Optimum system must be specially designed using multi-layer architecture. Each thin-film layer of the coating system has a specific purpose. The thin-film adjacent to the substrate must provide good adhesion; the outer most working layer must provide the required corrosion/oxidation and wear resistance and non-wetability, while the intermediate layers provide the required accommodation and minimization of thermal and residual stresses [4].

The surface engineered die coatings can improve the cost competitiveness of die-castings thus enabling a wider range of die cast components.

The benefits of surface engineered die-castings are

- Improves the quality of die casting coatings and therefore die casting dies.
- Improves cost competitiveness of die cast components.
- Reduces downtime in die casting operations.

Colora do school of Mines, Ohio state University and North Atlantic Die Casting association (NADCA) have joined hands to develop a coating system that minimizes premature die failure and to extend die life.

CrN, as against VC, TiC because of its high oxidizing temperature hardness and ability to withstand the die cast surface expansion/contraction cycle, is used for coating presently. But the surface engineered coatings i.e. preparing a substrate of TiN, TiAlN or Al TiN before to the coating of CrN improves the soldering resistance.

In a test conducted by Ohio state university, USA, it has been found that soldering recurring after every 900 shots was delayed to 15,000 shots by the pre-application of substrate. In accelerated corrosion tests, this substrate coating exhibits soldering resistance 100 times greater than CrN at 710C. However, the selection of substrate and coatings and their combination for best results is under 3-year research project (from 2001) by NADCA along with others.

5.3.2. Flashing:

The cast metal forms a thin layer on the compound, preferably on the parting line, causing dimensional inaccuracies and reducing the die life [9].

The occurrence of flash means extra thick casting is made, this extra thickness causes extra heat input to the die and may result in additional problems.

Cause:

High metal temperature and either poor die fir or poor machine locking when high pressure is applied.

Factors Influencing Flashing:

- Locking force
- Injection pressure
- Projected area of casting
- Die distortion

Solutions for Flashing:

- Properly setting the Tie bar nuts resulting in appropriate clamping force.
- Properly controlling the injection pressure.
- Pouring in appropriate amount of melt.

5.3.3 Breakage of Core pins And Ejector pins:

Ejection pins help in holding the castings at the end of solidification and when the die opens.

Core pins are used to have holes or cavities in the produced component.

The breakage of core pins and ejection pins hinders the production and at any cost it has to be avoided. The reasons for such a breakage may be

- Improper Draft
- High Injection pressure
- When the injection pressure is much higher than the designed or required pressure, the pin, unable to withstand such a force is high.
- The diameters of the pins are smaller and hence are unable to withstand the high force of melt flow.

Recommendations:

The downtimes because of earlier failure of the core and ejection pins may be reduced by

1. Replacing pin after every lot.
2. Using surface coated pins.
3. Maintaining proper ejection rod length.
4. Pre-identifying the internal/external failure.

5.4 Crucible Changing Time

Pure aluminium has a melting point of 660C and the common cast-able aluminium alloys have a melting temperature below this temperature. This being much lower than cast iron melting temperature, melting and holding of aluminium is comparatively easy, however because aluminium has a tendency to get oxidized and ability to dissolve hydrogen, extra care needs to be taken.

The melting furnaces that are used in the company concerned are crucible furnaces. In crucible furnaces heat transfer from heat source i.e. burner or electric coil is indirect. The crucible gets heated first and then the heat is transferred to the change.

The furnace consists of a steel shell lined inside with insulating ceramic fiber blanket or fiberboard and refractory bricks. The crucible is placed on a graphite block.

The crucible is a consumable and normally lasts 3 to 12 weeks depending upon whether it is used purely for holding the metal or for melting also. Crucibles are expensive and are to be used with care. There are two types of crucibles. They are

a. Clay graphite crucibles where in clay is used as bond.
b. Silicon Carbide crucible where in carbon is used as bond.

