Design and Analysis of a Fixture for Slotting Operation in Bearing Manufacturing Process

A Project Report

Submitted by

G.Seetharaman - 71203114043
A.S.Sivasubramanian - 71203114046
P.S.Vijay - 71203114053

in partial fulfillment for the award of the degree
of

Bachelor of Engineering
in
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DEPARTMENT OF MECHANICAL ENGINEERING
KUMARAGURU COLLEGE OF TECHNOLOGY
COIMBATORE – 641 006

ANNA UNIVERSITY :: CHENNAI 600 025

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ANNA UNIVERSITY:: CHENNAI 600 025

BONAFIDE CERTIFICATE

Certified that this project report entitled "**Design and Analysis of a Fixture for Slotting Operation in Bearing Manufacturing Process** (for M/s.Bimetal Bearings Ltd., Coimbatore)" is the bonafide work of

Mr.G.Seetharaman	-	Register No. 71203114043
Mr. A.S.Sivasubramanian	-	Register No. 71203114046
Mr. P.S.Vijay	-	Register No. 71203114053

who carried out the project work under my supervision.

N. Gunasekaran 20/04/07
Signature of Head of the Department
(Dr.N.Gunasekaran)

20/4/07
Signature of the Supervisor
(Mr.R.Sudhakaran)

N. Gunasekaran 23/04/07
(INTERNAL EXAMINER)

23/4/07
(EXTERNAL EXAMINER)

DEPARTMENT OF MECHANICAL ENGINEERING

KUMARAGURU COLLEGE OF TECHNOLOGY

COIMBATORE 641 006

Bimetal Bearings Limited

371, Maruthamalai Road, P.N. Pudur, Coimbatore - 641 041.

Telephones : 2438652
2432280, 2432033
Telegrams : BIMITE
Fax : 0422 - 2430483
E-mail : bblcbe@airtelbroadband.in

Manufacturers of **BIMITE** *Thinwall Bearings, Bushings and Thrust Washers*

Ref: BB8/HR/Box-17/2030/07-08

13.04.2007

TO WHOMSOEVER IT MAY CONCERN

This is to certify that **MR.G.SEETHARAMAN**, ROLL NO: 03 ME 44 of Final Year MECHANICAL ENGINEERING Student of KUMARAGURU COLLEGE OF TECHNOLOGY, COIMBATORE has done a Project on "DESIGN AND ANALYSIS OF A FIXTURE FOR SLOTTING OPERATION IN BEARING MANUFACTURING PROCESS " in BIMETAL BEARINGS LIMITED, COIMBATORE for a period from 19st January 2007 to 31th March 2007 in our Organization. He has been regular in his attendance during this period.

We found his performance and conduct satisfactory.

WE WISH HIM ALL SUCCESS.

for BIMETAL BEARINGS LIMITED

S.JAYAKUMAR
MANAGER-HUMAN RESOURCES

Bimetal Bearings Limited

371, Maruthamalai Road, P.N. Pudur, Coimbatore - 641 041.

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This is to certify that **MR.A.S.SIVA SUBARAMANIAN**, ROLL NO: 03 ME 47 of Final Year MECHANICAL ENGINEERING Student of KUMARAGURU COLLEGE OF TECHNOLOGY, COIMBATORE has done a Project on "DESIGN AND ANALYSIS OF A FIXTURE FOR SLOTTING OPERATION IN BEARING MANUFACTURING PROCESS " in BIMETAL BEARINGS LIMITED, COIMBATORE for a period from 19st January 2007 to 31th March 2007 in our Organization. He has been regular in his attendance during this period.

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This is to certify that **MR.P.S.VIJAY**, ROLL NO: 03 ME 54 of Final Year MECHANICAL ENGINEERING Student of KUMARAGURU COLLEGE OF TECHNOLOGY, COIMBATORE has done a Project on "DESIGN AND ANALYSIS OF A FIXTURE FOR SLOTTING OPERATION IN BEARING MANUFACTURING PROCESS " in BIMETAL BEARINGS LIMITED, COIMBATORE for a period from 19st January 2007 to 31th March 2007 in our Organization. He has been regular in his attendance during this period.

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ABSTRACT

The demand for a product depends upon the supply. The supply depends upon the time at which the product is produced and the time at which the product is delivered. The product production involves in-numerous number of processes which decides the time at which the product is produced and delivered. Thus the time plays a major role in a production process which decides the productivity. The urge today is to reduce the production time. Our area of study focuses on reducing the set up time done at M/s.Bimetal Bearings Ltd., Coimbatore.

The process chosen for our study in which the setup time has to be reduced is the slotting operation. The current problem in the slotting operation is the lack of positioning of the punch and the die and the alignment between the punch and die. Due to this problem, while changing the punch and die set for the next slot size the setup time is more which in turn decreases the productivity.

To solve this problem and reduce the setup time, a fixture is being designed in pro E 2001 software depending upon the measurements of the various parts made. After designing the fixture, the punch and die is assembled in that fixture and their alignment is checked to be along the same axis. Further the load acting member in the fixture is analyzed for its safe stress limit using ANSYS software.

ACKNOWLEDGEMENT

We take the privilege to express our deepest gratitude to our project guide **Mr.R.Sudhakaran, Senior Lecturer** who rendered his valuable guidance and support to perform our project work extremely well.

We are extremely thankful to **Dr. N. Gunasekaran, H.O.D.** Department of Mechanical Engineering for his valuable advice and suggestions throughout this project.

We are immensely grateful to our principal **Dr. Joseph.V.Thanikal**, for his invaluable support to come out of this project.

We are also thankful to **Mr.Narayanan, Tool Room Incharge,** M/s. Bimetal Bearings Ltd., for his valuable guidance, support and encouragement during the course of our project work.

We would be failing in our duty, if we do not thank **Mr.Saravana Kumar, Manufacturing Manager,** M/s. Bimetal Bearings Ltd., who took pains to guide us in this endeavor. Our sincere thanks to him without whose worthy suggestions, morale support and above all his valuable guidance, this report would not have seen the light of the day.

Finally, we thank our parents and friends for always being there for us in times of need.

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CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

In present industrial scenario, the production time reduction in various processes has been of more importance which can increase productivity and an earlier return on investment. Our area of study focuses on reducing the tool setup time in bearing manufacturing process done at M/s.Bimetal Bearings Ltd., Coimbatore.

The bearing manufacturing includes various processes where each process has its own tool setting time. By study it had been found that the tool setting time for the notching and slotting operation has the highest of about 90 minutes. The operation we have chosen to reduce the tool setting time was the slotting operation since it's the most important auxiliary operation performed on the bearing and most of the customer's requirement include slotting operation.

1.2 PRESENT PROBLEM IN SLOTTING

The problem in the present slotting operation is the high setting time for locating and aligning the punch block and the die since both are fixed directly to the machine by work holding devices. The capacity of the slotting machine is 100 bearings per hour. So a high set up time of 90 min decreases the productivity of the bearings marginally and also increases the inventory.

1.3 SCOPE

The scope of our project is to provide a solution to reduce the setting time of the punch block and the die which in turn increases the productivity. For that various methods were found out to solve the problem. One of such method which is the suitable alternative is designing of a fixture for the punch block and the die. The fixture provides the exact location and alignment between the punch block and the die which decreases the tool setting time thereby increasing the productivity

1.4 OBJECTIVE

Our objective in this project is to design a fixture for the slotting operation and validate the design by analysis. For designing the fixture the various types of fixtures were analyzed and a fixture which best suits the operation was found. The type of fixture to be designed was chosen as a "removable fixture" or the "capsule fixture".

1.5 LIMITATIONS

The various constraints in the designing of the fixture for the slotting operation is given by

- The vertical distance between the hitting ram and the base
- The vertical distance between the bottom surface of the punch block tool and the top surface of the die.
- The axis of the punch block and the die should coincide in the same line.

1.6 LITERATURE SURVEY

The same problem of high tool setup time was encountered in the blanking operation of the bearing manufacturing process in the company. They came out with a solution of designing a fixture model that locates the tool and die thereby reducing the setup time.

1.6.1 Brief Study

The blanking operation consists of three simultaneous operations performed on the bearing. They are stamping, blanking, scrap cutting. A fixture was designed which can be capable of holding all the three cutting tools for stamping, blanking, scrap cutting respectively. The base of the fixture provides the guide and support for the operations carried out. The whole design of the fixture looks like a capsule and it can be easily clamped to the blanking machine and taken out easily after the operation is finished.

The setting time of the tool and die in that machine before introducing the fixture was about 240 minutes. After introducing the fixture, the setting time was reduced to 30 minutes. The fixture designed by the company for blanking operation is given by the following figure.

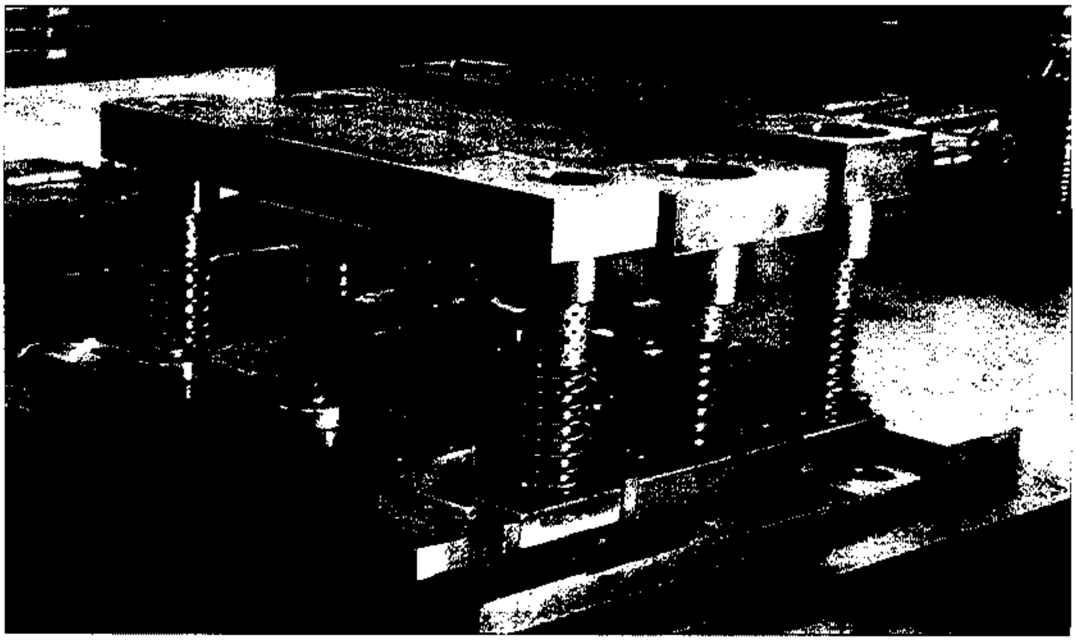

FIG 1.1 BLANKING FIXTURE

1.7 METHODOLOGY

The various steps carried out for designing and analyzing the fixture are as follows

- The dimensions of the punch block and the die and other auxiliary components used for slotting operation were taken.
- A fixture design was made in *pro e 2001* software suiting to the dimensions of the various components used in the operation.
- The various components were assembled in the fixture.
- The alignment between the punch block and the die is checked.
- The designed fixture was analyzed and validated based on the design formulas.

CHAPTER 2

ABOUT THE COMPANY

M/s.Bimetal bearings ltd., was the company established in 1961 in collaboration with Clevite Corporation USA and Repco ltd Australia. The head of the company is **Mr. Krishnamurthy**. Now the company has 70% market share in bearing manufacturing in India. BIMITE, the company's brand name is ably supported by a well - defined distribution Network in India.

It is an organization with

- A Penchant for Continuous Technology Improvement
- All Plants QS 9000 Certified
- Trained and Skilled Manpower
- Customer - centric Approach

At BBL, the culture is to build quality into the product and process. Quality Management System (QMS) is introduced in Sintering Process, Bearing Lines, Aluminium Tin Bonding Lines, Alloy Powder Composition, to name a few. Modern & latest technological updates are continuously deployed in ensuring utmost quality of products resulting in customer delight.

Right from inception, BBL has been convinced that technology advantage would be the decisive differentiating factor that would give it a quantum jump over competition at the market place. And this has been proved time and again by virtue of being the market leader

BBL has eminently positioned itself to be the first source for all new international vehicle models. BBL effectively uses a segmentation strategy to listen to its different categories of customers such as Fleet Operators, State Road Transport Undertakings, and Export Markets.

Its brand BIMITE is well-recognized in markets as far-flung as USA, UK, Germany, Italy, Austria, Croatia, and near-home markets as Dubai, Iran, Korea, SriLanka and Bangladesh.

BBL's customer community has benefited much from the strategic tie-ups that it has built up with International Companies such as

It is the first preferred source for all new international vehicle models. It is the only dedicated single source for *Hyundai Motors India.* Major clients of the company include Mahindra & Mahindra(International Harvester / AVL), TAFE (Massey Ferguson) , Simpsons (Perkins) , Maruti (Suzuki) , Ashok Leyland , Hyundai , Cummins, TELCO, Escorts & HM.

The manufacturing plants of the company are in Hosur, Coimbatore and Chennai. Their main products include *thin wall bearings, bushings and thrust washers.* In the Coimbatore plant they are producing Aluminium Tin and Non-Plated Copper Lead Bearings used as the connecting rod main rod bearings in various multi cylinder engines. The capacity of the plant is 1.2 million bearings per month. Further the plant also has a fully integrated tool-room for in-house Jigs & Fixtures.

