DESIGN OF TWIN SPINDLE SPM FOR FINE BORING OF CONNECTING ROD

Project Report 1998 - 99

CHARACTER IS LIFE

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BACHELOR OF ENGINEERING
In the Mechanical Engineering Branch
of the Bharathiar University.

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Certificate

This is to certify that the Project Report entitled **"DESIGN OF TWIN SPINDLE SPM FOR FINE BORING OF CONNECTING ROD"**

Is a bonafide record of the project work submitted by

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In partial fulfillment for the award of the degree of

Bachelor of Engineering
In Mechanical Engineering

Branch of the Bharathiar University, During the academic year 1998 – 99.

Head of the Department

Guide

Submitted for the University Examination Held on 15 · 3 · 99

Internal Examiner

External Examiner

ACKNOWLEDGEMENT

We would like to express our humble thanks to our principal **Dr.K.K.Padmanabhan, Ph.D.,** for the facilities provided to carry out this project.

We express our faithful thanks to our beloved Head of the Department **Prof. T.L.Sitharama Rao, Ph.D.,** for his worthful guidance and advice.

We take this opportunity in thanking our faculty guide **Mr.S.Sellappan, M.E.,** for his valuable guidance and suggestions throughout this project.

We express our deep rooted thanks to **Mr. N. Mohandas Gandhi, M.E.,** the project co-ordinator for his best suggestions.

It is our duty to thank **Mr.K.Babu,** Assistant Manager, Developments & Production, CPC Premier who gave his invaluable guidance in doing the project.

Last but not the least we take this opportunity to thank all the members of the faculty of Mechanical Engineering and our friends who directly or indirectly helped us in all ways to complete this project in a successful manner.

SYNOPSIS

As we approach the 21st century, revolutionary changes are taking place in the industrial scenario across the world. Customers are demanding high quality products at competitive costs. Their ever increasing expectations are driving organisation to strive hard for technological innovations and upgradations.

Automation is a process of technological development that will propel organisation into the foreseeable future. It is a technology concerned with application of Mechanical, Electrical and Electronics based systems to operate and to achieve high precision control systems. By introducing automation in the machining of connecting rod, the rate of production can be increased to a greater extent and at the same time quality product can be obtained.

The function of the connecting rod is to convert the reciprocating motion of the piston into the rotary motion of the crankshafts.

The connecting rod is a drop forging made from steel or duralmin, an alloy of aluminium. The small end of the rod has either a solid eye or split eye, this end holding the piston pin. The big end works on the crankshafts and is always split.

In conventional method the two bores are fine bored independently on a lathe and the required tolerances are not more exactly and correctly met with. Thus many rejections occurs and the desired efficiency is not obtained in many cases. The proposed machine fine bores both the hole at a single pass and thereby the required centre distance is achieved within the tolerance limit.

The ultimate aim of our project is to increase the production rate by eliminating manual interventions and to maintain precise bore diameters and reduce the cost of manufacturing.

CONTENTS

INTRODUCTION

Globalisation of business has triggered vast changes in the industrial environment. The focus of these changes is to maintain and expand the customer base amidst highly cometitive business atmosphere.

Customers satisfaction is an important factor which can be achieved only by,

- Maintaining prompt delivery schedule.
- Achieve consistency in quality
- Value for the cost.

The proposed project is twin spindle fine boring machine in which the rate of production could be increased. The project aims to eliminate all the hindrances in the currently used manufacturing process. The conventional process uses a lathe in which the rate of production is low. In this machine we have incorporated double spindle boring tool for higher rate of production.

'Automation' is an ultimate solution for all the above expectations of the customer. This has motivated the engineers and scientists to seek and develop innovative methods of automated production techniques.

1.1 Role of Automation in Industrial Growth.

In most of the manufacturing processes in any industry achieving the twin objectives of precision and high production rate with consistency is possible only by reducing manual interventions.

Thus automation has become a powerful tool for decreasing the cost of production thereby increasing profitability. Increased return on investment will automatically propel organisation growth.

1.2 Level of Automation.

Automation can be integrated in a manufacturing process either at all stages of manufacturing, known as fully **automatic system (flexible manufacturing system)** or at selecting few work stations when it is referred as **semi automatic system.**

In fully automated system, some parts (like crankshaft, engine block, engine head, etc.,) may be too heavy and complicated mechanisms may be required to convey them. The process may thus become more expensive. The capital cost involved is also very high. Hence in most of the industries semi automatic systems are normally preferred.

1.3 Existing Machining Method.

HMT – NH26 geared lathe with indexing arrangement fixture is utilised for boring operation. A fixture is mounted on the machine face plate and the connecting rod is held in position. An operator indexes, the indexing plate to 1st position. Now operator starts the longitudinal motion of the machine and bores the bigger end hole. Again the fixture is indexed to bore the smaller end hole.

The above process has following drawbacks:

- High capacity machine is used for light work.
- By manual operation, it is difficult to achieve the centre distance.
- Skilled operator is required for machining.
- Centre distance should be checked and maintained everytime of machining.
- Low precision rate.

- No. of rejections is high.
- Low processions.
- High machining cost
- High machining time
- Machining depends on the mental tension of the labour.

Maintaining the centre distance in the connecting rod is important since it influences the clearance between the piston top and cylinder head assembly.

Due to spurt in export orders and entry of foreign auto majors "Market need" changed drastically calling for,

- High quality and precise connecting rods.
- High volumes of different sizes of connecting rods, and
- Timely delivery.

1.4 Broad Basing of Automations.

Current global automobile market needs different size of connecting rods, requiring different size of machining. To accommodate these requirements the special purpose machine has to be suitably designed.

2.1 Principle Of Special Purpose Machine.

Keeping in view of the said facts, a special purpose machine has been designed, whose principle of operation is as follows:

The rotary motion of the twin spindle of the head unit and linear movement of slide are combined to effect the fine boring operation on connecting rod by using single point HSS tools. The twin spindle of the head unit is driven by a main motor.