In graphite crucible after about a short period of time the glaze goes off and the graphite gets burnt off and only clay remains. The colour changes from black to dark grey to brown. The burnt clay is not a good conductor of heat. The melting time increases, heat losses increase and efficiency of the furnace reduces. In comparison SiC is a better conductor of heat, it leads to much quicker heating of charge.

Problem:

The crucibles fail abruptly without any prior indication, halting the production. It takes hours to clean up and replace the crucible with a newer one. This is a downtime and needs to be eliminated. The best option could be to increase the life of the crucibles.

Recommendations:

1. Use SiC crucibles rather than graphite as the former has better heat conducting capacity than the later.
2. As can be seen from the Crucible history card the life of the SiC crucibles is nearly thrice that of graphite crucibles.
3. At the first heat of SiC crucible it should not be heated slowly as slow heating damage it
4. The crucible should not be rolled on a hard floor.
5. Change light scrap first to form a cushion for a heavier metal to follow.
6. Place ingots and large pieces vertically.
7. Melt as quickly as possible and avoid overloading.
8. Any unnecessary increase in melt treatment will result in accentuated attack in the crucible with a drastic reduction in crucible life.
9. Crucibles should be cleaned out by careful scraping when the crucible is red hot
10. Slag should not be left in the crucibles, as it leads to rapid thinning of crucible wall in subsequent melts.

5.5 Productivity Improvement On The Part Of The Worker:

Productivity is the quantitative relation between what we produce and what we use as a resource to produce them, i.e., arithmetic ratio of amount produced to the amount of resources.

Productivity can be increased

1. When production is increased without increase in inputs.
2. The same production with decrease in inputs.
3. The rate of increase in output is more compared to rate of increase in input.

This program is a continuous improvement program based on the first rule stated above to improve the productivity. The objective of the program is to make the operators aware of the normal production rate and by constant monitoring enabling them to exceed the limit to excellence.

Problem:

The problem is, a variety of components (over 120) are manufactured and each requires different times of production owing to the number of cavities, time of die close, die open etc., Hence the normal rate of production of a particular component is usually not clear and hence the production may be under par.

Recommendation:

In order to make the operator aware of the normal production rate and also to constantly monitor the production rate, a trend chart is suggested. This trend chart consists of a target, which is 20% higher than the average production rate, and trend line depicts the day's working trend of the operator. The operator trying to catch-up with the target ends up with increased production.

Fixing the Target:

The fixing of target cannot be done by Timestudy, in this case, because a large number of varieties of are manufactured. It will take much time to go for Timestudy for the production of each component. There are around 125 components. Hence the target is fixed as follows,

- The previous production records are studied and the maximum of them is noted. This is done for all the 125 components.
- The maximum production is simplified to hourly production rate.
- A margin of 10 % is added to it and is made the target.

6. SOFTWARE DEVELOPMENT

6.1 Introduction:

The downtime analysis becomes a tedious process as it takes much time to retrieve the data from the hourly production report or production logbook. Hence computerization is necessary to enable the mangers to generate the periodical report of the downtime.

Visual Basic 5.0 is used as a front end and Microsoft Access is used as a back end tool.

6.2 Features of Visual Basic:

Visual Basic is tool of choice when programming in windows. There are few programs that take Visual Basic into areas that we may not have thought possible. The salient features are as follows. Visual refers to the method used to create the graphical user interface. Rather than writing numerous lines of code to describe the appearance and location of interface elements, pre-built objects are simply added into place on screen.

- It is a very user-friendly GUI (Gtaphic User Interface) language.

  The tray icon property holds the icon that will be displayed in the system tray. It holds a string of text that will be displayed above the icon in the tool bar, when the mouse pointer hovers over the icon for about a second or so.

- Building screen savers

  This constitutes of creating the display portion, declaring module level variables, displaying the form in full screen mode. Adding a configuration form, Adjusting the program's properties and adding a module and a subroutine.