CHAPTER 3

BEARING MANUFACTURING PROCESS

3.1 INTRODUCTION

The bearings produced by the company are made of Aluminium Tin alloy and Non plated Copper Lead alloy (bimetal). The types of bearing produced by the company include thin wall bearings, bushings and thrust washers which are used in various multi cylinder engines camshafts. The production of bearings in the company involves the following sequence of processes

- Blanking
- Forming
- Facing
- Notching
- Slotting
- Grooving (Automated)
- Drilling (Automated)
- Counter Sinking (Automated)
- Shaving (Automated)
- Deburring

The raw stock is brought from the storage in the form of big wounded coils. The cross section of the stock is a rectangular bar.

The blanking and punching are the basic processes to be performed on the raw stock while the other processes depend upon the requirement of each customer. For carrying out these processes the various machines used are classified into three types.

They are,

Blank and form – These machines gives input to all other manufacturing machines. It includes blanking and punching machine respectively.

Transfer line machines – These machines decide the major production quantity of the products per month. It includes notching, slotting, grooving, facing machines.

Aerobore machines – These machines decides the final production per month. It includes counter sinking, shaving machines

3.1.1 Blanking

This is the first process carried out in the bearing manufacturing processes. In this process the raw stock in the form of continuous rectangular bar is fed continuously to the blanking machine where it is cut into required size for the bearing. There are three operations performed in this blanking machine simultaneously using a single die set. They are stamping, blanking, scrap cutting

Stamping – embossing the symbol of the customer for whom bearing has to be produced.

Blanking – cutting of the bar into single pieces according to the size of the bearing specified.

Scrap cutting – the cutting of the waste material in the stock after the blanking operation

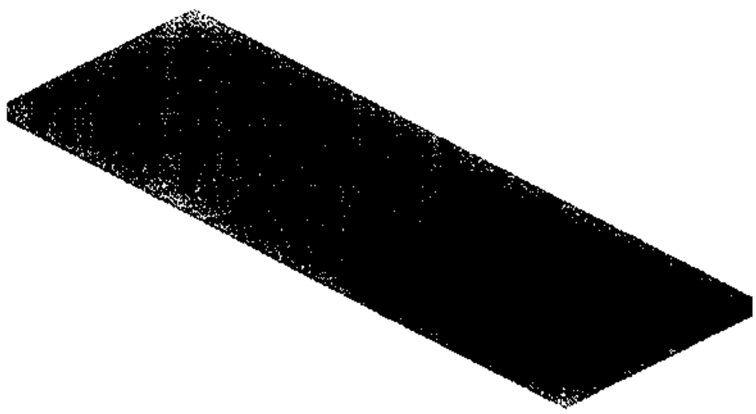

FIG 3.1. BLANKING

3.1.2 Forming

Punching operation is performed after completion of the blanking operation. The rectangular billet which is blanked in the blanking machine is formed into semi circular cylindrical shell by using the punching die in the punching machine.

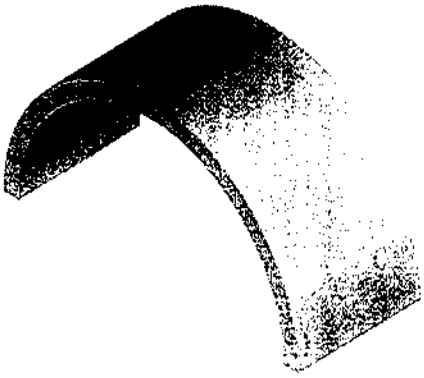

FIG 3.2. FORMING

These two machines performing the operation is known as Blank and Form machines which gives input to all other machines.

3.1.3 Facing

This is a pre machining operation performed after the punching operation for removing the burrs and other waste material on the bearing surface after punching. It also increases the surface finish and accuracy of the bearing.

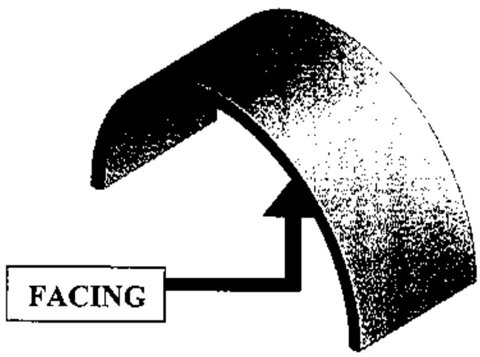

FIG 3.3. FACING

3.1.4 Notching

Notching operation is an auxiliary operation being performed on the bearing depending upon the requirement of each customer in order to increase the strength of the bearing. About 80% of the customers require notching operation to be done on the bearing. So this operation is of more importance in the auxiliary operations performed on the bearing. This operation is performed by the transfer line machine which decides the production quantity per month.

This a forming operation where a small protrusion at outside edge of the bearing is formed as shown in figure (Fig 3.4) by pressing from inside of the bearing using a small precision pressing tool.

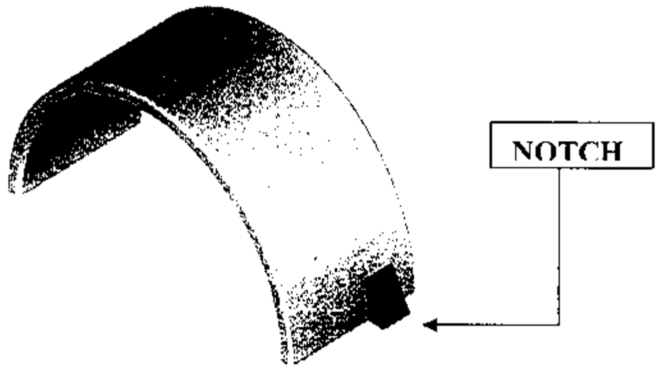

FIG 3.4. NOTCHING

3.1.5 Slotting

Slotting operation also falls in the category of transfer line machines which decides the major production quantity of bearings produced per month and so possesses more importance. Moreover, the requirements of most of the customers of the company include the slotting operation.

Slotting operation is a machining operation performed on the bearing which involves producing a slot on the bearing with the given profile using a punch block tool and the die as shown figure

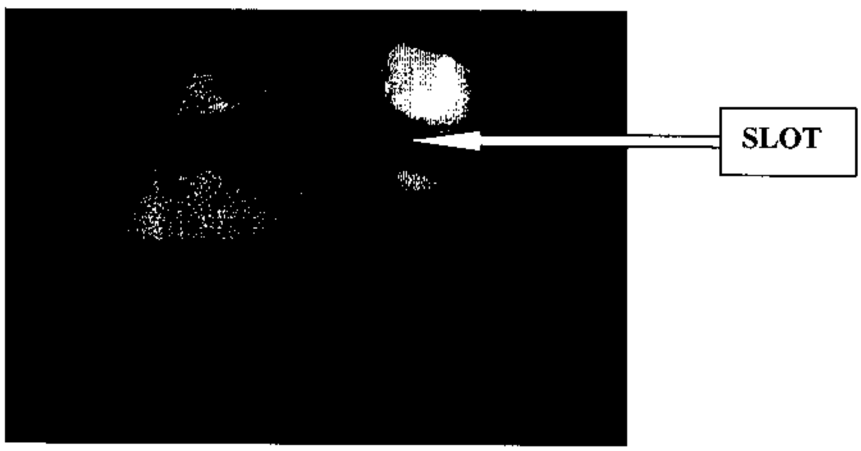

FIG 3.5. SLOTTING

3.1.6 Grooving

This is an auxiliary operation performed on the bearing which is preferred only by few numbers of customers of the company. It falls under the category of Aero bore machines. In this operation the inside circumference of the bearing is grooved by a grooving cutter which rotates and slides over the inside surface of the bearing to perform the grooving operation. The grooved bearing is shown in the figure (Fig 3.6). There are two types of grooving machines used for this purpose. They are

- Semi Automatic Grooving Machine
- Automatic Grooving Machine

Semi Automatic Grooving Machine – In this machine the loading and unloading of the bearing is done manually.

Automatic Grooving Machine – In this machine the loading and unloading of the bearing is done automatically with the help of conveyor belts.

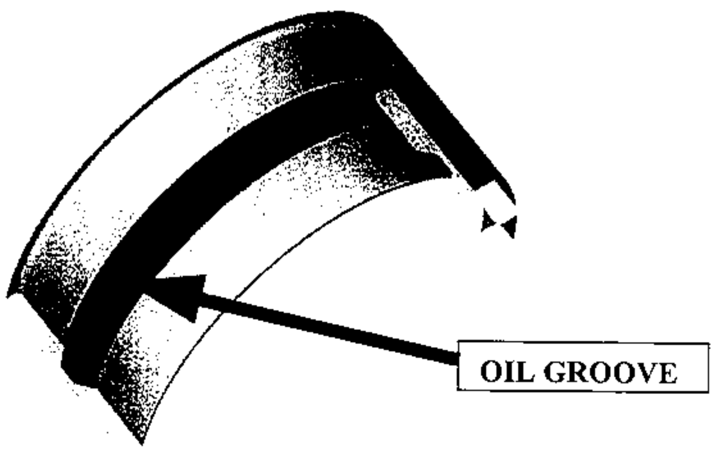

FIG 3.6. GROOVING

3.1.7 Drilling

This is an auxiliary operation performed on the bearing which is also being preferred by only very few customers of the company. It also comes under the category of aero bore machines. In this operation, a hole is drilled on the outer circumference of the bearing at a particular position specified by the customer using a drilling tool which is fixed in drill jig. The drilling operation is a fully automatic operation where loading and unloading of the bearing is carried out by conveyor belts. The drilled bearing is shown in the figure (Fig 3.7)

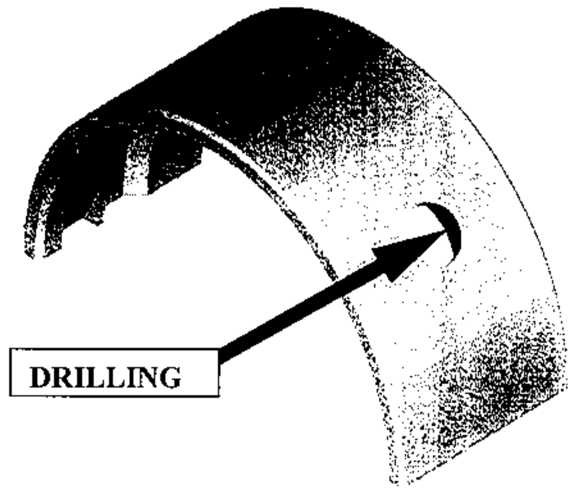

FIG 3.7. DRILLING

3.1.8 Counter Sinking

Counter sinking is the auxiliary operation performed on the bearing which comes under the Aerobore machines category which decides the final production per month. This operation involves in producing a counter sunk hole on the already drilled bore in the drilling operation. It is a fully automated process.

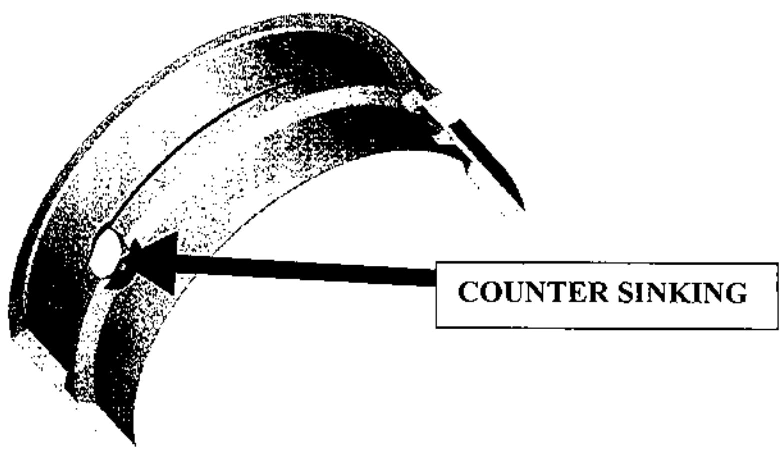

FIG 3.8. COUNTER SINKING

3.1.9 Shaving

It is also an automated process which involves in removing the extra material in the bearing, being produced and ensures the exact profile of the bearing provided by the customer. It comes under the Aerobore machines category.

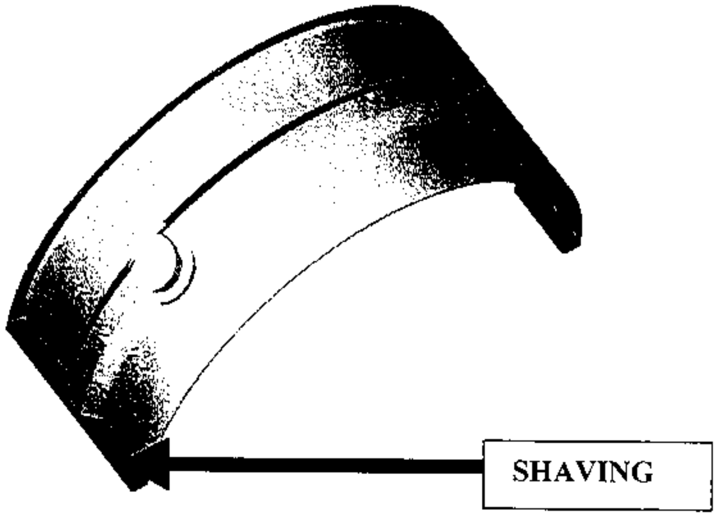

FIG 3.9. SHAVING

3.1.10 Deburring

It is the process in which the bearing is given the final touch of operation where is checked for any burrs present in it and the necessary correction made to make burr free components. It is also an automated process and comes under the Aerobore machines category.