2.2 Operation Sequence.

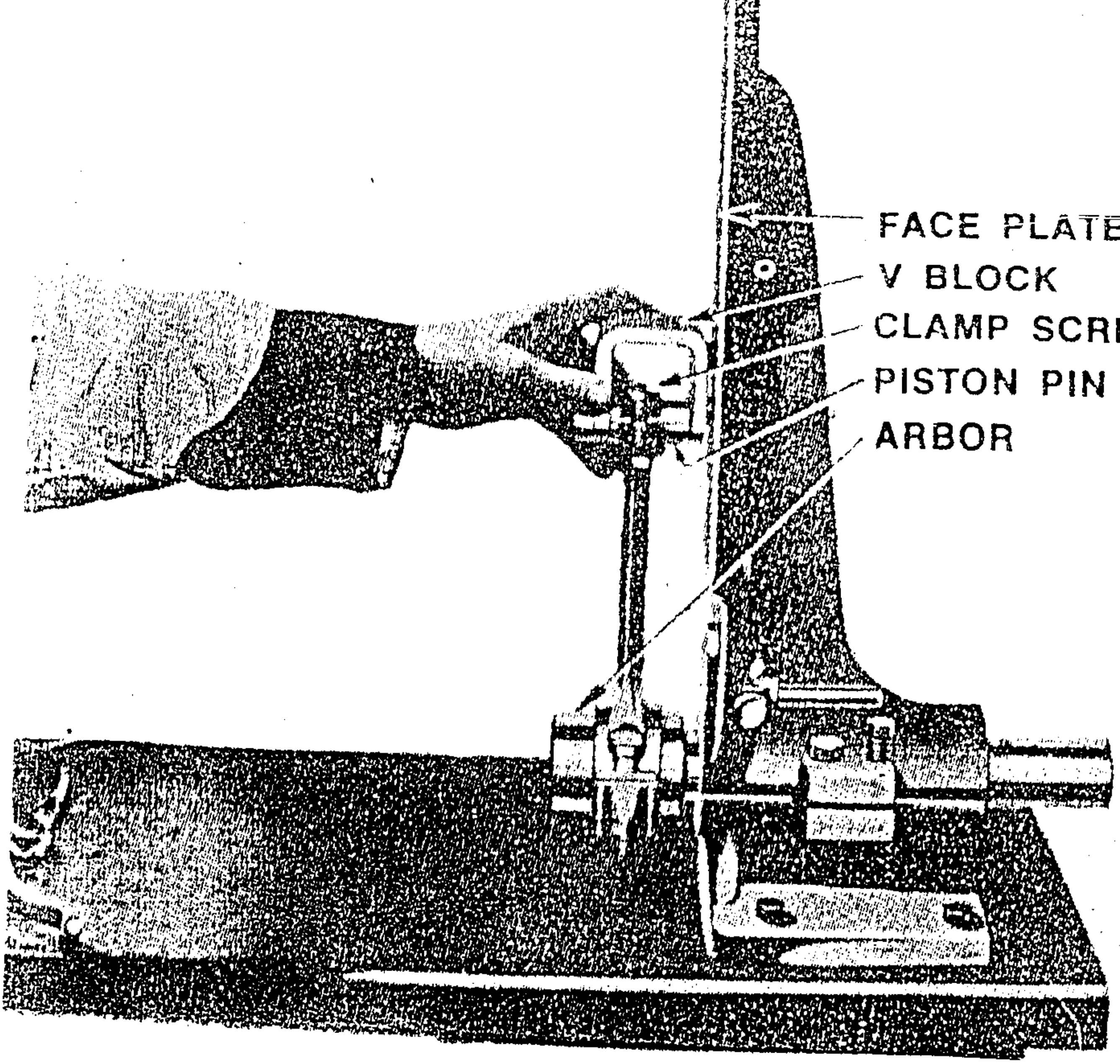
- The job is loaded, positioned and clamped on the fixture.
- The electrical switch is operated manually.
- Hand wheel is operated manually to move the job.
- The travel of job is restricted mechanically by limiting blocks.
- After fine boring the connecting rod, the connecting rod is unclamped.
- Now the job is unloaded and the fixture is cleaned by an air gun and the next job is loaded.
- The above sequence is repeated.

2.3 Inspection of connecting Rod.

The connecting rod should be checked for twist and bend on special alignment tool.

Inspection of connecting rod for twists and bends is a must at the time of engine assembly as slight bend in connecting rod will make the piston rub against the wall of the cylinder and slight twist will put undue pressure on big end shells and small end bearing resulting in its premature failure.

Twist in the connecting rod must not exceed 0.025 mm in every 152.4 mm length of connecting rod and the axis of bore of small end should be parallel to bore of big end. This should not exceed 0.025 mm of every 152.4mm length of connecting rod.



A Check Of The Alignment Of A Connecting Rod In A Special Alignment Tool.

CONSTRUCTION OF SPECIAL PURPOSE MACHINE

This special purpose machine consists of a holding fixture, with a slide of dove tail type, one which carries an angle plate along with it enabling the work-piece, to perform the machining operation (fine boring). The cutting operation is made effective by means of a high speed steel, single point throw away insert tool. This tool mounted on the shaft by means of a special arrangement that has a screw type adjustment for changing the diameter of bore that is to be performed.

This arrangement is attached to a shaft that is a special one which is splined at one end and the other end is attached to the driven gear which is a spur gear type, as they enable better transmission and lesser losses. The module has been suitably made as high precision accuracy is to be maintained.

This shaft is made to rotate by means of a drive gear, similar to that of the driven gear in all aspects. On the other side of the drive gear, an arrangement of, a replica of the shaft and tool arrangement explained earlier.

The driving force for the gears is transmitted by means of a pulley and V-belt drive from the motor. The V-belts are three in number and thus causing effective speed transmission.

The gears and shafts arrangements are covered by means of a solid cubical box which has the driving unit, the motor above it. The entire arrangement is kept on a machine base, that is a rigid case from slab to withstand shocks and vibrations, which are mounted on a standard channel.

3.1 Function of components.

Some of the major components and their functions are listed below:

- Table & Table Frame – Serves as a structural support of the machine
- Spindle unit – to transmit power from driver pulley.
- Motor - Prime mover
- Fixture - Locate and guide the connecting rod to align with machine axis.
- Slide - To transmit the motion.

3.2 Exploded View.

The exploded view of the special purpose machine was shown in diagram.

OPERATION AND INSTRUCTIONS MANUAL

Preface

This manual has necessary details for the manufacturer, operator and maintenance staff of the special purpose machine.

It is suggested that a copy of this manual be made available to the manufacturer, operator and maintenance staff on the shop floor who will be directly handling the machine.

For easy reference and understanding this manual is broadly divided into the following sections.

4.1 Operation Instruction

4.2 Maintenance Instruction

4.3 Technical specification

4.1 Operation Instruction:

Ensure the following, before starting the special purpose machine.

- As it is a sump type lubrication system the oil level is to be checked frequently.

- Any unwanted material, obstruction on the fixture plate and clamp should be checked and cleaned.
- Before loading the job, clean the fixture with air gun.
- Switch on electrical main.

At the end of operation

- Switch off the main
- Clean the machine with air gun.

4.2 Maintenance Instruction.

- Lubricate the spindle bearing with proper lubricants.
- Maintain oil level.
- Lubricate the slide periodically.

4.3 Technical Specification.

Job Specification:

Job designation	:	Connecting Rod
Bore size	:	Bigger end : φ 60mm
		Smaller end : φ 20mm
Tolerance	:	0.02 mm
Centre distance	:	139.7 mm

5.1 Selection of material.

Material selection is an important part of engineering practice. The choice of the material for our machine requirements, the proper use of those materials, including the development of new ways of using them for greater effectiveness all were our direct responsibilities.

The main engineering requirements of material fall under groups.

- Fabrication requirements
- Economic requirements.

Fabrication Requirements.

This includes the possibility to shape the material to join to other material. The assessment of fabrication segments concern the question of machining ability, hardenability, ductility, costability and weldability, solderability qualities which are some times quite difficult to assess.

Economic Requirements:

It is essential that the overall cost of machining and fabrication to be maintained to an optimum level without comparing on the quality.

In general, the choice of materials, for engineering purposes, depends upon the following factors.

- Availability of the materials.
- Suitability of the materials for the working conditions in service, and
- The cost of the materials.

5.2 Properties of Materials.

- **Mild Steel**

It is a low carbon steel. It contains 0.20 to 0.30% of carbon. It has a tensile strength of 555 N/mm^2 and hardness of 140 BHN.

It is used for making valves, gears, crankshafts, connecting rods, railway axles, etc.

- **Cast Iron.**

Cast iron is the least expensive of all the metals. As the name implies, they are intended to be cast instead of being worked in solid state.

It is primarily an alloy of iron and carbon. The carbon contents in cast iron varies from 1.7% to 4.5%. It also contains small amounts of Silicon, Manganese, Phosphorous and Sulphur.

The compressive strength of cast iron is much greater than the tensile strength.

Tensile strength	:	100 to 200 N/mm^2
Compressive strength	:	400 to 1000 N/mm^2
Shear strength	:	120 N/mm^2

Some of the important types of cast iron,

Grey cast iron:

- Carbon 3 to 3.5 %; Silicon 1 to 2.75%; Manganese 0.4 to 1.0%; Phosphorous 0.15 to 1% Sulphur 0.02% to 0.15% and the remaining is iron.