- Creating form dynamically

The most fundamental object in a visual basic program is the form collection. This object contains one property count and one method item. To demonstrate the techniques for using the form collection and creating forms dynamically, this program performs three basic tasks namely,

a. Create new forms.
b. List all the forms in the application.
c. Delete all the newly created forms.

- It is easy to connect with MS office application.

The final requirement is the chart that is displayed in the MS Excel form. By adding a command button to the form with events this can be done.

- Easy for coding

- East file accessibility

- Event driven programming

When programming in Visual Basic the application developer must decide how the application interacts with the user. The user may click a mouse on various controls, or press a key combination on the user interface. These are known as events. The application developer must decide how the application must react to each of the user actions. This is called event driven programming.

- Microsoft Developer network (MSDN) is used for online help facility

- Interactive Help Features like Auto List Members and Auto Quick Info that no longer wait for the user to interact and interface.

6.3 Database Design:

A database is a repository of collections of related data or facts. It arranges them in a specific structure. Data in a database is most commonly viewed in one or more two-dimensional tables, each consisting of columns and rows. The entire collection of related data in one table is referred to as a file or Table. Each row in a table represents a Record, which is set of data for each database entry. Each table column represents a Field, which groups each piece or item of data among the records into specific categories or types of data.

The data are stored in the back end i.e. MS Access is very easy to access. It costs less because it is coming along with windows.

Four tables were created namely,

- Breakdown
- Breakdown master
- Machine
- Machine master

6.3.1 Database Structure.

Based on the conceptual structures, the database can be classified as follows.

a. Flat-File database
b. Relational database
c. Hierarchical database
d. Network database
e. Object-oriented database.

The relational database structure is the most prevalent database. A relational structure represents a database made up of related tables. In this project work, relational type of database is used. In relational type of database, one or more common fields existing in two or more tables create a relationship between these tables. The common fields called the keys.

Various fields are created in each of the tables along with their data type. This help full in fetching all details of the process. Database structures of the tables are shown in the following tables.

Table no: -1 Breakdown

The table is used to store the details of Machine Code, Reason code and time taken in hours and minutes.

Date	Machine	ReasonCode	TimeTakenHrs	TimeTakenMins
10/13/02	1	2	2	0
10/13/02	2	5	24	0
10/13/02	1	1	5	0

Table no: - 2 Breakdown master

The Breakdown master table is used to store the details of Breakdown causes with appropriate codes.

ReasonCode	Reason
1	DIE CHANGING TIME
2	MELT TREATMENT
3	DIE REGULAR MAINTENANCE
4	DIE BREAKDOWN
5	ELECTRICAL BREAKDOWN
6	MECHANICAL BREAKDOWN

ReasonCode	Reason
7	INITAL MELTING
8	CRUCIBLE CHANGING
9	IDLE(NO ORDER)
10	MISCELLANEOUS 1
11	MISCELLANEOUS 2

Table no: - 3 Machine

The Machine table is used to store the details of inputs and the calculated quantities. The input codes are Available hours, Utilized hours, Idle hours, Planned Quantity, Achieved quantity and Rejected quantity. The same table is used to store the details of calculated values of Availability, Performance, Quality rating and Overall Equipment Effectiveness (O.E.E.).

Table 4: Machine master:

In this table the details of the machines are stored. If any new is incorporated in the unit the data can be updated here.

Machine	MachineName
1	DC01
2	DC02
3	DC03
4	DC04

6.4 How To Work On Software:

1. Select Machine from the Mater Menu and enter the details of the machines available in the organisation and Save.

2. Select Breakdown from the Master Menu and enter the expected reasons for Breakdown in the organisation and Save.

3. If any changes occurs in the details of machine or reasons of downtime enter changes and pick Modify button.

4. Select Machine from the Input Menu and enter the daily inputs such as Available hours, Utilized hours, Idle hours, Planned Quantity, Achieved Quantity and Rejected Quantity.
5. Pick the Hit to Process button in order to calculate Availability, Performance, Quality Rating and Overall Equipment Effectiveness (O.E.E) and Save. Re-entering the values and picking Modify button can incorporate changes.