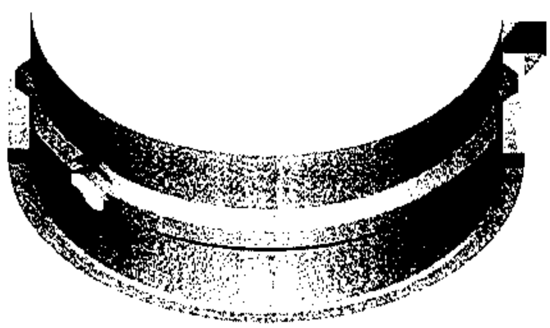

FIG 3.10. DEBURRING

The sequence in which the operations will be performed if all the operations are required by the customer is given by the following process sequence flowchart.

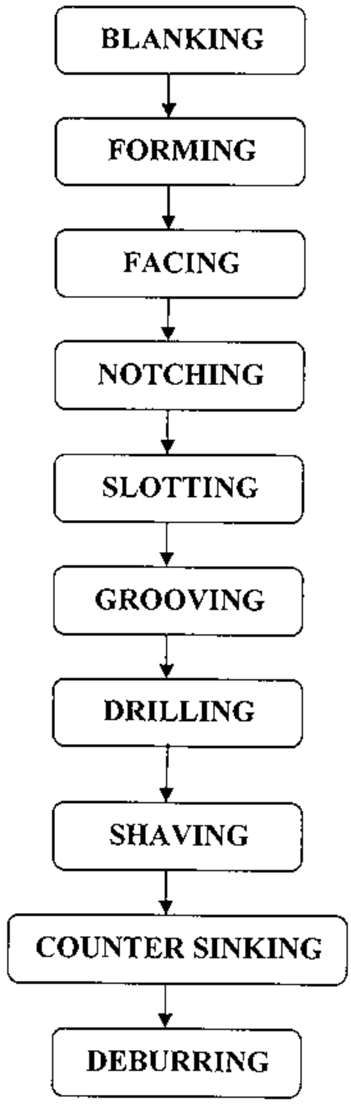

FIG 3.11. PROCESS SEQUENCE

3.2 QUALITY INSPECTION

There are two types of inspection made on the bearing in the company. They are,

- After completion of each process the bearing is checked for its dimensional accuracy
- After completion of all the processes on the bearing, finally the bearing is tested for its accuracy and if rework has to be made it will be returned to the manufacturing division.

The devices used for checking the dimensional accuracy in the manufacturing division are Digital Vernier Calipers, Screw gauge, Slip gauge, etc. The final checking of the bearing after completion of all the operations is done by an Automatic checking machine

This automatic machine consists of three light sensors which senses for the dimensional accuracy of the bearing. The bearings are loaded to this machine automatically through the belt conveyors. The characteristic of each light sensor is given by

- **Blue** – The dimensions of the bearings are within the limit and accepted.
- **Green** – The dimensions of the bearings are above the tolerance limits, so rework of the bearing has to be made.
- **Red** – The dimensions of the bearing are completely wrong and the bearing is rejected.

Based on the sensor detection, the machine itself categorizes the bearing in each row. After the checking is finished completely the bearings can be collected from the respective row and further operation is carried out.

CHAPTER 4

SLOTTING OPERATION

4.1 INTRODUCTION

As discussed in the previous chapter the slotting operation is performed as an auxiliary operation on the bearing in which a slot is produced in the bearing as per the requirements of the customer.

4.2 IMPORTANCE OF SLOTTING OPERATION IN BEARING MANUFACTURING

Basically the slotting operation involves producing a punch with the impression of the die, on the bearing. These types of bearings are called bush bearings used in the main end of the connecting rod. The slot provided in the bearing makes it easy to be located and fitted in the correct position specified in the connecting rod.

4.3 COMPONENTS OF SLOTTING OPERATION

The slotting operation requires various components. They are given by

- Punch block
- Punch pad
- Core
- Core holder
- Left side stopper
- Right side stopper

These components are provided by the customer itself to the company for whom the bearing is being manufactured. The component set varies from customer to customer.

4.3.1 Punch block

Punch block is the main component involved in the slotting operation. The punch block contains the punch tool which has the profile of the slot to be made on the bearing as shown in the figure (Fig 3.1). The punch block is fitted to the slotting machine with the help of a work holding device which is permanently fixed to the machine.

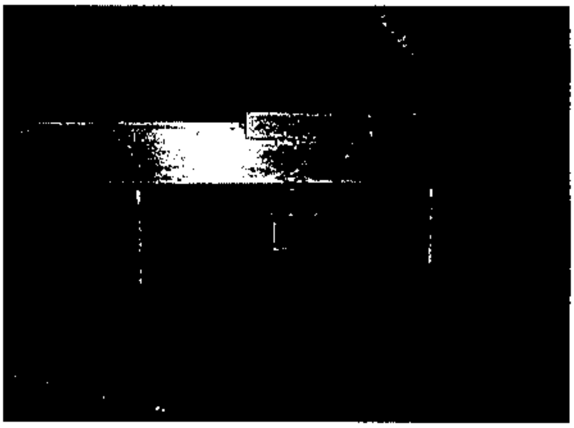
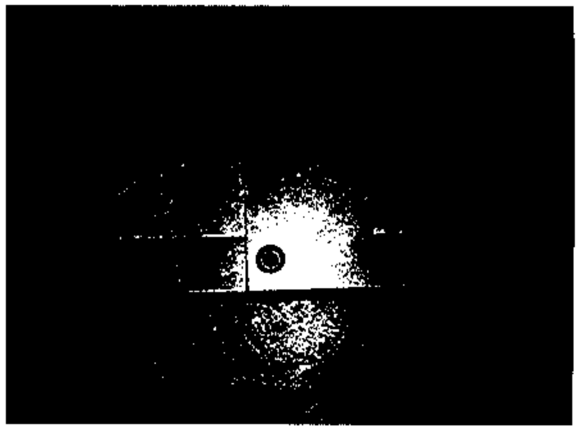

FIG 4.1 & 4.2. FRONT AND TOP VIEW OF PUNCH BLOCK

4.3.2 Punch pad

The punch pad is the component which is fixed to the bottom of the punch block. The work of a punch pad is to guide the punch block tool so that it coincides with the slot provided in the die over which the bearing is being kept. It consists of a guiding slot as shown in the figure (Fig 4.3) through which the punch block tool slides over.

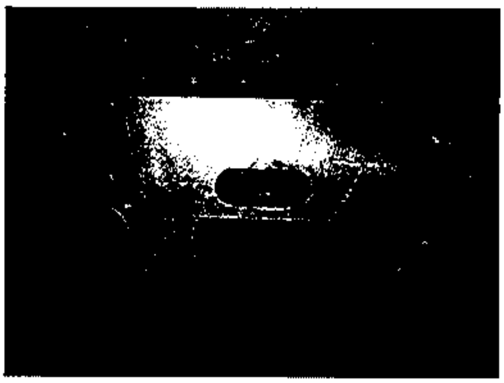
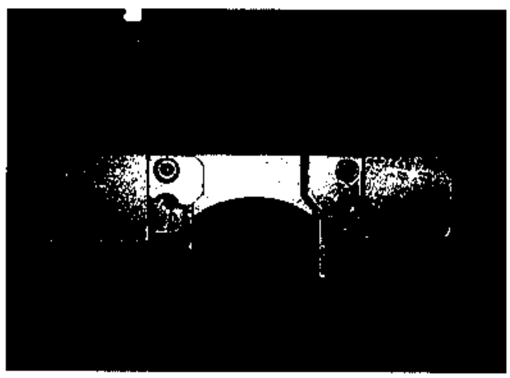

FIG 4.3 & 4.4. TOP AND FRONT VIEW OF PUNCH PAD

4.3.3 Core

The core is also the main component required in the slotting operation. The core contains the die which has the slot profile as shown in figure (Fig 4.5) which is same as the profile of the punch block tool. The bearing is kept over the slot provided in the core. As the punch tool hits the bearing the slot is made on the bearing similar to the profile of the slot in the die. The waste material is removed through this slot in the die after the slotting operation is done on the bearing.

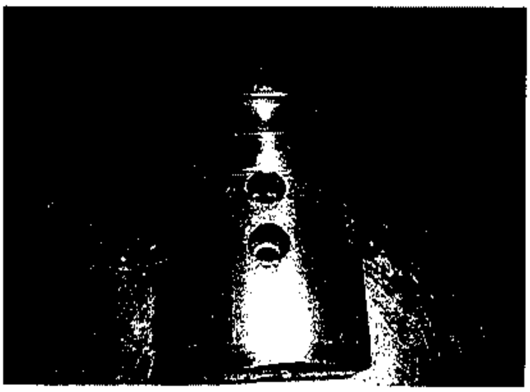

FIG 4.5 & 4.6. TOP AND FRONT VIEW OF CORE

4.3.4 Core holder

This component is the one which is used to hold and support the core during the slotting operation (Fig 4.7&4.8). It is fixed to a work holding base which is permanently fixed to the slotting machine. The core holder is mounted on the base with a small rectangular plate which is fixed to the base.

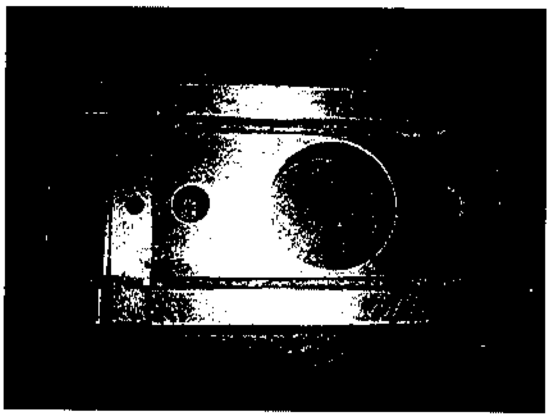

FIG 4.7 & 4.8. TOP AND FRONT VIEW OF CORE HOLDER

4.3.5 Stoppers

These are the auxiliary components used for the slotting operation. There are two type of stoppers used. Both of these stoppers are used for adjusting the position of the bearing on the core. They are

- Left side stopper
- Right side stopper

Left side stopper – It is fixed to the base and to the left of the core and core holder setup as shown in figure (Fig 4.9). It is mounted on the base on the plate in which the core holder is mounted. It is used for adjusting the bearing position in the left hand side of the core.

Right side stopper – It is also fixed to the base but to the right side of the core setup (Fig 4.10). It is used for adjusting the bearing position in the right hand side of the core.

FIG 4.9 & 4.10. LEFT SIDE and RIGHT SIDE STOPPERS

These components shown above are assembled in the slotting machine as shown in the figure (Fig 4.11).

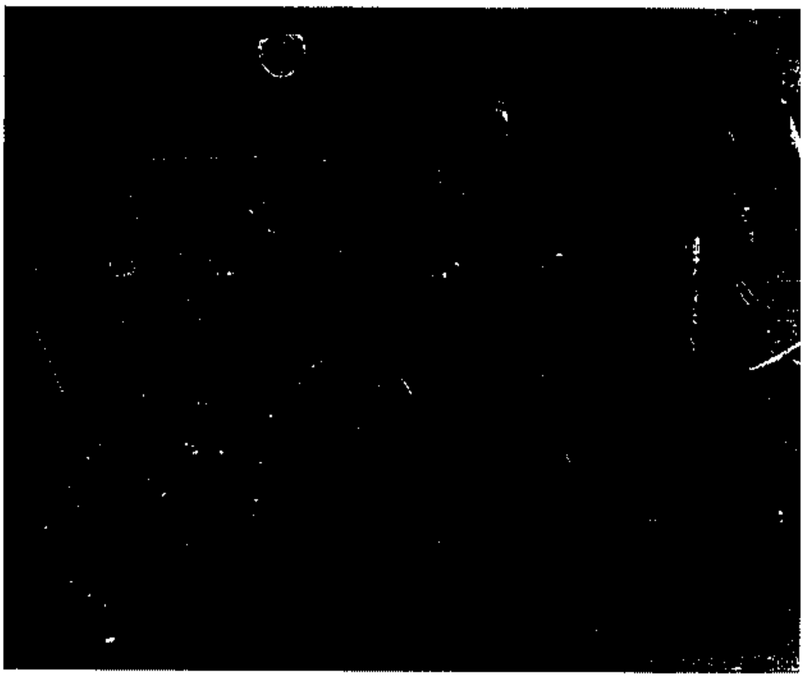

FIG 4.11. COMPONENT ASSEMBLY

4.4 SLOTTING MACHINE

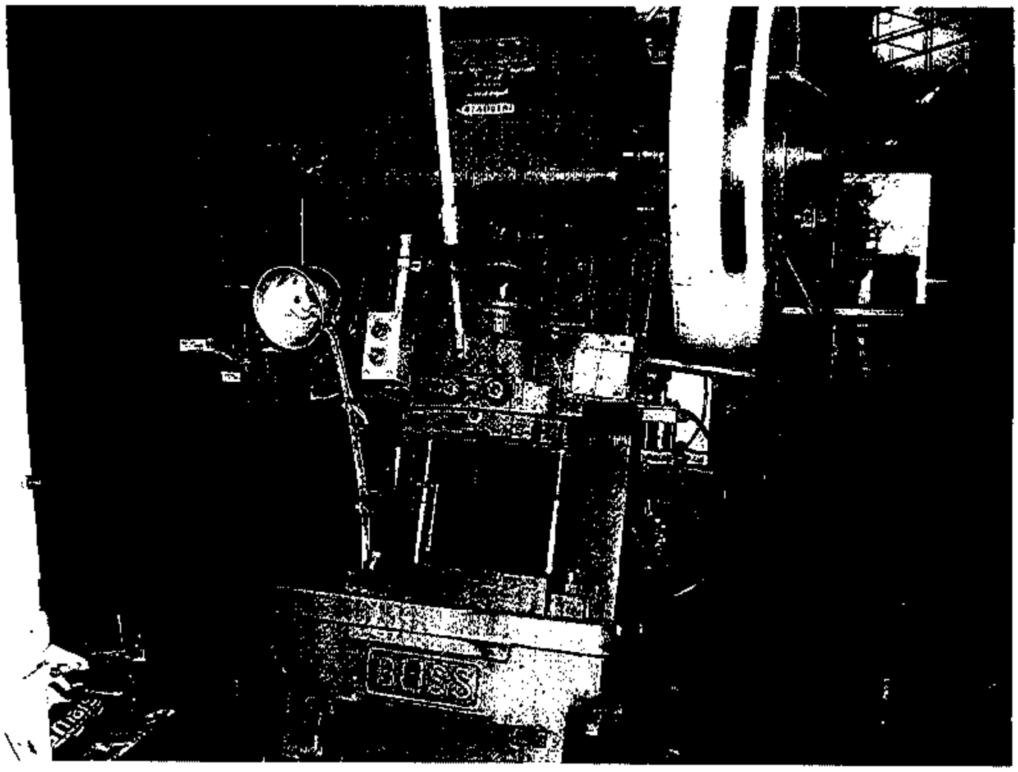

FIG 4.12. SLOTTING MACHINE

4.4.1Machine description

Type - C22 press (Company BLISS)