White cast iron:

- Carbon 1.75 to 2.3%; Silicon 0.85 to 1.2%; Manganese less than 0.4; Phosphorous less than 0.2%; Sulphur less than 0.12%

Malleable cast iron

Chilled Cast Iron.

- **C 45 – British standard : EN 8D**

It is a low carbon steel. It is a material having a composition of 0.35 to 0.45% of Carbon, 0.6 to 1% of Manganese, 0.05 to 0.35% Silicon. The tensile strength varies from 540 – 700 mpa. The yield stress varies from 280 – 500 mpa. The hardness varies from 150–260BHN. It is used for Bolts and machine components in general. It is having high strength and wear resistance. Engine components such as connecting rod and parts requiring strength and high wear resistance are made of this material. It is also used for spindles of machine tools, ball gear, and shafts.

- **105 Cr 1 Mn60 - British standard : EN31**

It is an alloy of steel having a chemical composition of 0.9 to 1.5% Carbon, 0.3 to 0.75% of manganese, 0.1 to 0.35 % Silicon, 1.0 to 1.6% Chromium, and maximum % of Sulphur and Phosphorus is 0.05%. It is having a tensile strength of 800 – 1000 mpa. The hardness in the range of 400 – 500 BHM. It is used for bolt making axle shafts, bolts, ball races, etc.

- **13 Ni 3 Cr 80 - British standard EN36**

It is an alloy of steel having a chemical composition of 0.1 to 0.2% of Carbon 2 to 3% of Nickel, 0.80% of Chromium.

It is used in heavy duty ears, Pinions, etc. It is used for very highly stressed machine parts which are to be hardened with high strength and toughness in core after hardening.

DESCRIPTION OF MAJOR COMPONENTS

Shaft

A shaft is a rotating machine element which is used to transmit power from one place to another.

In order to transfer the power from one shaft to another, the various members such as gears, pulleys etc., are mounted on it.

The material used for ordinary shafts is mild. When high strength is required, an alloy or steel such as nickel, nickel chromium or chrome-vanadium steel is used.

The two types of shafts are,

1. Transmission shafts.
2. Machine shafts.

Transmission shafts transmit power between the source and the machine absorbing power. The counter shafts, line shafts, over head shafts and all factory shafts are transmission shafts. Since these shafts carry machine parts such as pulleys, gears etc., therefore they are subjected to bending in addition to twisting.

Machine shafts form an integral part of the machine itself. The crank shaft is an example of machine shaft.

The following stresses are induced in the shafts.

- Shear stresses due to transmission of torque. (i.e. due to torsional load).
- Bending stresses (tensile or compressive)

Due to the forces acting upon machine elements like gears, pulleys etc., as well as due to the weight of the shaft itself.

Stresses due to combined torsional and bending loads.

Gears.

Gearing is the means of transmitting power through toothed wheels.

Toothed gears find wide applications in various branches of mechanical engineering.

Toothed gears can be classified according to,

- Relative position of shafts such as shafts whose axes are parallel (Spur, helical and herring bone), intersecting (straight level and spiral bevel) and non-intersecting (hypoid and worm).
- Number of steps, single, two and multistage.
- The relative motion of shafts, simple, planetary, differential etc.,
- Type of engagement, internal and external and
- Position of both in wheel rim such as spur, helical, herringbone and curved teeth.

The cast iron is widely used for the manufacture of gears due to its good wearing properties, excellent machinability and ease of producing complicated shapes by casting method.

The following are the requirements of gear drive design.

- The gear teeth should have sufficient strength to withstand static loading such as that at high starting torques and dynamic loading during normal running conditions.

- The teeth should have good wear characteristics so that their life will be satisfactory.
- Spur gears have teeth parallel to the axis of the wheel.
- Helical gears have teeth inclined to the axis of the wheel.

Bevel gears are those which connects two non-parallel or intersecting, but co-planner shafts.

Bearings

A bearing is a machine element which support another moving machine element (known as journal). It permits a relative motion between the contact surfaces of the members, while carrying the load.

Bearing are classified as,

Based upon the direction of load to be supported,

1. Radial Bearings.
2. Thrust Bearings.

In radial bearings, the load acts perpendicular to the direction of motion of the moving element.

In thrust bearings, the load acts along the axis of rotation.

Based upon the nature of contact.

1. Sliding contact bearings.
2. Rolling contact bearings.

An sliding contact bearings, the sliding takes place along the surfaces of contact between the moving element and fixed element.

In rolling contact bearings, the steel balls or rollers are interposed between the moving and fixed elements.

V-Belts And Pulley.

V-Belt is mostly used in factories and workshops where a great amount of power is to be transmitted from one pulley to another when the two pulley are very near to each other.

The V-Belts are made of fabric and cords moulded in rubber and covered with fabric and rubber.

The included angle for the V-Belt is usually $30° – 40°$.

In order to increase the power output, several V-Belts may be operated side by side.

It may be noted that in multiple V-Belt drive, all the belts should stretch at the same rate so that the load is equally divided between them. When one of the set of belts break, the entire set should be replaced at the same time. If only one belt is replaced, the new unworn and unstretched belt will be more tightly stretched and will move with different velocity.

The pulleys for V-belts may be made of cast iron or pressed steel in order to reduce weight.

Some of the advantages of V-belt drive are,

- It gives compactness due to the small distance between centers of pulleys.
- The drive is smooth and positive.
- Longer life of 3 to 5 years.
- Easily installed and removed.
- Operation of the belt and pulley is quiet.
- High velocity ratio (maximum 10) may be obtained.

Machine Tools

A machine tool is a power driven machine for making articles of a given shape, size and accuracy (According to the blue prints) by removing metal from workpieces in the form of chips.

The cutting tool is subjected to static and dynamic forces, high temperatures, wear and abrasion.

The selection of a proper tool material depends upon a number of factors such as,

- Type of cutting operation.
- Material of the work piece.
- Machine tool to be used and
- Surface finish required.

The various cutting tool materials can be grouped as,

1. Plain carbon steels.
2. Medium alloy steels.
3. High speed steel (H.S.S)
4. Non-ferrous cast alloys
5. Diamond, etc.,

7.1 Selection Of Motor.

From P.S.G. Design data book,

The power required for boring is given by,

$$= 1.80 \times 10^{-3} \times KVZ\,(D-d)\,(0.15 + 7.875)$$

Where, K = Material factor

V = Cutting speed (M/min)

D = Larger diameter of hole (mm)

d = Smaller diameter of hole (mm)

s = Feed (mm/rev)

Z = Number of cutting edges in contact.

Here, K = 0.55

V = 12 m/min

D = 60 mm

d = 20 mm

s = 0.075 mm/rev

Z = 1.

∴ Power required

$$= 1.80 \times 10^{-3} \times 0.55 \times 12 \times 1 \times (60 - 20) \times (0.15 + 7.87(0.075))$$

= 0.35 KW

= 0.45 HP

= 0.5 HP (Approx.)

Specification:

Motor : 3.0 HP

RPM : 1440

Here we select 3 HP for safe design since it has to drive two spindle units.

7.2. Table Frame Selection.

The frame should be a rigid structure to carry all loads, shocks and vibrations. The various components are mounted on the top of the frame. So we considered the load which is acting at the centre. The frame is considered as a beam. The length of the beam is 510 mm (assumed)

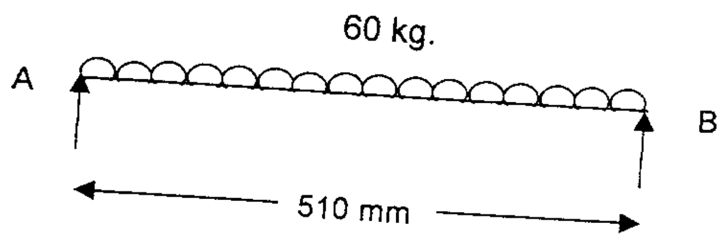
Total weight of Slide / angle plate; Machine base and other components= 60 Kg (approx)

The maximum bending stress in tension (σ_t) or in compression (σ_c) is usually in the extreme of the beam and should not exceed the maximum permissible stress in compression or tension.