6. As and when breakdown occurs Pick Breakdown from the Input Menu and enter the details such as Date, Machine Number, Reason for breakdown and time taken to rectify it and Save.

7. Select Machine Monitoring Report from the Report Menu and enter the period for which the report is to generated and pick Generate Report. Option is available whether the report is to be generated machinewise and periodically.

8. Select the Breakdown report from Report Menu and repeat as said in previous step to have the Report.

9. The EXIT Command is used to quit the software.

7.RESULTS AND DISCUSSIONS

The causes of various down times are identified, analyzed and appropriate recommendations are made in order to eliminate these causes.

The suggestions are implemented to the possible extent and the results are as follows,

- The time taken for the die change operation is reduced from 60 minutes to 35 minutes i.e., nearly 50% of the time is saved. This operation is one of the most frequently done one and hence this saving could do well to improve productivity.
- The reasons for soldering and flashing are identified and highlighted. This has resulted in bringing down the die regular maintenance time.
- The pin failure is one of the most causing reasons for die break down. The study revealed that the surface coating the pin if improved could increase the life of the pins.
- Also the design engineers should take care while designing the die, such as avoiding the location of the pin in the gate area. As the melt rushes through the gate with a very high velocity, the pin unable to withstand such a force fails.
- When the trend chart is used, the operator efficiency showed a steady progress of improvement.

- The software model helps the top management to easily take the reasons for down times. The report generation process is made easier and can be had for periodical means as well as machine wise.

- The main reason behind the electrical downtime is identified as the Burner problem and is suggested that the burners are to reconditioned or replaced with newer ones. When implements it saved considerable amount of idle time.

Improvements After Implementation

- The melt treatment takes around 120 hours per month. If two extra furnaces could be installed for this purpose the down time of 120 hours could be eliminated altogether.

- If the surface engineered coatings are used which are better than the CrN coatings, the soldering problem can be avoided.

Financial Benefits Of The Project:

Time is Money and hence reduction of downtime could be expressed as monetary benefits. The recommendations suggested, if implemented in full are expected to yield following savings in idle time.

- About 20 hours of die changing downtime is eliminated.
- Burners were replaced and resulted in a saving of around 30 hours.
- Soldering and flashing can be reduced to bare minimum if the suggested surface engineered coatings are used resulting in a net saving of around 40 hours

- Improving the frequency of Nitriding and hardness of pin would avoid the die breakdown and hence could save about 40 hours.
- By using 2 separate furnaces for melting the aluminium melting could well eliminate the melt treatment downtime and could save around 120 hours.
- Using SiC crucibles could help to keep the crucible changing to bare minimum.

Considering the average Machine hour rate and summing up the above listed savings, the financial benefit can be had as,

Machine hour rate	= Rs. 450
Average idle time saved	= 250 hours
Cost of down time saved	= 250 * 450
	=(around) Rs.1,00,000 per month.

8. CONCLUSION

Downtime is nonproductive time. It is costly to a firm under the current liberalized and globalized environment. Controlling the downtime is not always easy, because hidden downtime occurs right in front of us. Downtime is the one of the greatest obstacles the manager faces to increase the productivity.

This work is done focusing mainly on downtime, to improve the productivity. Though a considerable amount of idle time is reduced, there is still scope for further reduction and reaching the ideal condition of 'no stoppage'. The software model developed would help to effectively monitor the downtime as well as improvements in a better manner.