Capacity - 22 tonnes

Stroke Length - 4 inches

Slide area - 10 ¼ * 8 1/8 inches

Bed area - 23 ½ * 14 ½ inches

Die height - 11 * 7/8 inches

Strokes /min - 100

Motor - 2 hp, 750 rpm

Lubrication - Automatic oil

Electric power - 220 volts, 50 Hz

Clutch Control - 110 volts, 60 Hz

CHAPTER 5

FIXTURE DESIGN

5.1 INRODUCTION

Fixture is a work holding used to manufacture duplicate parts accurately. It is a production tool that locates, holds, and supports the work securely so the required machining operations can be performed. A fixture should be securely fastened to the table of the machine upon which the work is done. Fixtures vary in design from relatively simple tools to expensive, complicated devices. Fixtures also help to simplify metal working operations performed on special equipment.

5.2 STEPS TO BE FOLLOWED BEFORE DESIGNING A FIXTURE

Successful fixture designs begin with a logical and systematic plan. With a complete analysis of the fixture's functional requirements, very few design problems occur. The work piece, processing, tooling, and available machine tools may affect the extent of planning needed. Preliminary analysis may take from a few hours up to several days for more complicated fixture designs. Fixture design is a five-step problem-solving process. The following is a detailed analysis of each step.

5.2.1 Step 1: Definition of Requirements

To initiate the fixture-design process, clearly the problem to be solved or needs to be met should be stated. Here the requirement is to reduce the tool setting time in the slotting operation.

5.2.2 Step 2: Gather/Analyze Information

All relevant data should be collected and assembled for evaluation. The main sources of information are the part print, process sheets, and machine specifications. Work piece specifications usually are the most important factors and have the largest influence on the fixture's final design.

Additional factors usually considered in this category are operator fatigue, efficiency, economy of motion, and the speed of the operation. The designer also must know and understand the general aspects of design safety and all appropriate government and company safety rules and codes.

5.2.3 Step 3: Developing Several Options

This phase of the fixture-design process requires the most creativity. A typical work piece can be located and clamped several different ways. The natural tendency is to think of one solution, then develop and refine it while blocking out other, perhaps better solutions. In the interest of economy, alternative designs should be developed only far enough to make sure they are feasible and to do a cost estimate.

5.2.4 Step 4: Choosing the Best Option

The fourth phase of the tool-design process is a cost/benefit analysis of different tooling options. In analyzing fixture costs, the emphasis is on comparing one method to another, rather than finding exact costs. Sometimes these methods compare both proposed and existing fixtures, so that, where possible, actual production data can be used instead of estimates.

5.2.5 Step 5: Implementing the Design

The final phase of the fixture-design process consists of turning the chosen design approach into reality. Final details are decided, final drawings are made, and the tooling is built and tested.

Once sketches and the basic fixture design have been completed, final engineering drawings, also called shop prints, are used in the tool room to build the fixture. After the fixture is completed and inspected, it should be tested. The fixture is set up on the machine tool and several parts are run. When the fixture proves itself in this phase, it is ready for production.

5.3 TYPES OF FIXTURES

Based on the application, the various types of fixtures are given by

Plate Fixture – It is the simplest form of fixture. The basic fixture is made from a flat plate that bas a variety of clamps and locators to hold and locate the part. The simplicity of this fixture makes it useful for most machining operations. Its adaptability makes it popular

Angle Plate Fixture – It is a variation of a plate fixture. With this tool, the part is normally machined at a right angle to the locator. While most angle plate fixtures are made at 90 degrees, there are times when other angles are needed. In this case, a modified angle plate fixture can be used.

Vise-Jaw Fixture – Theses fixtures are used for machining small parts. With this type of tool, the standard vise jaws are replaced with jaws that are formed to fit the part. Their use limited only by the size of the vise available.

Indexing Fixture – These fixtures are very similar to the indexing jigs. These fixtures are used machining parts that must have machined details evenly spaced.

Multi Station Fixture – It is used primarily for high-speed, high volume production runs, where the machine cycle must be continuous. Duplex fixtures are the simplest form of multi station fixture, using only two stations.

Profiling Fixture – These fixtures are used to guide tools for machining contours that the machine cannot normally follow. These contours can be either external or internal. Since the fixture continuously contacts the tool, an incorrectly cut shape is almost impossible.

Further fixtures are classified by the type of the machine on which they are used. For example, if a fixture is designed to be used on a milling machine, it is called milling fixture. Some special types of fixtures are explained as follows.

Die Fixture – This type of fixture are designed for the punching tools and dies used in the press tool operations. The work of this die fixture is to hold and support the die or tool and locate it at the correct position for the operation to be carried out.

Capsule Fixture – It is a type of industrial fixture which is deigned for the machining dies. In this type of fixture, for the tool and die, fixtures are designed respectively and both are assembled to form like a capsule which can be fixed in the machine during the operation and taken out after the operation is over.

5.4 SELECTION OF SUITABLE FIXTURE

The requirement in our project is to design fixture for the punch block tool and the die and the alignment of the punch block tool with the die. For this requirement the die fixture is suitable for designing the fixtures of punch block tool and die. In order for the alignment of the tool and the die both the fixtures are combined to form a capsule fixture or removable fixture.

5.5 COMPONENT SET DETAILS FOR WHICH FIXTURE IS DESIGNED

The component set selected is the set provided by the customer M/s. **PERKINS** to the company. The requirement of this customer is to manufacture bearings for using in the connecting rod main end in a **3.152 litre diesel 4 cylinder engine.** Since the data of the dimensions of each component was not available in the company the dimensions of each component was taken. Digital Vernier Caliper is the device used for measuring the dimension of the components.

5.6 BEARING SPECIFICATIONS

The bearing produced for PERKINS customer is a bush bearing used in the connecting rod main end. The specifications of the bearing produced is given by

- Shaft Diameter – 57.112 mm
- Housing Diameter – 60.833 mm
- Standard Wall Thickness – 1.816 mm
- Bearing Length – 29.972 mm

5.7 DIMENSIONING OF THE COMPONENTS

The dimension of the various components are measured and drafted in Auto CAD 2004 software for further modeling