The maximum permissible bending stress in tension (σ_t) or in compression (σ_c) is 0.6 σ_u.

For mild steel, σ_u = 34 kgf / mm^2.

Let the load acting on the beam will be UDL and the load at the centre.



UDL = Load / Length

= 60 / 510 = 0.1176 Kgf/mm

As the total weight is 60Kg, the reaction at B and A are equal.

$\therefore$ $R_A = R_B$ = 30 Kg.

We know that, $Z = \frac{Mt}{\sigma}$

Where, Z = Section Modulus

Mt = Maximum bending movements.

σ = Permissible stress

= 0.6 σ_u

= 0.6 x 34 = 20.4 Kgf/mm^2

From design data book

Mt = Bending moment due to UDL + Load at the centre

$$= \frac{WL^2}{8} + \frac{PL}{4}$$

$$= \frac{0.1176 \times 510^2}{8} + \frac{30 \times 510}{4}$$

= 7650 Kgf –mm

∴ Section modulus, Z = 7650 / 20.4

= 375 mm^3

Using the steel table,

The channel size is,

Depth of section, h = 75 mm

Width of flange, b = 40 mm

Thickness of flange, t_f = 6 mm

Thickness of Web t_w = 3.7 mm

Designation = ISLC 75.

7.3 Design Of Machine Base.

The base plate for the slide and tool assembly is designed by considering the bending stresses.

The base should be rigid is structure to carry the loads, shocks and vibrations.

Assume the load acts on the centre of the plate.

The plate is considered as a beam.

Length of plate = 600 mm (Assume)

Breadth of plate = 550 mm (Assume)

Load acting on the machine base = 40 Kgs (approx)

We know that,

$$\frac{M}{I} = \frac{f}{Y}$$

Where, M = Bending moment at centre.

f = Maximum bending stress.

I = Moment of Inertia at cross section of beam.

Y = Distance between centre of gravity and extreme fibre section.

The centre load will be half of the total load acting on the plate.

Therefore, centre load, w = 20 Kg.

The cross section of the beam is rectangular, let 't' be the thickness of the beam.

Maximum bending moment, $M = \frac{WL}{4}$

$= \frac{(20 \times 0.6)}{4}$

= 3 Kgm

Moment of Inertia, $I = \frac{bt^3}{12}$

$= \frac{0.55 \times t^3}{12}$

$= 0.0458\ t^3$.

The material used is mild steel.

For mild steel ultimate tensile stress.

f = 3400 Kgf/cm^2

= 34 x 10^6 Kgf/m^2.

Centre distance, $Y = \frac{t}{2}$

= 0.5 .

Substituting the above values in the formula

$$\frac{3}{0.0458t^3} = \frac{34 \times 10^6}{0.5t}$$

i.e. t = 0.00158 m

= 1.6 mm

Considering the factor of safety of 5,

t = 5 x 1.6

= 8 mm

The load is not acting exactly at the centre. It is same what acting at an eccentricity.

Let the eccentricity factor be 1.5.

∴ Thickness, t = 1.5 x 8 = 12 mm

Specification:

Machine Base.

Material	: Mild Steel
Length	: 600 mm
Breadth	: 550 mm
Thickness	: 12 mm

7.4 Design Of Gear.

Available Data:

Centre distance, a = 69.85 mm

Speed, N2 = 650 rpm

Required Gear Ration, i = 1

P.C.D of gear = 69.85 mm

Type of gear = Spur gear

Pr. Angle, α = 20° (assumed)

Profile = Involute (Assumed)

Power to be transmitted = 3 HP

Calculation:

From P.S.G. Data Book,

Selection of Material = EN 8 ie. C 45 steel.

We know,

Pitch circle dia = Module x No. of teeth

Module, M $= 1.26 \times \sqrt[3]{\frac{(Mt)}{Y(\sigma_b)\psi m Z_1}}$

Twisting moment, (Mt) = Mt . K_d . K

$= 71620 \times \frac{hp}{n} \times Kd.K$

$= 71620 \times \frac{3}{650} \times 1.3$

Where, $K_d . K$ = 1.3 (assume)

$[M_t]$ = 429.72 Kgf. Cm

Y = 0.389 (For, Z_1 = 20 assumed)

$\psi_m = \frac{b}{m}$ = 10 (assume)

Z_1 = 20.

$$[\sigma_m] = \frac{1.4}{n}\frac{kbl}{k\sigma}\sigma_{-1}$$

Where n = 2

kbl = 1

$K\sigma$ = 1.5

σ_{-1} = 0.22 ($\sigma_u + \sigma_y$) + 500

= 0.22 (72 + 36) x 10^2 + 500

= 2876 Kgf/cm^2.

$\therefore [\sigma_b] = \frac{1.4}{2}\times\frac{1}{1.5}\times 2876$ = 1342.13 Kgf/cm^2.

$\therefore$ Module, M $= 1.26\times\sqrt[3]{\frac{429.72}{0.389\times 1342.13\times 10\times 20}}$

= 0.26 cm

= 2.6 mm

Module, M = 3 mm

$\therefore$ No. of teeth = Pitch circle Dia / Module

= 69.85 / 3

= 23.28

= 24 Teeth.

No. of teeth, Z_1 = 24.

We know, $i = \frac{Z_2}{Z_1}$

$\therefore Z_2 = Z_1$ = 1 x 24 = 24.

$\therefore$ No. of teeth, Pinion, Z_1 = 24.

Wheel, Z_2 = 24.

Calculation of teeth width (b)

i). For open type gear Transmission, ψ = 0.3,

$$\therefore \Psi = \frac{b}{a} \Rightarrow \therefore b = \Psi a = 0.3 \times 9.85 = 21.155mm$$

ii). For sliding gear type of gear transmission,

$$b = \Psi_m \times M$$

= 10 x 3 = 30 mm

$\therefore$ Required gear width, b = 30 mm.

Tip diameter, da = $da_1 = (Z_1 + 2Fo)m$

= (24 + 2 x 1)3

= 78 mm

$$da_2 = (Z_2 + 2Fo)m$$

$$= (24 + 2 \times 1)3$$

$$= 78 \text{ mm}$$

Root diameter,

$$df_1 = (Z_1 - 2Fo)m - 2c$$

$$= (24 - 2)3 - 2(0.25 \times 3)$$

$$= 22 \times 3 - 2(0.75)$$

$$= 64.5 \text{ mm}$$

$$df_2 = (Z_2 - 2Fo)m - 2c$$

$$= 64.5 \text{ mm}$$

Check for compressive strength,

$$\sigma_c = 0.74 \frac{i \pm 1}{a} \sqrt{\frac{i \pm 1}{ib} E[Mt]} \leq [\sigma_c]$$

$$= 0.74 \times \frac{i \pm 1}{6.985} \sqrt{\frac{i \pm 1}{1 \times 3} \times 2.15 \times 10^6 \times 429.72}$$

$$= 5258.49 \text{ Kgf/cm}^2.$$

$$[\sigma_c] = C_B \, H_B \, Kcl \text{ Kgf/cm}^2.$$

$$= 25 \times 350 \times 1$$

$$= 8750 \text{ Kgf/cm}^2$$

Here, $\sigma_c \leq [\sigma_c]$

$\therefore$ safe Design.