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Appendix A

Machine Down Time Details - January 02

Description	DC 01	DC 02	DC 03	DC 04	DC 05	DC 06	Total	%
Metal Cleaning	20.00		29.00		55.50	14.50	119.00	24.10
Die Regular Maintenance	8.40	7.50	17.25	7.00	18.75	7.50	66.40	13.45
Die Loading	15.50	9.50	11.70	5.75	4.20	8.00	54.65	11.07
Meeting	8.25	8.25	8.25	8.25	8.25	8.25	49.50	10.02
Electrical Break Down	4.10	5.50	13.50	21.80	1.83	0.66	47.39	9.60
M/c Maintenance	6.00	5.00	14.00	4.00	12.50	5.00	46.50	9.42
Die Breakdown	9.50	2.50	1.60	1.70	27.40	0.00	42.70	8.65
Die Trials	21.00	6.00				15.20	42.20	8.55
Metal Changing	4.80	0.00	9.50	0.00	4.16	7.00	25.46	5.16
Total	97.55	44.25	104.80	48.50	132.59	66.11	493.80	100.00
%	19.75	8.96	21.22	9.82	26.85	13.39	100.00	

Machine Down Time Details - February 02

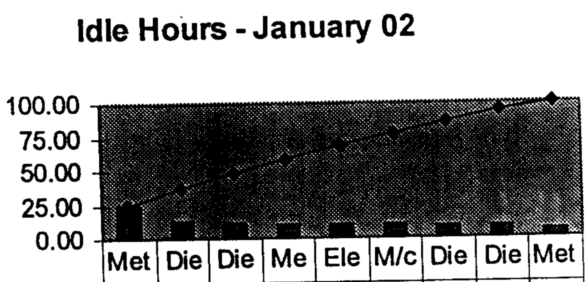
Description	DC 01	DC 02	DC 03	DC 04	DC 05	DC 06	Total	%
Metal Cleaning	26.00	14.50	17.50	20.50	73.00	35.00	186.50	30.30
Die Regular Maintenance	15.00	8.00	9.50	7.50	45.00	19.00	104.00	16.90
M/c Maintenance	22.00	12.00	13.50	16.50	22.50	17.00	103.50	16.81
Initial Melting	15.40	6.00	6.50	11.20	10.20	15.00	64.30	10.45
Die Loading	8.80	14.20	7.70	5.50	7.50	8.50	52.20	8.48
Die Breakdown	1.09	0.75	0.00	0.00	36.60	1.50	39.94	6.49
Die Trials	9.00	0.00	0.00	0.00	0.00	15.00	24.00	3.90
Metal Changing	8.30	0.00	0.00	2.50	12.30	0.00	23.10	3.75
Electrical Break Down	1.00	1.60	2.90	8.50	4.00	0.00	18.00	2.92
Total	106.59	57.05	57.60	72.20	211.10	111.00	615.54	100.00
%	17.32	9.27	9.36	11.73	34.30	18.03	100.00	

Machine Down Time Details - March 02

Description	DC 01	DC 02	DC 03	DC 04	DC 05	DC 06	Total	%
Metal Cleaning	16.50	9.30	7.30	18.00	47.00	15.60	113.70	20.38
Initial Melting	15.50	7.50	9.00	14.20	12.50	18.50	77.20	13.84
Die Trials	46.00		6.00	3.00		21.00	76.00	13.63
Die Regular Maintenance	10.20	11.20	10.00	7.20	20.70	12.40	71.70	12.85
Die Breakdown	3.90	1.40	6.50	10.10	39.36	4.70	65.96	11.83
Electrical Break Down	4.25	3.46	3.00	13.90	35.10	0.00	59.71	10.70
Die Loading	20.41	5.00	9.30	7.30	1.80	9.70	53.51	9.59
Metal Changing	5.00				6.60	4.50	16.10	2.89
Meeting	2.00	2.00	2.00	2.00	2.00	2.00	12.00	2.15
M/c Maintenance	1.80	2.30	1.70	4.70	0.80	0.60	11.90	2.13
Total	125.56	42.16	54.80	80.40	165.86	89.00	557.78	100.00
%	22.51	7.56	9.82	14.41	29.74	15.96	100.00	