5.7.1 Punch Block

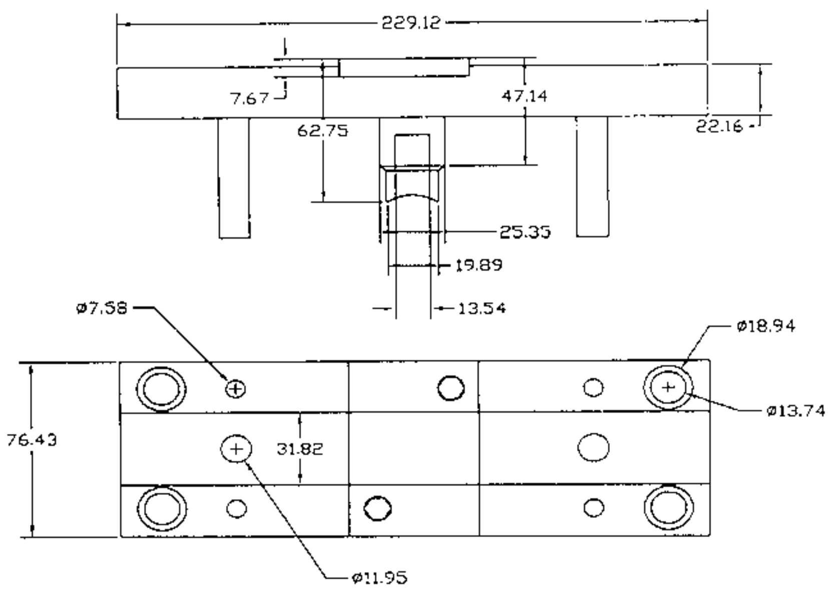

FIG 5.1.PUNCH BLOCK

5.7.2 Punch Pad

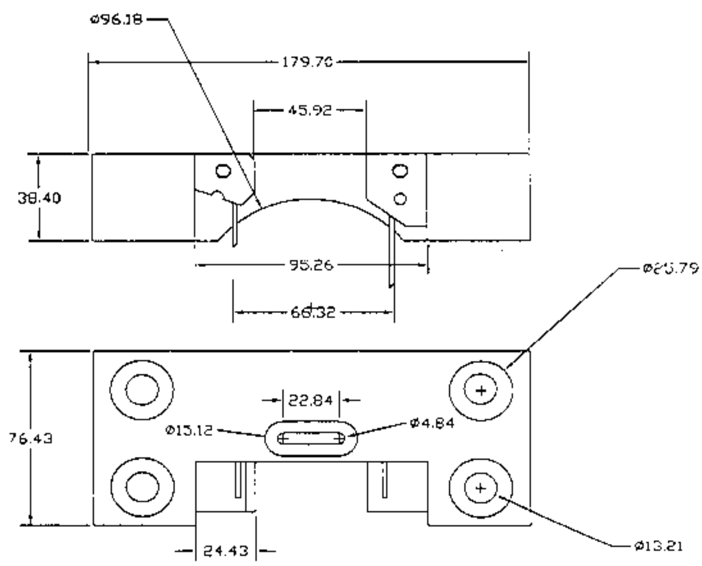

FIG 5.2. PUNCH PAD

5.7.3 Core

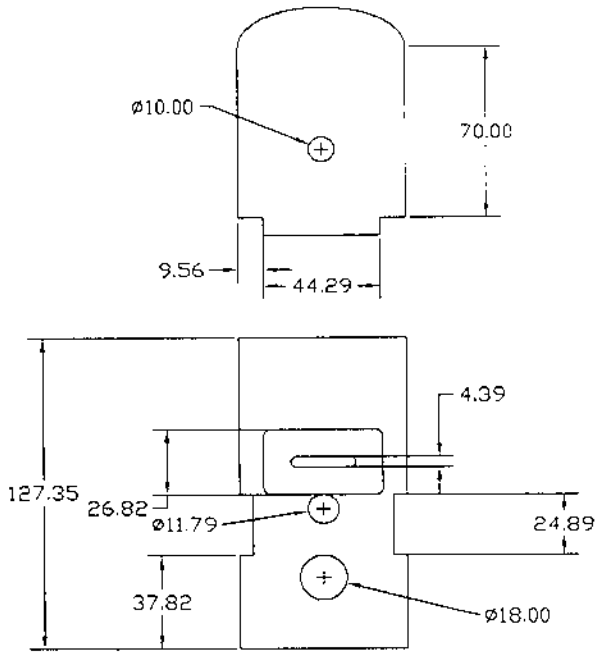

FIG 5.3.CORE

5.7.4 Core Holder

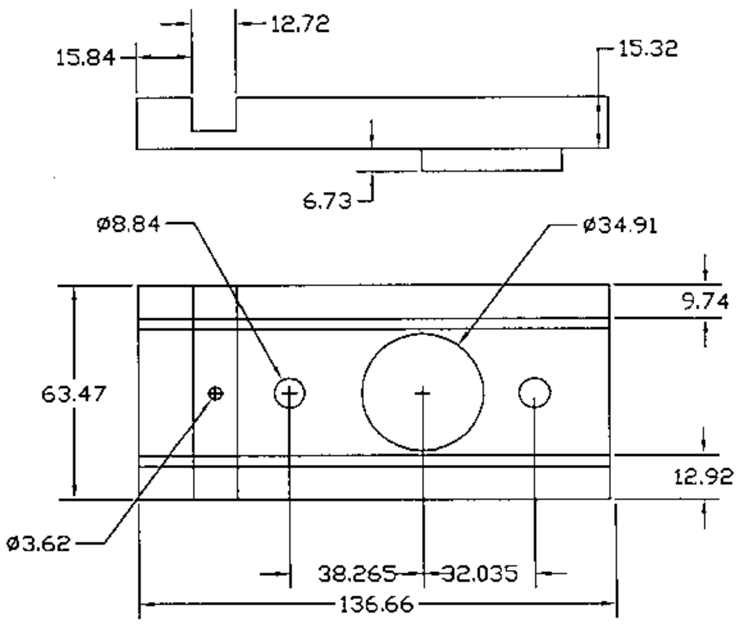

FIG 5.4.CORE HOLDER

5.7.5 Stoppers

5.7.5.1 Left Side Stopper

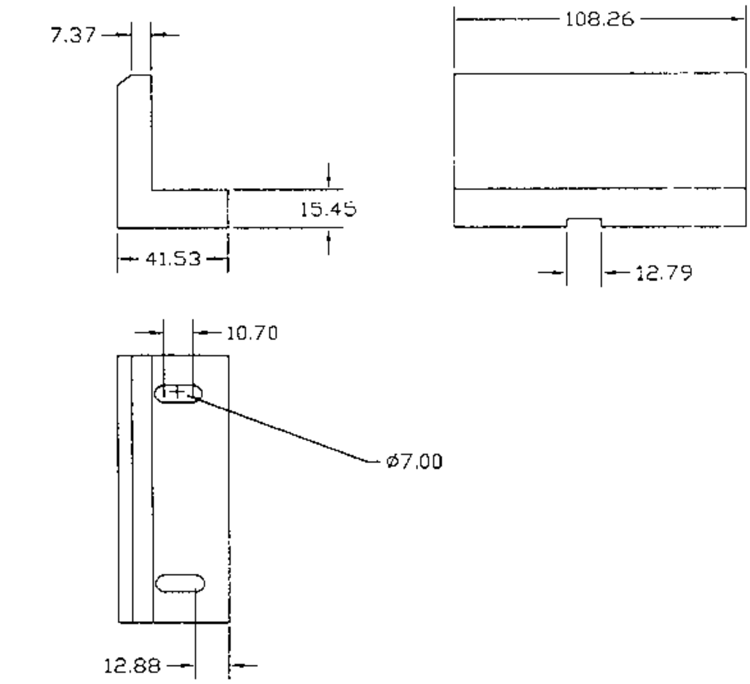

FIG 5.5. LEFT SIDE STOPPER

5.7.5.2 Right Side Stopper

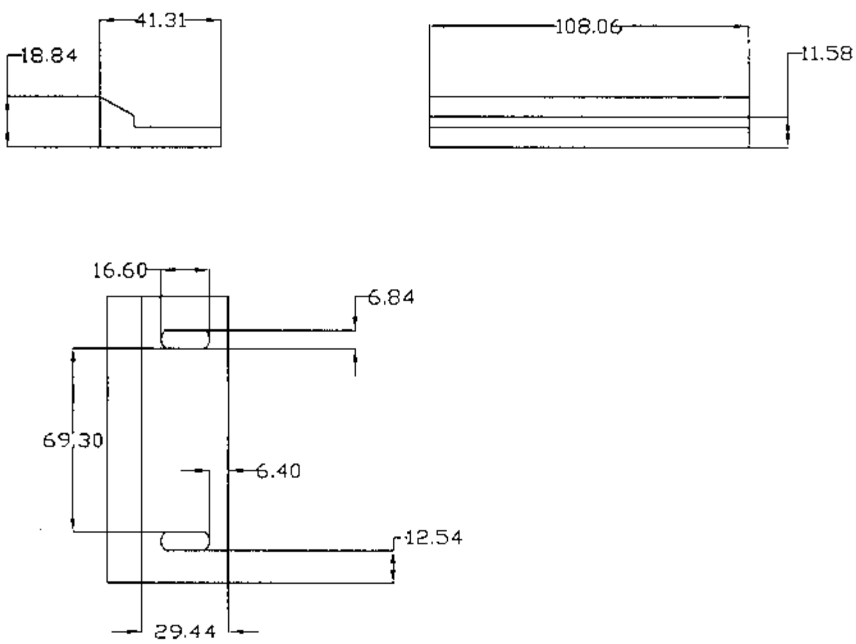

FIG 5.6. RIGHT SIDE STOPPER

CHAPTER 6

MODELLING OF THE FIXTURE

After taking the dimensions of the various parts involved in the slotting operation the die fixture is designed for punch tool and the die. Thus the punch tool and the die are located correctly to themselves. Then these die fixtures are combined to form a capsule fixture thereby the punch tool aligns with the die along the same axis.

6.1 FIXTURE MODEL FOR PUNCH BLOCK

The fixture model designed in Pro e 2001 software for the punch block is shown in figure (Fig 6.1). Its known as the top plate.

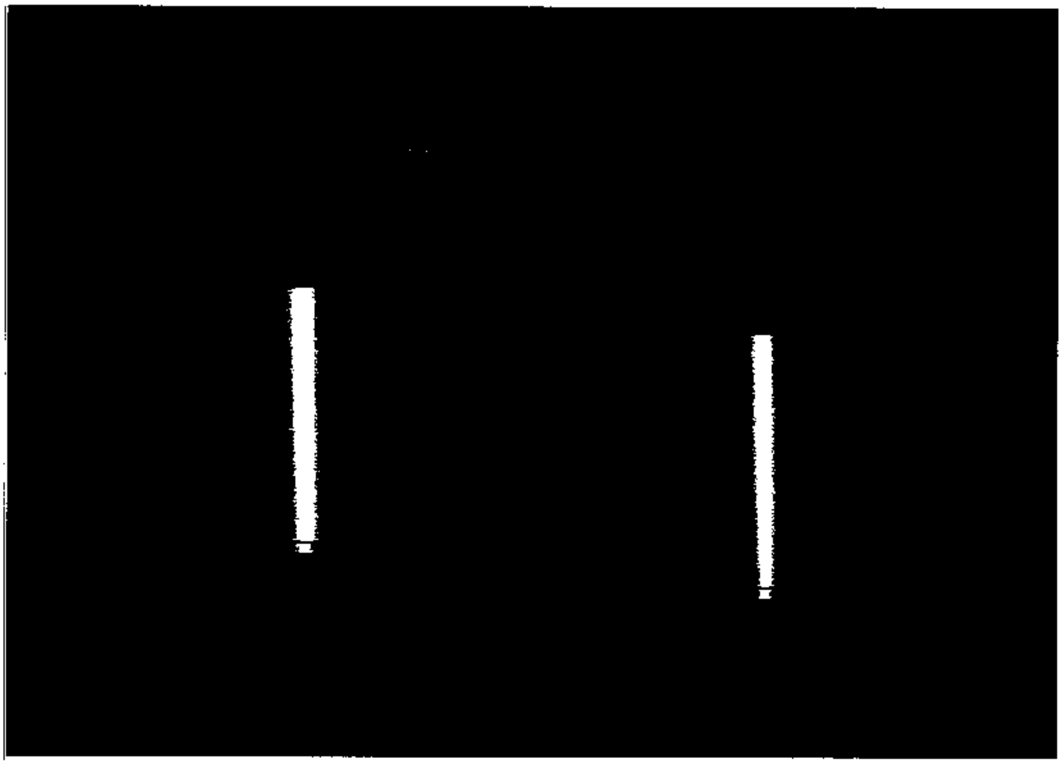

FIG 6.1. FIXTURE DESIGN FOR PUNCH BLOCK

The following figure (Fig 6.2) shows the detailing of the above fixture design.

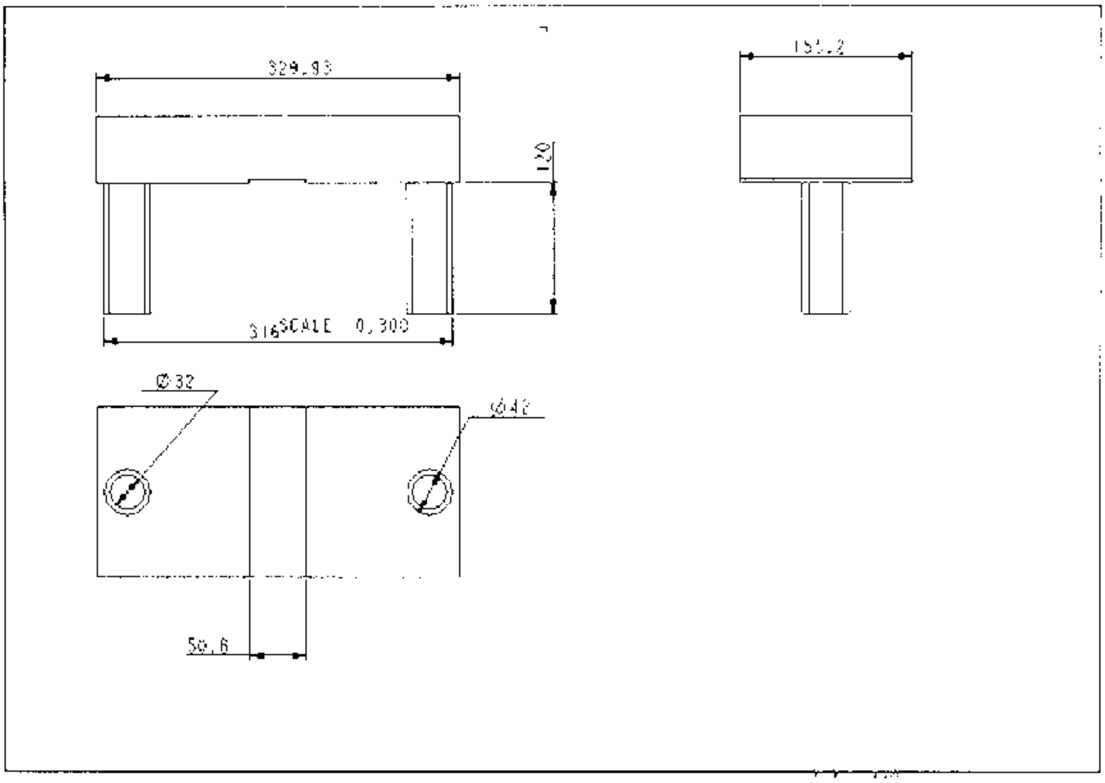

FIG 6.2. DETAILING OF FIXTURE DESIGN

6.2 FIXTURE MODEL FOR DIE

The fixture model designed in Pro e 2001 software for the die is shown in figure (Fig 6.3). It's known as the base plate.

FIG 6.3. BASE PLATE

The detailing of the base plate is shown in the following figure (Fig 6.4).

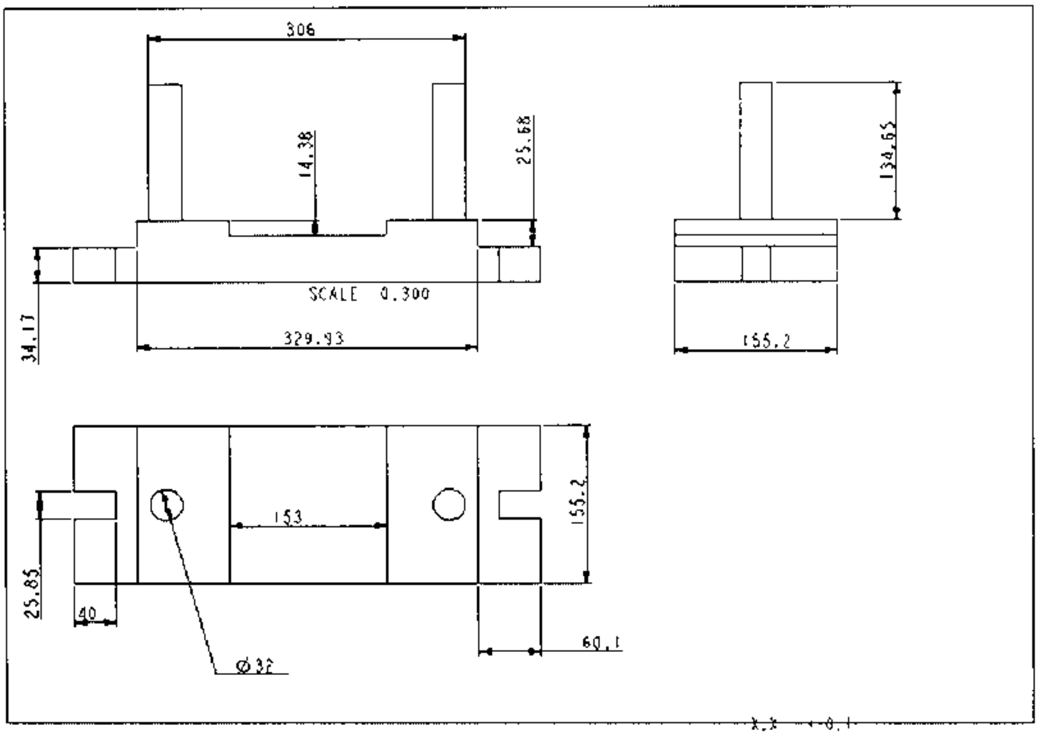

FIG 6.4. BASE PLATE DETAILING

6.3 COMPONENT MODELLING

After designing the fixture, the various components involved in the slotting operation are modeled in pro E 2001 software with the dimensions taken and drafted using Auto Cad 2004 software. These modeled components are then assembled in the fixture designed in order to check for the tool and die alignment. The components modeled for checking the alignment are the