Check for bending stress $[\sigma_b]$

$$\sigma_b = \frac{i \pm 1}{amby}[Mt] \le [\sigma_b]$$

$$= \frac{1+1}{6.985 \times 3 \times 3 \times 0.389} \times 429.72$$

$= 351.44$ Kgf / cm^2

$[\sigma_b] = 1342.13$ Kgf / cm^2.

Here, $\sigma_b \le [\sigma_b]$

$\therefore$ safe Design.

Specification.

Type	: spur Gear
Material	: C 45 (EN 8)
Heat treatment	: Tempered or normalised
Profile	: involute
Pressure Angle	: $20°(\alpha)$
No. of teeth, Z_1, Z_2	: 24
No. of gears	: 3
PCD	: 69.85 mm

Allowance of centre distance, a for 1st quality,

$= K \pm 7\ \mu m$

Total composite error = 18 microns.

7.5 Design of 'V' Belt And Pulley

Available Data:

Motor speed, N_1	: 1440 rpm
Spindle speed, N_2	: 650 rpm
Centre distance, c	: 450 mm (assume)
Pitch dia of drive pulley, d	: 80 mm (assume)

Calculation:

Speed ratio $= \frac{N_1}{N_2} = \frac{D}{d}$

$$\frac{1440}{650} = \frac{D}{80}$$

$\therefore$ D $= 177.23$ mm

$\therefore$ Pitch dia of driven pulley, D = 177.23 mm.

Peripheral belt velocity $= \frac{\pi D N_2}{60 \times 1000}$

$$= \frac{\pi \times 177.23 \times 650}{60 \times 1000}$$

= 6.03 m/sec.

Angle of arc of contact $= 180^\circ - \left(\frac{D-d}{c} \times 60^\circ\right)$

$$= 180^\circ - \left(\frac{177.2-80}{450} \times 60\right)$$

= 167°2'

= 168°

Pitch length of the belt, L = $2c+\frac{\pi}{2}(D+d)+\frac{(D+d)^2}{4c}$

$$= 2\times 450+\frac{\pi}{2}(80+177.2)+\frac{(177.2+80)^2}{4\times 450}$$

= 1340.55 mm

= 1341 mm

Nominal pitch length for cross section, A = 1372 mm

Design HP_1 = Rated HP x service factor x factor for length x arc of contact factor

Where, for heavy duty and over 16 hrs and continuous operation,

Ka =1.4.

Arc of contact factor = 0.76

Factor for length = 0.94

∴ HP = 1.5 x 1.4 x 0.76 x 0.94

= 2.939 HP

∴ Design KW = 2.06

So cross section 'A' is selected.

HP per belt for cross section A, kw = $0.45s^{-0.09} - \frac{19.62}{de} - 0.765\times 10^{-4} s^2)s$

Where, de = equivalent pitch dia = d_p x F_b

F_b = 1.13 for speed range of 1.185 – 2.941

d_p = 80mm

$\therefore$ de = 80 x 1.13 = 90.4 mm

s = 6.03 m/sec (belt speed)

$$\therefore Kw = \left(0.45 \times 6.03^{-0.09} - \frac{19.62}{80} - 0.765 \times 10^{-4} \times 6.03^2\right) \times 6.03$$

= 0.826

$\therefore$ HP per belt = 1.1 HP

$\therefore$ No. of belts required = Design HP / HP per belt

= 2.939 / 1.1

= 2.67

= 3 belts. (say)

Specification:

V belt – cross section A.

Pitch dia of drive pulley, d = 80 mm

Pitch dia of driven pulley, D = 178 mm

Pitch length for cross section, A = 1372 mm

No. of belts = 3

Pulley material : cast iron

7.6 Design Of Shaft.

Available data:

Gear dia, D = 69.85 mm

Power, P = 3HP

Speed, N = 650 rpm

Allowable shear stress, r_s = 14 N/mm

Calculation:

Torque transmitted by the shaft, T $= \frac{P \times 60}{2\pi N}$

$= \frac{3 \times 36 \times 60}{2 \times \pi \times 650}$

= 32.45 N-m

Tangential force on the gear teeth, F_1 $= \frac{2T}{D}$

$= \frac{2 \times 32.45}{69.85 \times 10^{-3}}$

= 929.13 N-m

Bending moment at the centre of the gear, M = $Ft \times \frac{D}{2}$

$= 929.13 \times \frac{69.85 \times 10^{-3}}{2}$

= 32.45 N-m

Let, d = dia of the shaft

Equivalent twisting moment. Te = $\sqrt{M^2 + T^2}$

$= \sqrt{(32.45)^2 + (32.45)^2}$

= 45.89 N-m

= 45.89 x 10^3 N-mm

We know that

Equivalent twisting moment (Te) is equal to

Te $= \frac{\pi}{16} \times f_s \times d^3$

= 14 N/mm^2 for C 45

$\therefore$ 45.89 x 10^3 $= \frac{\pi}{16}$ x 14 x d^3

$\therefore$ d = 25.56 mm

Standard dia of shaft, d = 30 mm

For d = 30 mm, l = 230 mm

Specification:

Solid shaft material	: CI – C 45
Shaft dia	: 30 mm
Shaft length	: 230 mm
Tolerance	: -13 46 $^{-00}_{-13}$ microns.

7.7 Design Of Bearing.

Available data:

Speed of the shaft, N = 650 rpm

Dia of shaft, d = 30 mm

Axial load (Fa) = 275 Kgf (assume)

Radial load (Fr) = 50 Kgf (assume)

Working hrs/ day = 16 hrs

Working days / year = 300 days

Year of service = 5 yrs

Service factor for bearing

carrying geared shaft, s = 1.5

Dynamic capacity factor, k= 3.

Calculation:

For deep groove ball bearing, $\frac{Fa}{Co} = 0.5$ (assume)

For SKF 6006, For dia = 30 mm

Basic static capacity Co = 710 Kgf

Basic Dynamic capacity C = 1040 Kgf

Maximum permissible speed = 13000 rpm

Life of the bearing in revolution = 5 x 300 x 16 x 60 x 650

= 9.36×10^8 rev.

Equivalent load, P = (X Fr + Y Fa)s

$$\frac{Fa}{Co} = \frac{275}{710} = 0.3 < 0.5$$

$$\frac{Fa}{Fr} = \frac{275}{50.035} = 5.49 > 0.44 = e$$

For e = 0.44, x = 0.56, r=1

$$\therefore P = (0.56 \times 50 + 1 \times 275)\ 1.5$$

$$= 454.5 \text{ Kgf}$$

For bearings, the equivalent load, P = 75.75 Kgf

Dynamic capacity, C $= \left(\frac{L}{L_{10}}\right)^{\frac{1}{K}} \times P$

$$= \left(\frac{9.96 \times 10^8}{1 \times 10^6}\right)^{\frac{1}{3}} \times 75.75$$

$$= 724.77 \text{ Kgf}$$

C is less than allowable dynamic capacity.

∴ selected bearing is suited for our design.

Similarly, design can be done for thrust bearing.

Specification – Bearing No.- 532060

Specification:

Deep Groove ball bearing SKF 6006

No. of bearings – 6

Thrust bearing - 532060

No. of bearings - 2

7.8 Design Of Dove Tail Slide.

In this part, we are calculating the length and breadth of the dove fail slide. From principles of machine tools – Amitabha Bhattacharya,

$$P = \left(\frac{6 \times \eta \times V \times L^2 \times B}{h_0^2}\right) k$$

Where, P = Pressure in Kg / cm²

η = Viscosity in Kgcm/s

V = Velocity in m/s

L = Length in mm

B = Breadth in mm

h_o = film thickness m

k = factor of safety = 0.8

For low velocity slide,

The pr. Range is 25 – 30 Kg / cm².