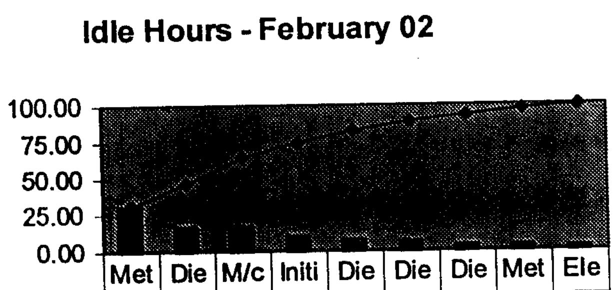
Appendix B

Pareto chart for the month of Jan 2002



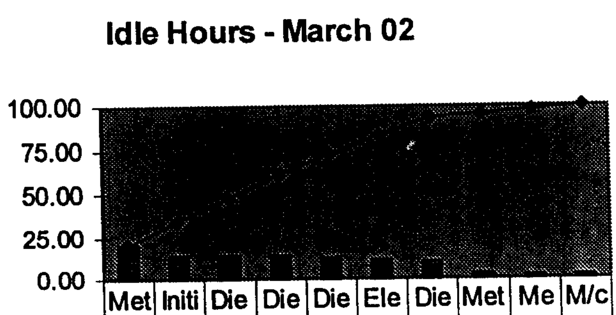
	Met	Die	Die	Me	Ele	M/c	Die	Die	Met
%	24.1	13.4	11.0	10.0	9.60	9.42	8.65	8.55	5.16
Cumm %	24.1	37.5	48.6	58.6	68.2	77.6	86.3	94.8	100.

Pareto chart for the month of Feb2002



	Met	Die	M/c	Initi	Die	Die	Die	Met	Ele
%	30.3	16.9	16.8	10.4	8.48	6.49	3.90	3.75	2.92
Cumm %	30.3	47.1	64.0	74.4	82.9	89.4	93.3	97.0	100.

Pareto chart for the month of Mar 2002



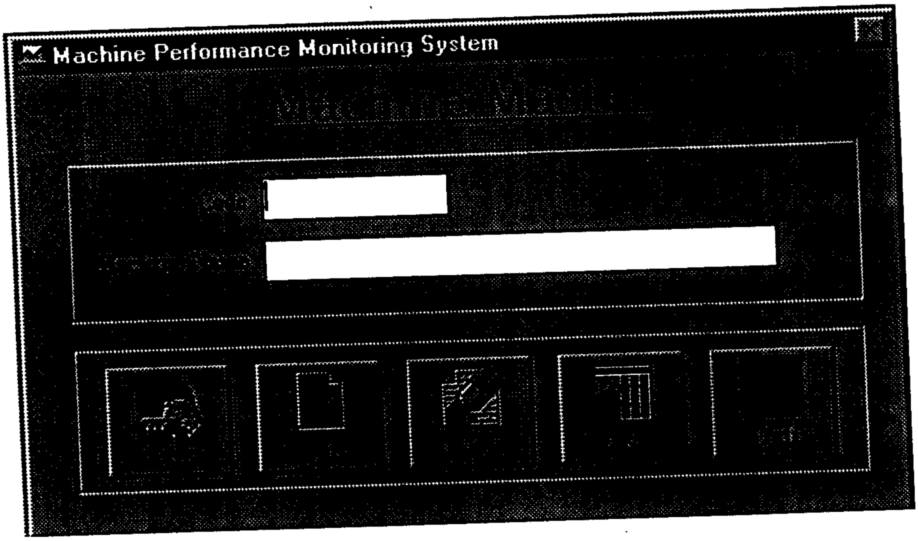
	Met	Initi	Die	Die	Die	Ele	Die	Met	Me	M/c
%	20.3	13.8	13.6	12.8	11.8	10.7	9.59	2.89	2.15	2.13
Cumm %	20.3	34.2	47.8	60.7	72.5	83.2	92.8	95.7	97.8	100