- Punch Block
- Core
- Core Holder

6.3.1 Punch Block

FIG 6.5.PUNCH BLOCK

6.3.2 Core

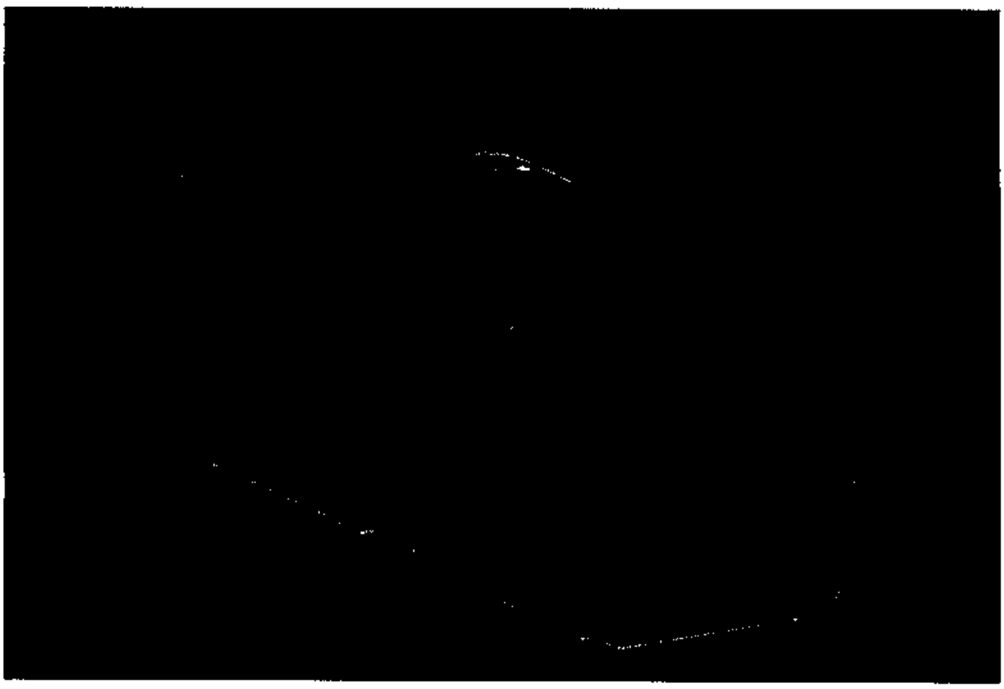

FIG 6.6.CORE

6.3.3 Core Holder

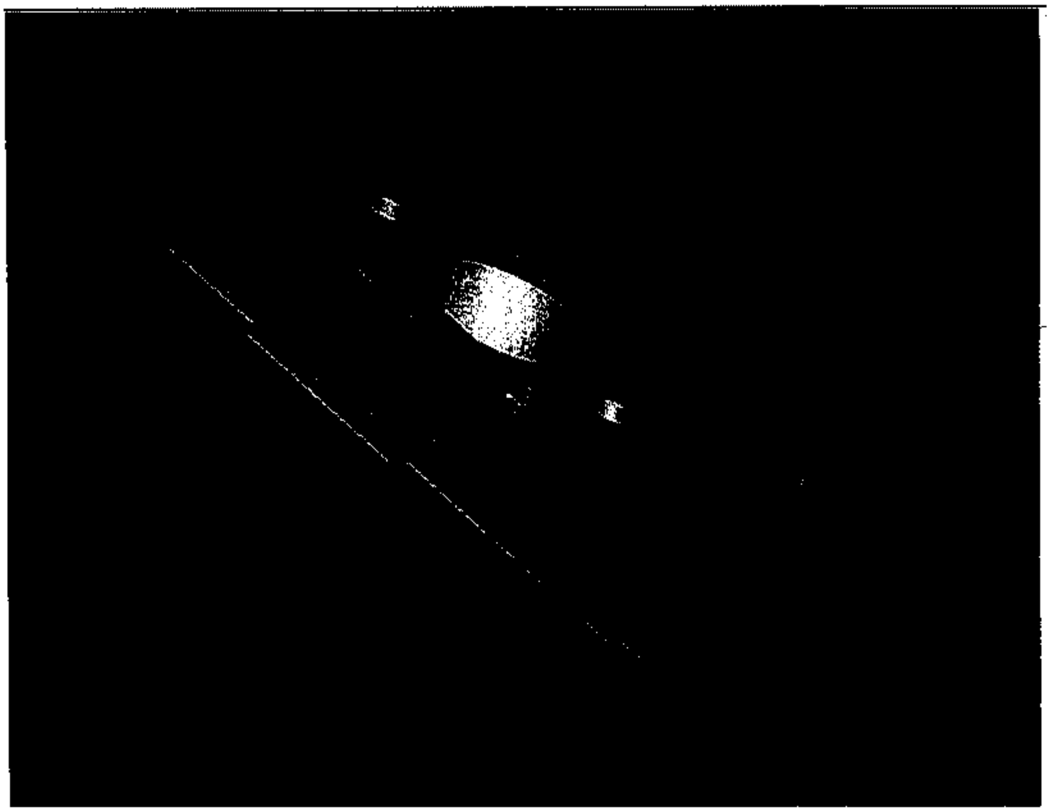

FIG 6.7.CORE HOLDER

6.4 THE ASSEMBLY

After modeling the components these components are assembled in the fixture designed in their respective locations. After assembling, the punch tool and die is checked for their alignment along the same axis. The assembled fixture is shown in the following figure (Fig 6.8).

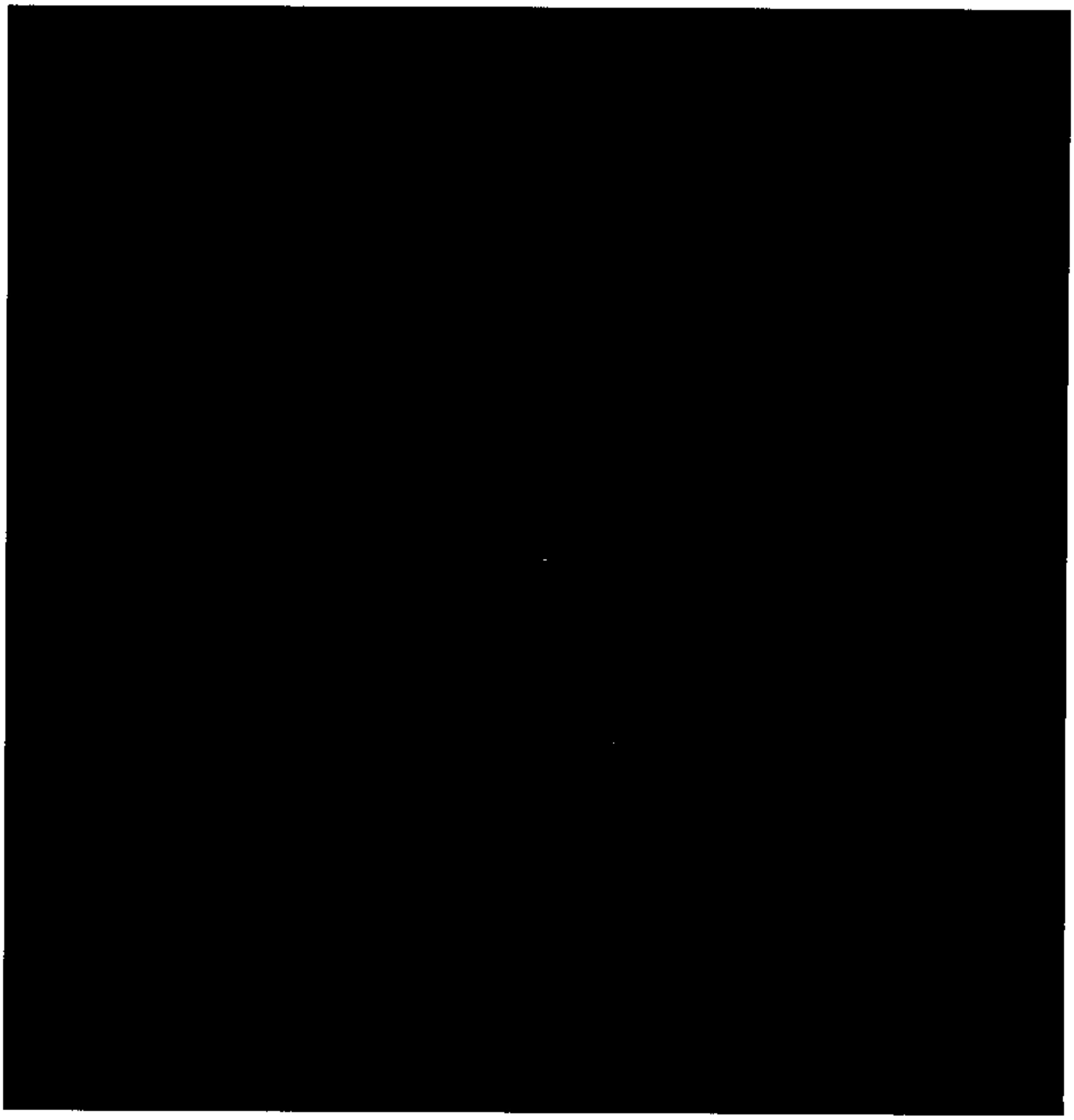

FIG 6.8. THE ASSEMBLY

6.5 DETAILING OF THE ASSEMBLY

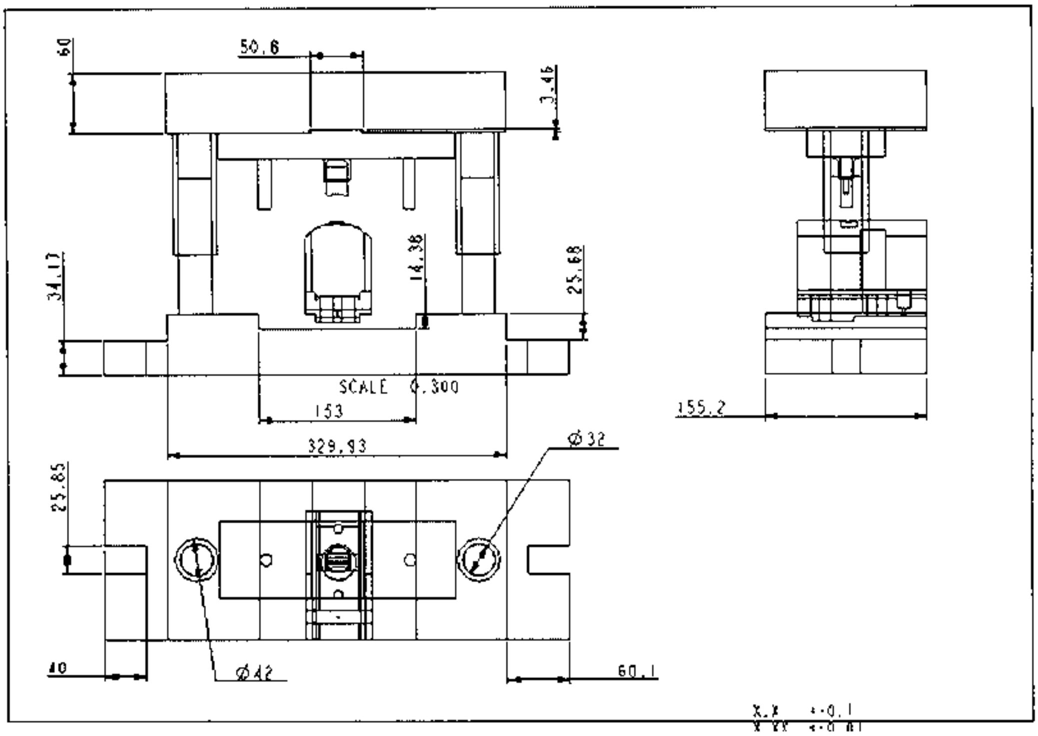

FIG 6.9. DETAILING

6.6 ALIGNMENT CHECKING

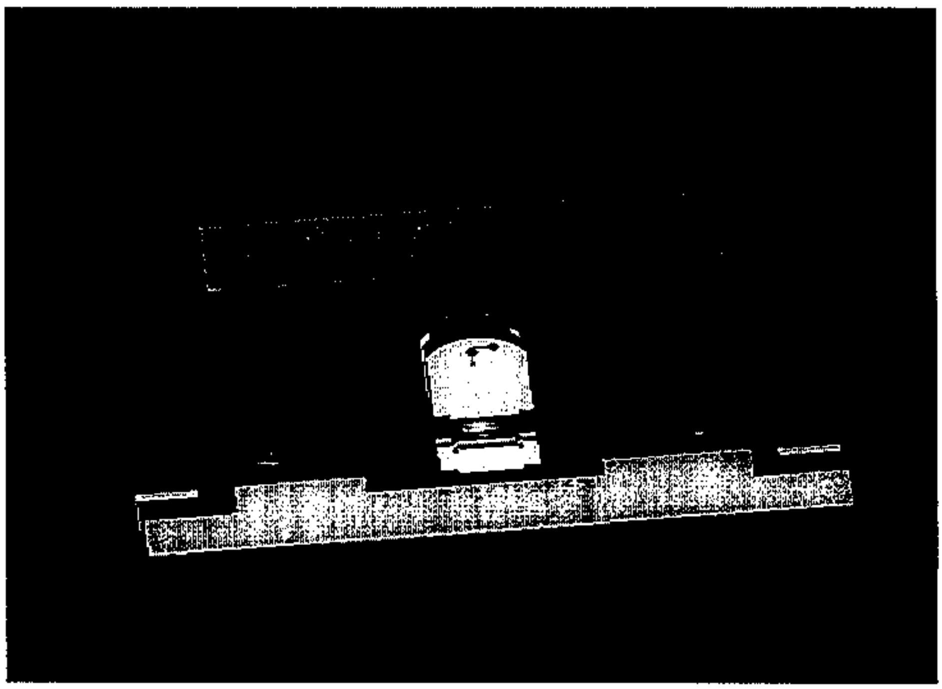

FIG 6.10. ALIGNMENT

CHAPTER 7

DESIGN OF SPRINGS

7.1 INTRODUCTION

A spring is defined as an elastic body, whose function is to distort when loaded and to recover its original shape when the load is removed. The various important applications of springs are in follows:

- To cushion, absorb energy due to their shock or vibration as in car springs.
- To apply forces, as in brakes, clutches and spring loaded valves.
- To control motion by maintaining contact between two elements as in cams and followers.