For our machine we assume pr. Value of 8 Kg / cm^2. For fine boring machine's $8\times10^{-4} = \left(\frac{6\times0.01\times10^{-2}\times\frac{3}{60}\times L^2\times B}{0.01^2}\right)0.8$

Since this equation contains two constant, by iterative method we find, B = 119 mm. Therefore L = 167 mm.

For our convenience we keep it is 200 mm.

Specification:

Dove tail slide,

Length	: 200 mm
Breadth	: 120 mm

a) Manufacturing Items.

Sl. No	Description	Material	Qty / wt.	Material cost	Machining cost / fabrication	Total cost Rs. P.
1.	Table & Machine base	MS/CI	112 kg.	2240	100	2340.00
2.	Angle plate	CI	20 kg	360	150	510.00
3.	Slide	CI	6.5	117	650	767.00
4.	Gear box	M.S.	32 kg	576	3200	3776.00
5.	Spindle shaft	EN8	2	300	450	750.00
6.	Main shaft	EN8	1	150	180	330.00
7.	Gear	EN8	3	280	450	730.00
TOTAL						9203.00

b) Bought up Items:

Sl. No	Description	Material	Qty / wt.	Material cost	Machining cost/ fabrication	Total cost Rs. P.
8.	Bearing		6			1080.00
9.	Bearing		2			980.00
10.	Ring Nut		4			52.00
11.	Locking Washer		2			12.00
12.	V-belt		3			240.00
13.	Motor		1			2800.00
14.	Pulley		2			220.00
15.	Fastners		-			300.00
16.	Electrical Panel		-			1200.00
	TOTAL					6884.00
17.	Material Transportation cost					1500.00
18.	Assembly cost					1,758.00
19.	Painting cost					400.00
	TOTAL					3658.00

Total Manufacturing cost : Rs.19,745.00

Add: 5% Miscellaneous expenses: Rs. 987.25

Total : Rs.20,732.25

Total cost : Rs.21,000/- (approx)

1) Machining cost on existing process.

a) Machine hour rate = Rs.40/-

b) Labour wages for helper = Rs.50/-

c) Machining cost per shift = Machine hour rate x 8 + additional labour

= 40 x 8 + 50 = Rs.370/-

d) Quantity produced per shift = 20 pieces

e) Operation cost per parts = 370 / 20

= Rs.18.50

2) Machining cost using new SPM.

a) Machine hour rate = Rs.10/-

b) Maching cost / shift = Machine hour rate x 8

= 10 x 8 = 80/-

c) Quantity produced /shift = 68 parks (approx)

d) Operation cost / park = 80 / 68 = Rs.1.17

e) Machining cost / connecting rod = Rs.1.17

3) Annual cost saving.

a) Annual requirement (approx) = 12,000 parts

b) Cost saving per part = Machining cost in existing method – Machining cost in new spm.

= 18.50 – 1.17

= Rs.17.33

c) Annual cost saving = Cost saving per parts x annual Requirement

= 17.33 x 12,000

= Rs.2,07,960/-

10.1 Tangible Benefits when compared to existing method.

S.No.	Feature	Existing method	New special purpose machine
1.	Machine	Geared Lathe	SPM
2.	Cost of machine	Rs.86,000/- (approx)	Rs.21,000/- (approx)
3.	Machine hour rate	Rs.40/-	Rs.10/-
4.	Power	7.5 HP	3 HP
5.	Man power	Skilled operator	Semi skilled operator
6.	Cost of the floor space utilization	Rs.2,500 per annum	Rs.660 per annum
7.	Job clamping devices	Requires more time	Quick clamping is possible
8.	Bore size	More dependency on skill and awareness of the operator	Easy to achieve irrespective of the awareness and skill of the operator
9.	Fatigue caused	More	Less

10.2 Intangible Benefits.

- Increased customer satisfaction due to prompt delivery
- Labour fatigue is reduced very much
- Less floor space is sufficient when compared to the existing method.
- Easy to install, operate and maintain
- Easy availability and replacement of spares.
- Increase in number of orders due to quick delivery.

CONCLUSION

This special purpose machine designed is viable and easily operatable for making the fine boring operation on connecting rod by any skilled or unskilled operator.

The time needed for machining is lesser and higher productivity is reached with more accuracy and lesser rejections.

This machine can be fabricated with low cost an some of the possibilities of automating the machine may be by providing a pneumatic or hydraulic attachment instead of manual feed control movement of slide. This machine is specially designed for the connecting rods used in trucks. Similarly the design could be made feasible for connecting rods of other sizes and used up in a small scale industries with lesser investments.

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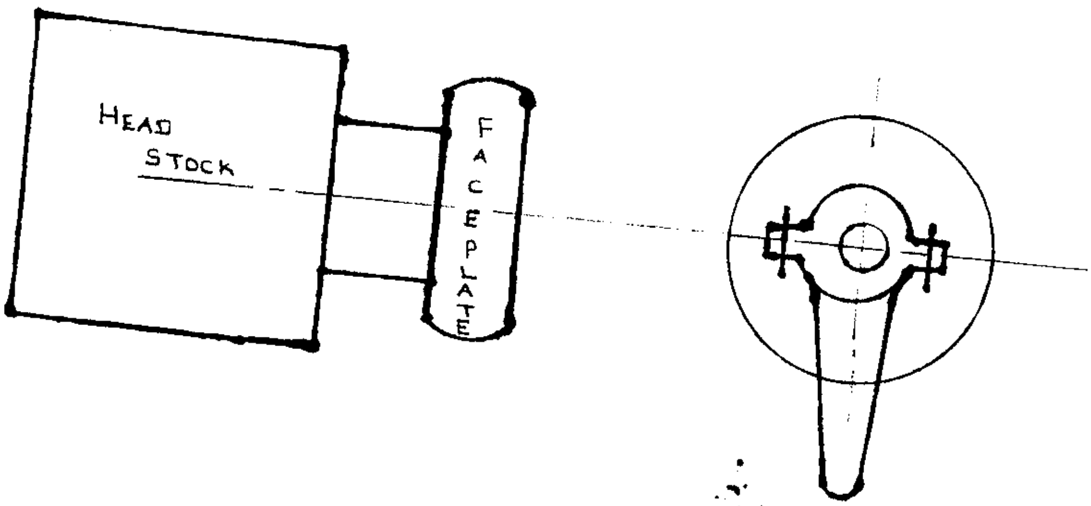
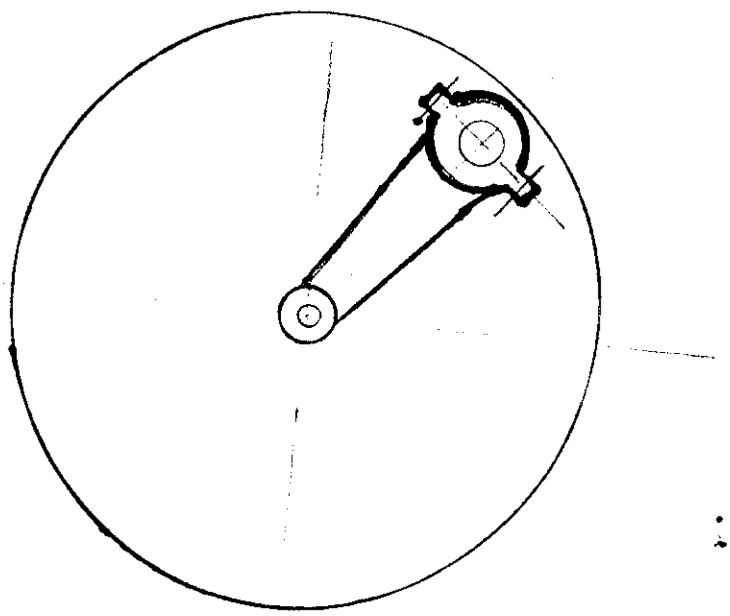
- Automobile Engineering - Manual Book
- Cost Estimation - Barka and Sharma
- Steel Table - R.Murugesan.