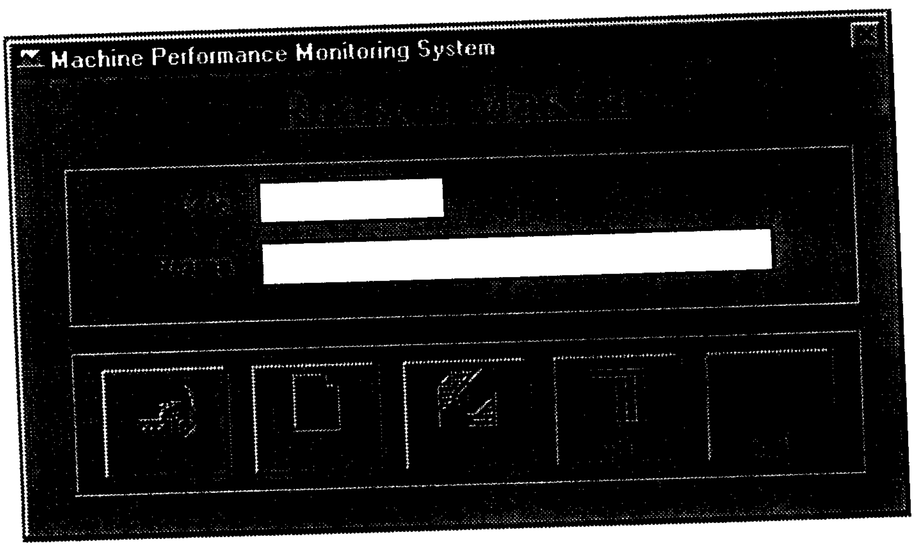
ndix C

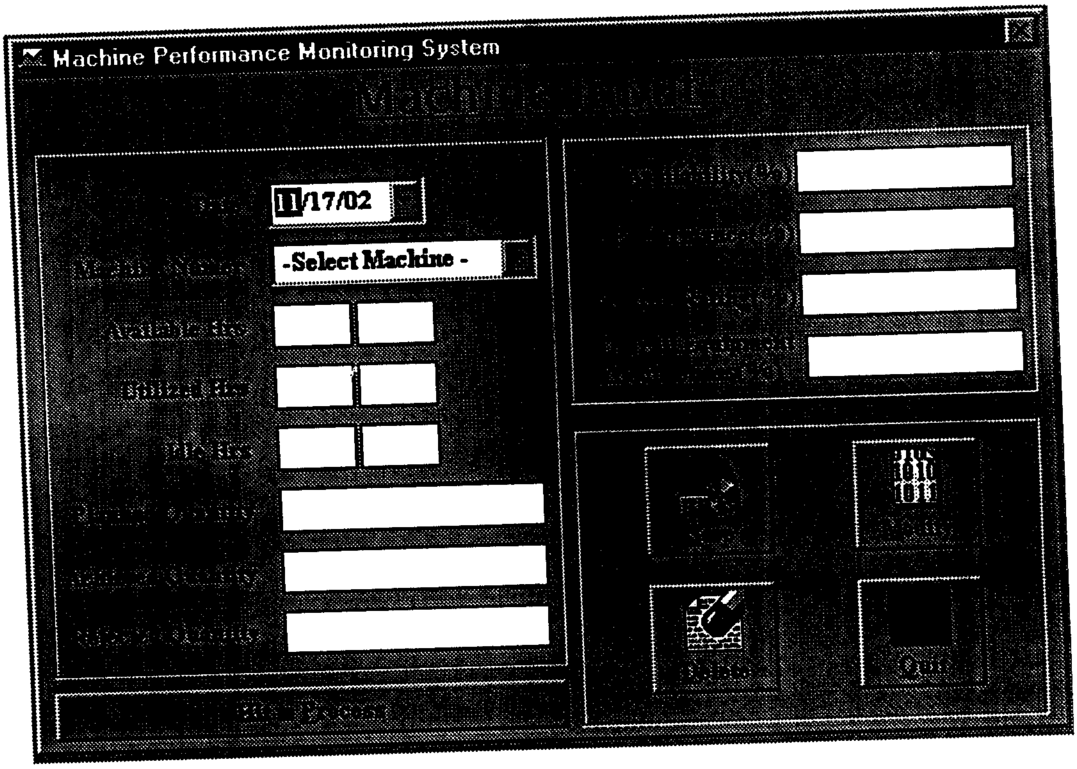
	DIE CHANGING TIME REDUCTION		Base level: 60 min. Target level: 25 min. Current level: 35 min							
O	ACTIVITY	B/A	TIME PERIOD IN MINUTES 1	2	3	4	5	6	7	8
	Removing of Mech./Hyd. Core	B	■	■	■					
		A	■	■						
	Return rod nut and moving die unclamping	B	■	■	■					
		A	■	■						
	Return rod and Bumper rod removing	B	■	■						
		A	■	■						
	Tie bar removing	B	■	■	■	■	■	■		
		A	■	■	■	■				
5	Moving die clamping and unloading	B	■	■	■					
		A	■							
6	Fixed die unclamping	B	■							
		A	■							
7	Removing of fixed die	B	■	■						
		A	■							
8	Shot sleeve, Plunger, Plunger rod changing	B	■	■	■					
		A	■							
9	New fixed die loading	B	■	■						
		A	■							
10	New fixed die parallel setting	B	■	■						
		A	■							
11	New moving die loading	B	■	■	■					
		A	■							
12	Die height setting	B	■	■	■					
		A	■							
13	return rod and bumper rod providing	B	■	■						
		A	■							
14	New moving die clamping	B	■	■						
		A	■	■						
15	Return rod tightening and lock setting	B	■	■	■	■				
		A	■	■						
16	Mech./Hyd. Core providing	B	■	■	■					
		A	■	■						
17	Die heating	B	■	■	■	■	■	■	■	■
		A	■	■	■	■	■	■		
18	Attribute free first shot	B	■	■						
		A	■	■						
19	Dim. Inspection and first off clearance	B	■	■	■					
		A	■	■	■					