7.2 IMPORTANCE OF SPRING DESIGN FOR THE FIXTURE

The springs are being designed for the fixture for the push back operation after completion of each stroke of the slotting operation is finished. These springs are fitted in the circumference of the base plate pillars. The mean coil diameter of the spring should be equal to the inner diameter of the top plate pillar.

7.3 TYPES OF SPRINGS

Though there are many types of springs, classification of springs according to their shape is of most importance. They are given by

Helical Springs – The helical springs are made up of a wire coiled in the form of a helix and are primarily intended for compressive and tensile loads. The cross section of the wire from which the spring is made may be circular, square or rectangular. The two forms of helical spring are **compression helical spring** and **tension helical spring.**

Conical and Volute springs – These springs are used in special applications where a telescoping spring or spring with a spring rate that increases with the load is desired. The conical spring is wound with uniform pitch whereas the volute springs are wound with in the form of paraboloid with constant pitch and lead angles. In either case, the number of active coils gradually decreases. The decreasing number of coils results in an increasing spring rate.

Torsion Springs – These springs may be of helical or spiral type. The helical type may be used only in applications where the load tends to wind up the spring and are used in various electrical mechanisms. The spiral type is also used where the load tends to increase the number of coils and when made of flat strip are used in watches and clocks.

Laminated or Leaf Springs – The laminated of leaf springs consists of number of flat plates known as leaves of varying lengths held together by means of clamps and bolts. These are mostly used in automobiles.

Disc or Belleville Springs – These springs consists of a number of conical discs held together against slipping by a central bolt or tube. These springs are used in applications where high spring rates and compact spring units are required.

Special Purpose Springs – These springs are air or liquid springs, rubber springs, ring springs etc. The fluids (air or liquid) can behave as a compression spring. These types are used for special type of applications only.

7.4 SELECTION OF SPRING TYPE

For our area of study, the suitable spring is the **helical spring** which is the best favorable for our fixture design and its application. Since the slotting operation involves compression loading the type of helical spring is chosen as the compression type. In the compression helical spring, the round wire type is chosen with heavy duty rating due to a high load of 30 tons acting on the fixture

7.5 SELECTION OF SPRING MATERIAL

The material of the spring generally should have high fatigue strength, high ductility, high resilience and it should be creep resistant. It largely depends upon the service for which they are used. They are

Severe service – it means rapid continuous loading where the ration of minimum to maximum load is one half or less.

Average service – includes the same stress range as in severe service but with only intermittent load.

Light service – includes springs subjected to loads that are static or very in frequently varied.

In the slotting operation since the load is intermittent the material for the average service is to be selected.

The load acting on the spring is *211.13968 kN*. This load comes under the range of severe impact load category for which the **Chrome – Vanadium valve Spring Steel** (En 47) material is selected.

7.6 PROPERTIES OF THE SPRING MATERIAL En 47

Material – Chrome Vanadium valve Spring Steel

Type – Round wire (heavy duty rating)

Designation – T 50 Cr 1 V 23

Carbon % = 0.45 to 0.55

Silica % = 0.1 to 0.35

Manganese % = 0.5 to 0.8

Chromium % = 0.5 to 0.8

Vanadium % = 0.15 to 0.3

7.7 SPRING DESIGN CALCULATIONS

From the fixture design,

(i) Free length of the spring = length of the base plate pillar – length covered by the

top plate pillar in the base plate pillar

∴ Free length, L = 150 – 20 = **130 mm**

(ii) Deflection of the spring = the distance travelled by the punch tool till the top

surface of the bearing

∴ Deflection, δ = **82.04 mm**

With the above details, the diameter of the wire and the spring rate is chosen from the PSG Design Data Book.

∴ Wire Diameter, d = **8 mm**

Based on the diameter of the base pillar (32 mm), the

Mean coil diameter of the spring, **D = 34 mm**

Stiffness of the spring,

$$W/\delta = (G * d) / (8 * C^3 * n)$$

Where,

W = Load acting on the spring (N)

G = Rigidity modulus of the spring material (N/mm2) = 0.8677*105 N/mm^2

C = Spring Index = D/d = 4.25

n = number of active turns

By calculating,

∴Number of turns of the coil, **n = 10**

Pitch of the coil,

$$P = \text{Free length} / (n^1 - 1)$$

Where,

n^1 = Total number of turns = n + 2 = 12

∴Pitch of the coil, **P = 11.818 mm**

7.8 DESIGN SPECIFICATIONS

Free length, **L** = 130 mm

Deflection, δ = 82.04 mm

Wire Diameter, **d** = 8 mm

Mean coil diameter of the spring, **D** = 34 mm

Number of active turns of the coil, **n = 10**

Pitch of the coil, **P** = 11.818 mm

CHAPTER 8

ANALYSIS OF FIXTURE DESIGN

8.1 INTRODUCTION

The analysis is been done on the top plate of the proposed fixture design which is the load acting member. The analysis is done in Finite Element Method (FEM) using the ANSYS software. The type of analysis made on the top plate is the structural analysis.

8.2 OBJECTIVE OF ANALYSIS

The primary objective of the analysis is to find the maximum bending stress acting on the top plate which is the load acting member. By this result the design of the fixture is validated for its safe stress limit for the selected material.

8.3 INTRODUCTION TO FINITE ELEMENT ANALYSIS

Finite element analysis (FEA) is a computer simulation technique used in engineering analysis. It uses a numerical technique called the finite element method (FEM). Development of the finite element method in structural mechanics is usually based on an energy principle such as the virtual work principle or the minimum total potential energy principle.

A common use of FEA is for the determination of stresses and displacements in mechanical objects and systems. However, it is also routinely used in the analysis of many other types of problems, including those in heat transfer, solid state diffusion and reactions with moving boundaries, fluid dynamics and electromagnetism. FEA is able to handle complex systems that defy closed-form analytical solutions.

Analysis can help the user in accomplishing the following tasks

- Reduce cost by simulating the testing of your model on the computer instead of expensive field tests.
- Reduce time to market by reducing number of product development cycle.
- Improve products by quickly testing many concepts and scenarios before making a final decision, giving you more time to think of new designs.

8.4 INTRODUCTION TO ANSYS

The ANSYS program is a powerful multipurpose finite element tool that can be used in a variety of industries such as automobiles, railways, electronics, power generation and power transmission. The ANSYS program has many finite-element analysis capabilities, ranging from a simple, linear, static analysis to a complex, nonlinear, transient dynamic analysis. ANSYS provides a cost-effective way to explore the performance of products or processes in a virtual environment. This type of product development is termed virtual prototyping. With virtual prototyping techniques, users can iterate various scenarios to optimize the product long before the manufacturing is started. This enables a reduction in the level of risk, and in the cost of ineffective designs. The multifaceted nature of ANSYS also provides a means to ensure that users are able to see the effect of a design on the whole behavior of the product, be it electromagnetic, thermal, mechanical etc.

8.4.1 Structural capabilities of ANSYS

Structural analysis is probably the most common application of the finite element method as it implies bridges and buildings, naval, aeronautical, and mechanical structures such as ship hulls, aircraft bodies, and machine housings, as well as mechanical components such as pistons, machine parts, and tools.

Static Analysis - Used to determine displacements, stresses, etc. under static loading conditions. ANSYS can compute both linear and nonlinear static analyses. Nonlinearities can include plasticity, stress stiffening, large deflection, large strain, hyper elasticity, contact surfaces, and creep.

Transient Dynamic Analysis - Used to determine the response of a structure to arbitrarily time-varying loads. All nonlinearities mentioned under Static Analysis above are allowed.

Buckling Analysis - Used to calculate the buckling loads and determine the buckling mode shape. Both linear (Eigen value) buckling and nonlinear buckling analyses are possible.

8.5 STEPS TO SOLVE ANY PROBLEM IN ANSYS

Like solving any problem analytically, the following are to be defined.

- Solution domain
- Physical model
- Boundary conditions
- Physical properties

You then solve the problem and present the results. In numerical methods, the main difference is an extra step called mesh generation. This is the step that divides the complex model into small elements that become solvable in an otherwise too complex situation. Below describes the processes in terminology slightly more attune to the software.

Build Geometry - Construct a two or three dimensional representation of the object to be modeled and tested using the work plane coordinates system within ANSYS.

Define Material Properties - Now that the part exists, define a library of the necessary materials that compose the object (or project) being modeled. This includes thermal and mechanical properties.

Generate Mesh - At this point ANSYS understands the makeup of the part. Now define how the modeled system should be broken down into finite pieces.

Apply Loads - Once the system is fully designed, the last task is to burden the system with constraints, such as physical loadings or boundary conditions.

Obtain Solution - This is actually a step, because ANSYS needs to understand within what state (steady state, transient... etc.) the problem must be solved.

Present the Results - After the solution has been obtained, there are many ways to present ANSYS' results, choose from many options such as tables, graphs, and contour plots.

8.6 CONSTRAINTS FOR OUR ANALYSIS

The various constraints taken for our analysis is listed below.

- The top plate is in its loaded condition
- The tool has just hit the work piece

At this point the top plate has been analyzed with load acting at the top which is a uniformly distributed load provided by the ram of the slotting machine and the stress developed at the bottom of the plate due to the punch block which hits the work piece.

8.7 MODELLING AND MESHING

The top plate is modeled directly in the ANSYS software from the modeling option provided. The modeled top plate is shown below.

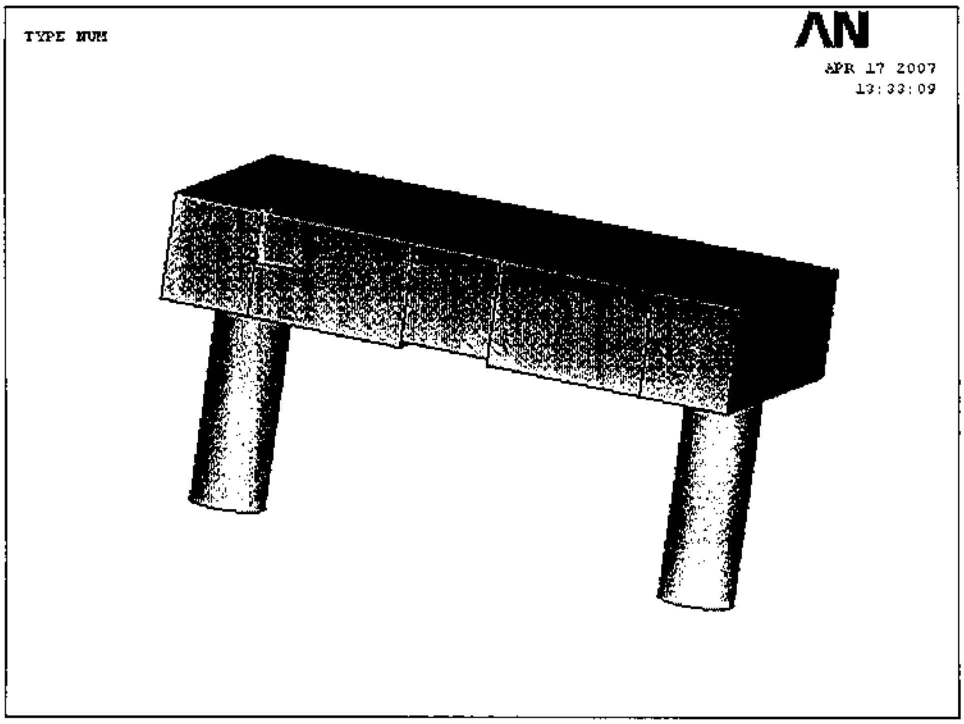

FIG 8.1 MODELLING

After the top plate is modeled, it is divided into innumerous number of parts by meshing tool provided in the software. In this case SWEEP mesh is selected and the model is meshed. Smart sizing gives the mesher a great opportunity to create reasonably shaped element during automatic element generation. In the mesh tool smart sizing option is enabled and set at value 1. With that fine sizing the total no of nodes what we got is 72090. The meshing of top plate is given below.