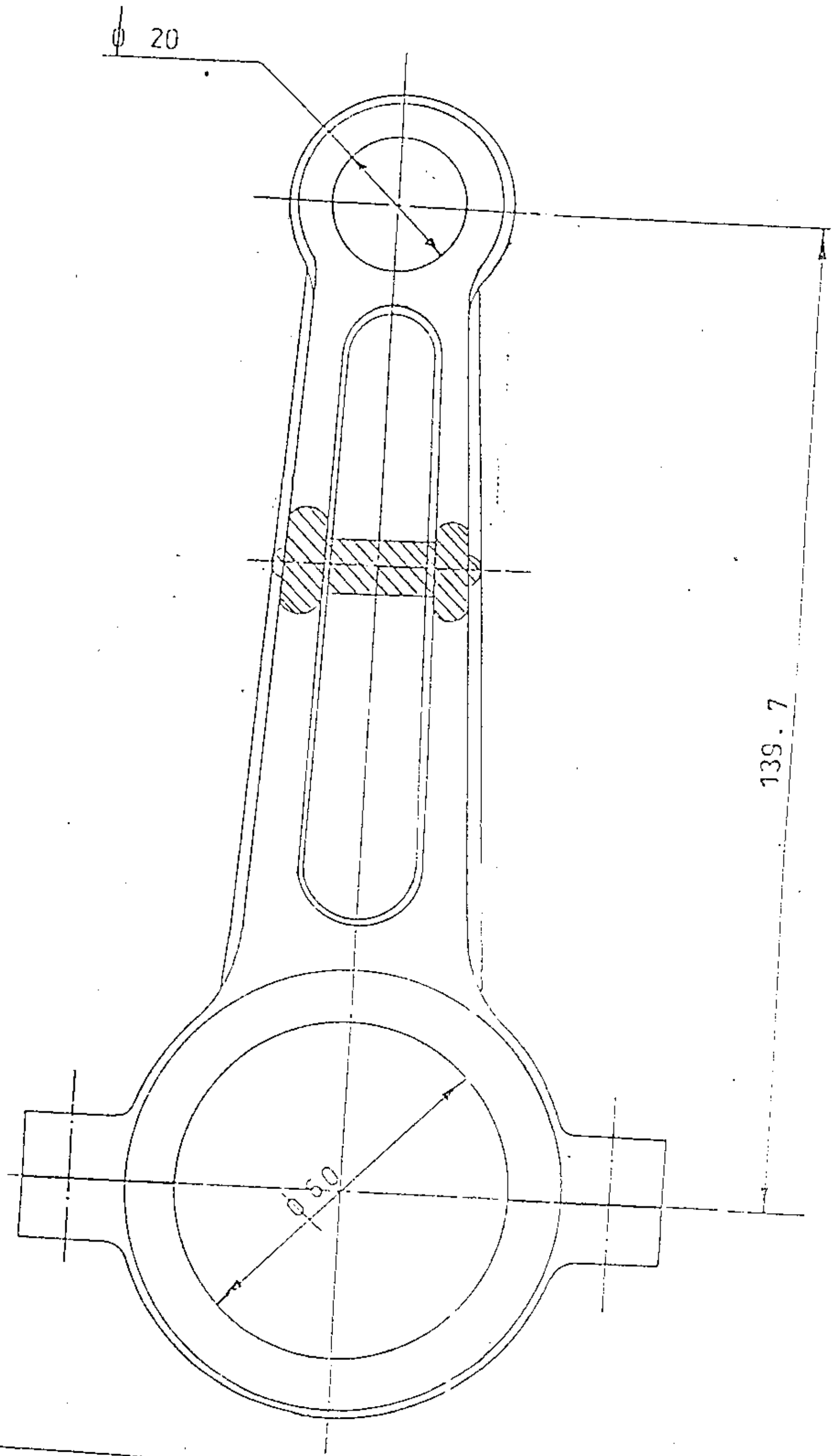
Existing Machining Method.

Operation - I. : Boring Bigger End Hole.



Operation - II. : Boring Smaller End Hole & Maintaining the Centre Distance.