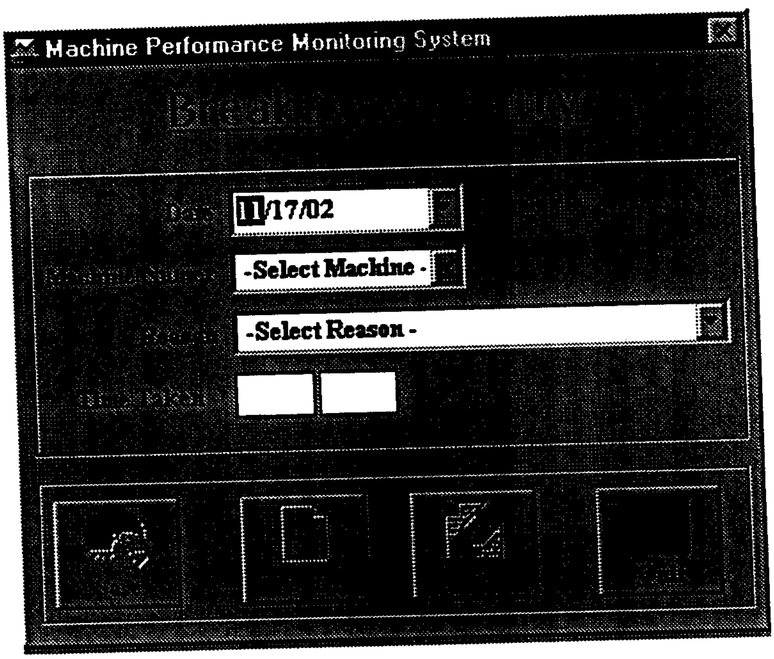
B - Before Improvement A - After Improvement

Appendix D


Machine Performance Monitoring System


Machine Performance Monitoring System


Machine Performance Monitoring System
11/17/02
-Select Machine -
Quit


Machine Performance Monitoring System
11/17/02
-Select Machine -
-Select Reason -