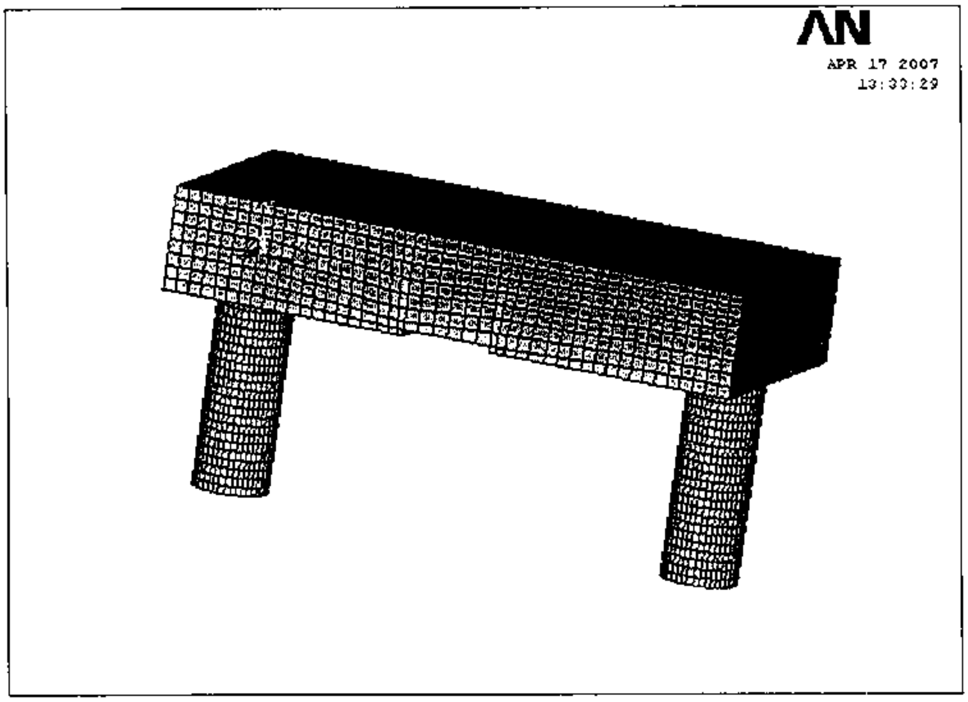

FIG 8.2. MESHING

8.8 DEFINING LOADS

Load acting on the top plate = 921.5244 N/m

Area of top plate on which the load is acting = 229.12 * 77.6 = 7779.712 mm^2

Converting UDL load into point load = 921.5244 * 229.12 = 211.64698 kN

Pressure acting in the top = Force / area = (211.64698 * 10^3) / 7779.712

= 27.205 N/mm^2

8.9 MATERIAL PROPERTIES

Material of the top plate = Cast iron

Young's modulus of the material = 1 * 10^5 N/mm^2

Poisson Ratio = 0.23

8.10 CONSTRAINING THE MODEL

The top plate is constrained at the bottom with the area of the punch block due to which the stress is induced in the top plate while the tool in the punch block hits the work piece. The load acting on the model and the constrain on the model is shown in the following figure

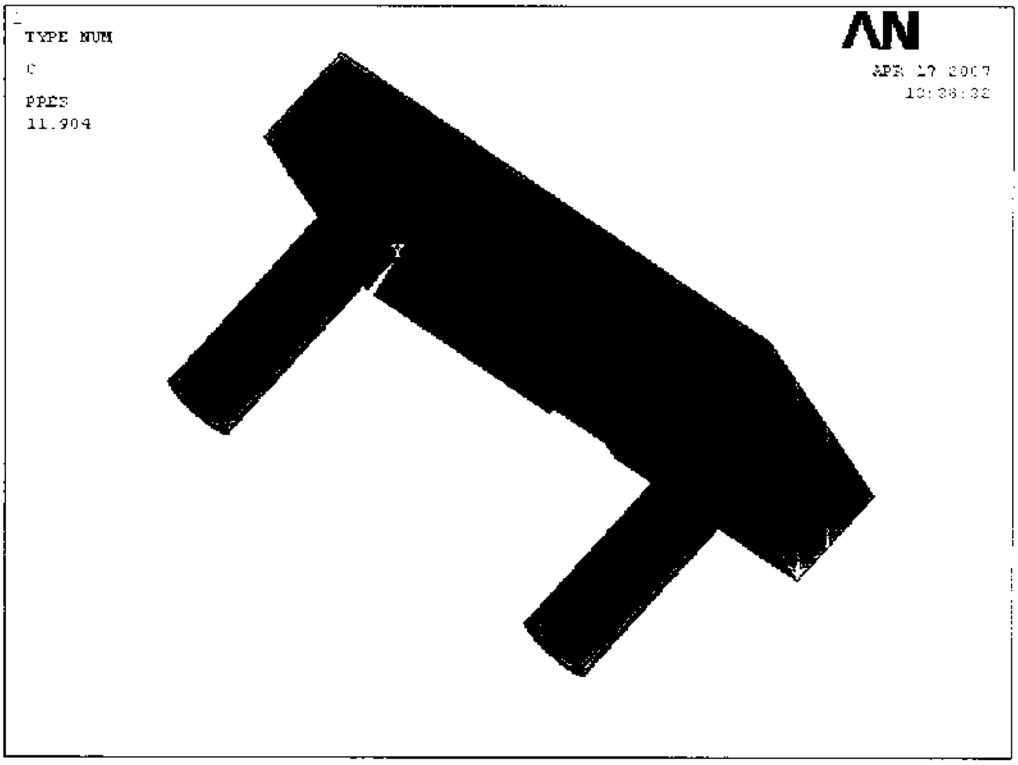

FIG 8.3. LOAD AND CONSTRAINT

8.11 SOLUTION

With the above data's being provided in the ANSYS software the solver analyses and gives out a solution. Those results can be seen in the result plots option provided. The various stress plots obtained are shown below

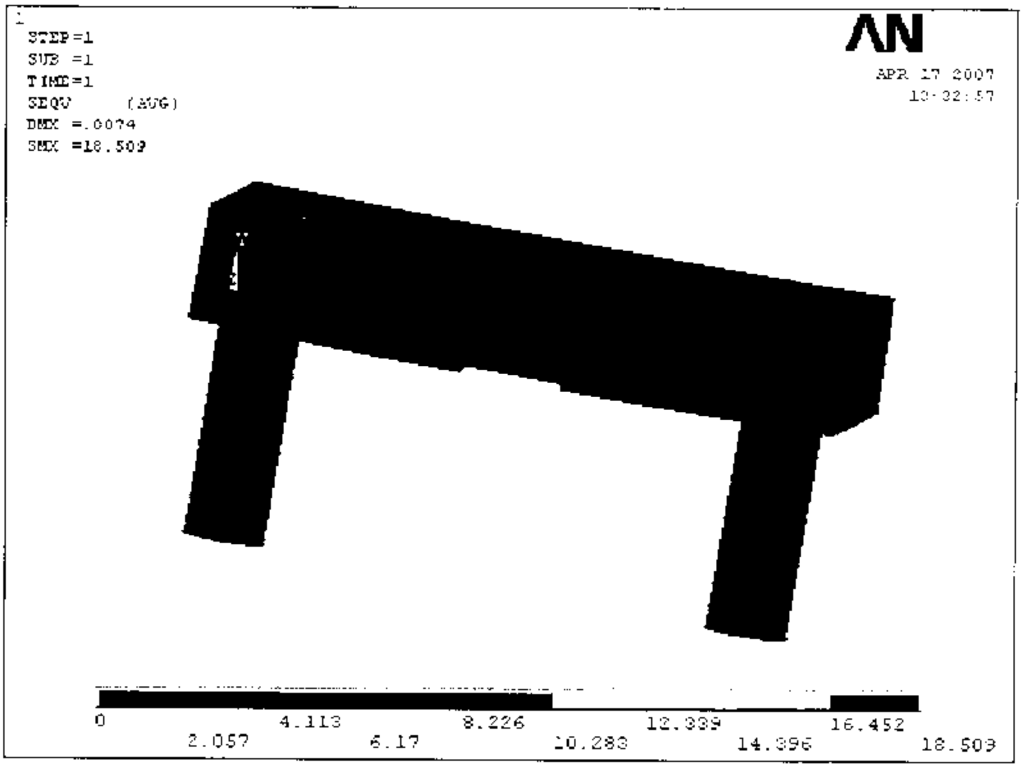

FIG 8.4 COMPRESSIVE STRESS

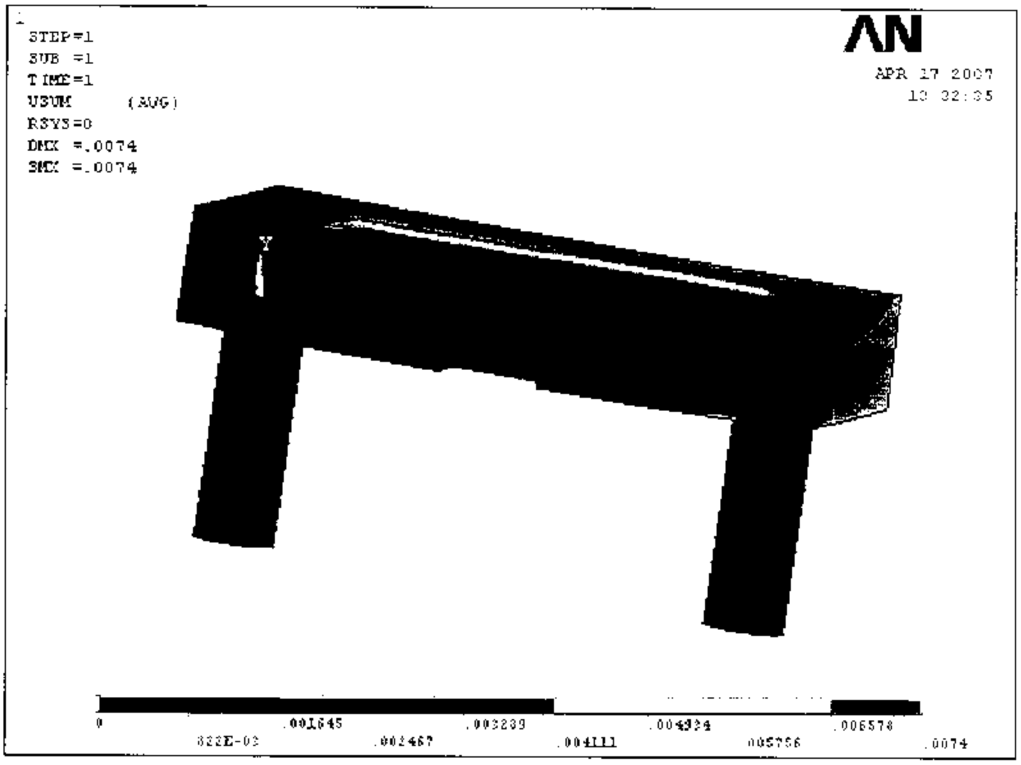

FIG 8.5. DISPLACEMENT

8.12 DESIGN OF TOP PLATE PILLAR EXTERNAL DIAMETER

The external diameter of the pillar should be such that the spring at the time of loading should not fail or buckle.

Assumption: According to the conditions given, the pillar is considered as a column with both ends fixed and load being acted on the spring side outwards.

- Pillar inner diameter = 34 mm
- Pillar outer diameter = D mm
- Length of the pillar = 120 mm

By Rankine's formula for columns

$1/W_{cr} = 1/W_c + 1/W_e$

Where, W_{cr} = Crippling load = W = 211.13968 kN

W_c = Compressive load = $\sigma_c * A$

W_e = Crippling load according to Euler's formula

$= (\pi^2 * E * I) / L^2$

Where,

L = l /2 = 120/2 = 60 mm

For cast iron, $E = 8*10^4$ N/mm^2

Moment of Inertia, $I = (\pi / 64) * (D^4 - 34^4)$

Compressive stress $\sigma_c = 550$ N/mm^2 (for cast iron)

Area of cross section, $A = (\pi / 4) * (D^2 - 34^2)$

Substituting these values in Rankine's formula we get

$$1/(211.13968*10^3) = \{(1/(550*(\pi/4)*(D^2-34^2))) + (1/((\pi^2 * 8*10^4 *(\pi/64)*(D^4-34^4))/60^2))\}$$

Therefore $D^4 - 488.7843D^2 - 1920982.238 = 0$

Solving we get **D = 43.64196 mm**

Thus the maximum outer diameter of the pillar should be 43.64 mm

External diameter chosen for the pillar, **D = 42 mm**

CHAPTER 9

RESULTS AND DISCUSSIONS

9.1 RESULTS OF ANALYSIS

The proposed design of fixture is analyzed for its safe stress limit in the analysis software and the results are furnished below.

- Maximum bending stress of the top plate, σ = 18.264 N/mm^2
- Safe stress limit of the material = 550 N/mm^2

Thus the design is safe and the stress limit is below the safe stress limit of the chosen material.

The external diameter of the top plate pillar is chosen such that the spring beneath it does not fail during the impact load.

- External diameter chosen for the pillar, D = 42 mm

9.2 DISCUSSIONS

The proposed design of fixture is based on the dimensions of the parts involved in slotting operation. After fixture design the analysis is made based on the condition that the tool hits the work piece and the maximum stress acting on the top plate is found out condition of the fixture when the punch hits the die, for compression and shear of the load acting member. Thus the design is made according to the safe stress limit based on the result of the analysis.

The fixture designed is validated by the analysis based on the load acting on the fixture. All the calculations were done based on the theoretical formulas and data's. Further study will be fabrication of the fixture designed and thereby practically validating the design.

CHAPTER 10

CONCLUSION

The advantage of this capsule fixture designed is, it can be easily fitted to the slotting machine and can be removed easily. By locating the punch and die it will reduce the setup time greatly. Since the shape of the fixture is like a capsule it also ensures safe operation. Such industrial fixtures further can be developed for most of the press tool operations and the setup time can be considerably reduced. The theoretical analysis of this fixture gives us the maximum stress developed in the top plate (load acting member) of the fixture which helps in validating the design for its safe design.

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