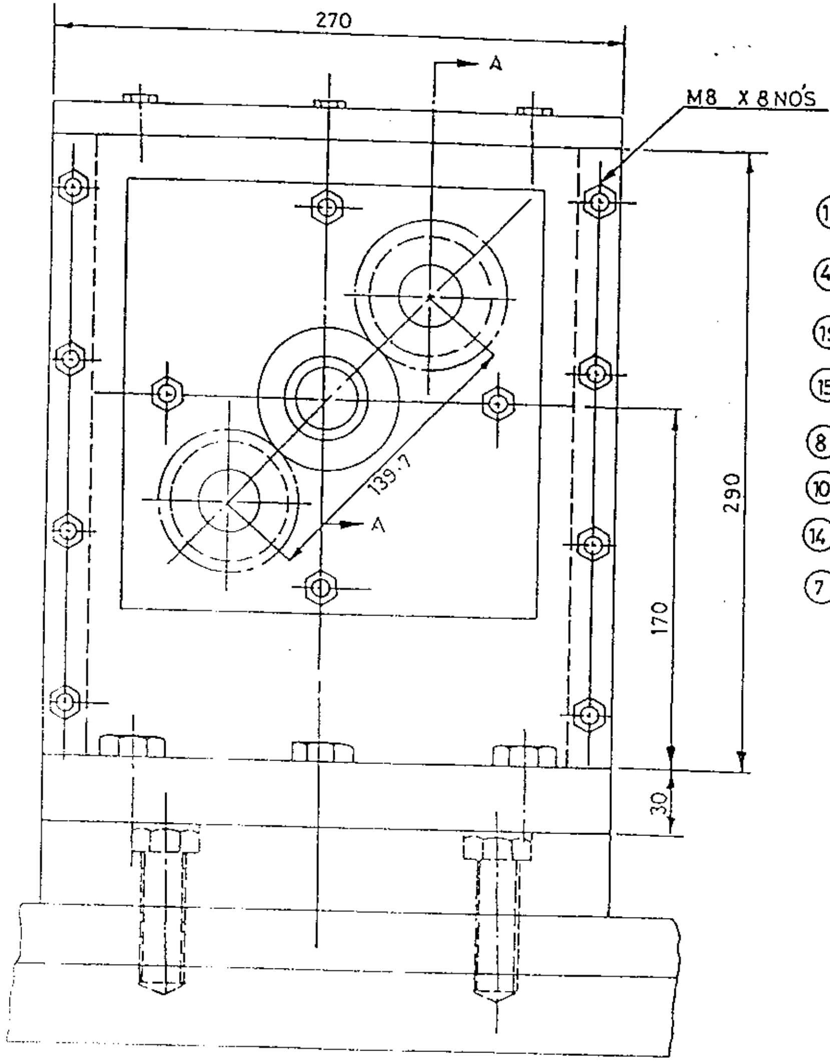


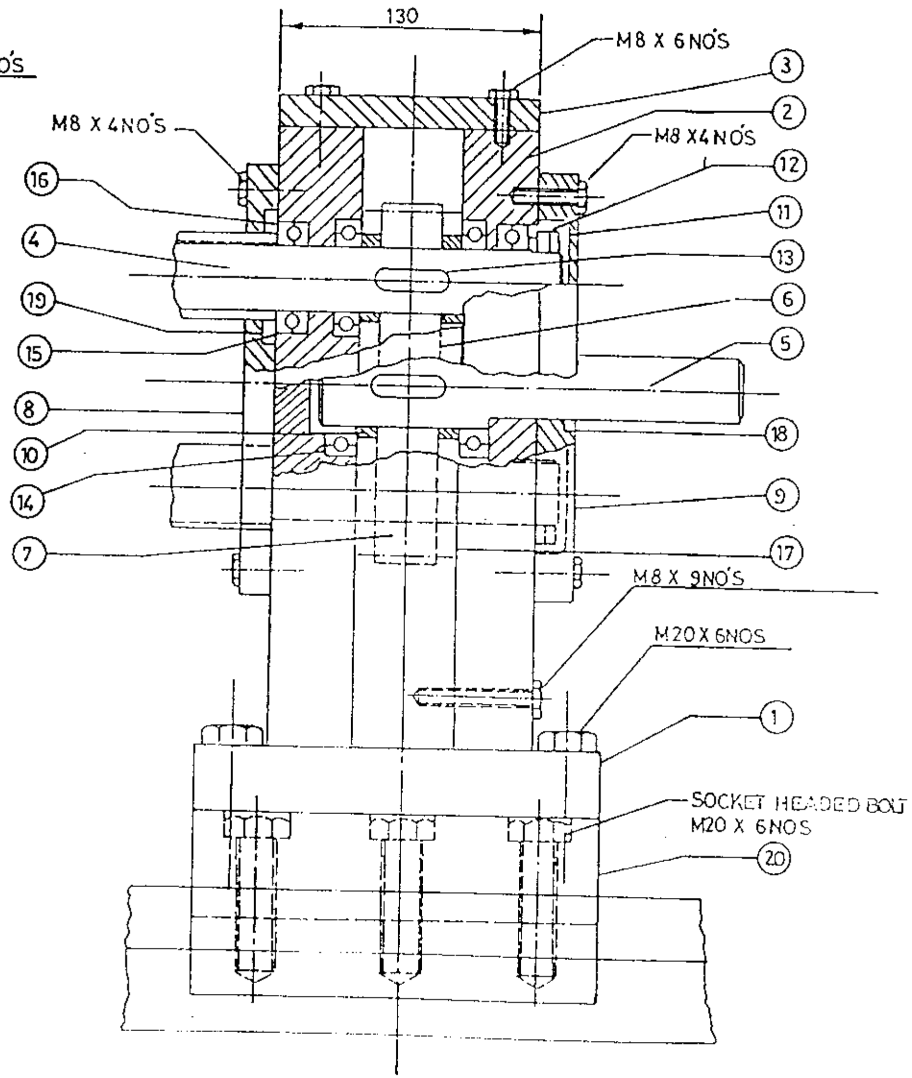


ALL DIMENSIONS ARE IN MM

MATL :- FORGED STEEL	DRN :-	CHD :-	APD :-
PROJECTION	SCALE NTS	QTY 1	PART NAME :- CONNECTING ROD
KUMARAGURU COLLEGE OF TECH COIMBATORE			DRG NO :- SPM 005/GR.2

SL.No	DESCRIPTION	QTY	MATL	REMARK
1	TABLE	1	M.S	
2	MOTOR	1	–	
3	GEAR BOX BODY	1	M.S	
4	TOP COVER	1	M.S	
5	DRIVE PULLEY	1	C.I	
6	DRIVEN PULLEY	1	C.I	
7	PARALLEL KEY	4	M.S	
8	MAIN SHAFT	1	EN8	
9	BEARING	3	STD	
10	BEARING	3	STD	
11	GEAR	3	EN8D	
12	SPACER	3	OHNS	
13	BEARING	3	STD	
14	SPINDLE SHAFT	2	EN8	
15	BACK COVER	1	M.S	
16	ANGLE PLATE	1	M.S	
17	HORIZONTAL SLIDE	1	C.I	
18	CLAMP	2	M.S	
19	BUTTONS	2	OHNS	
20	ELECTRICAL PANEL	1	–	

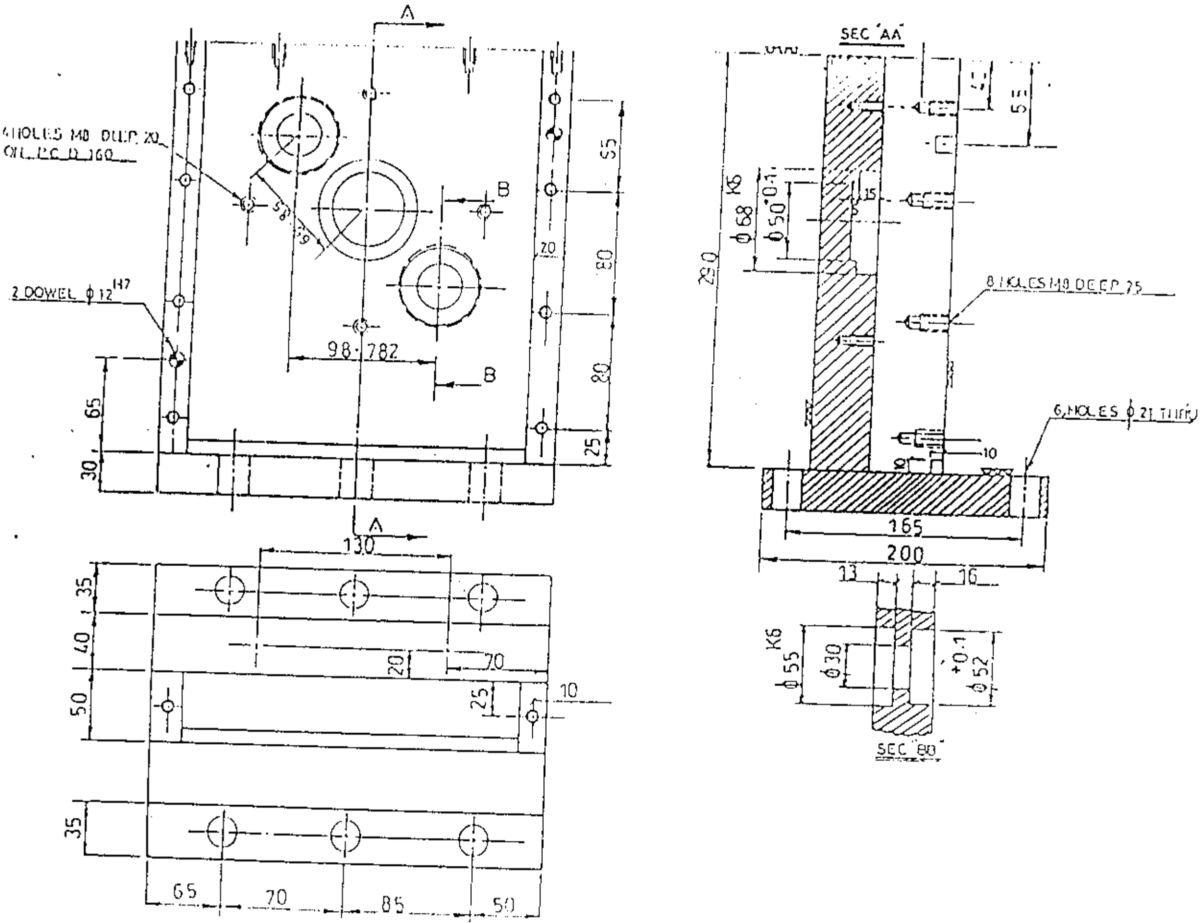




ALL DIMENSIONS ARE IN MM

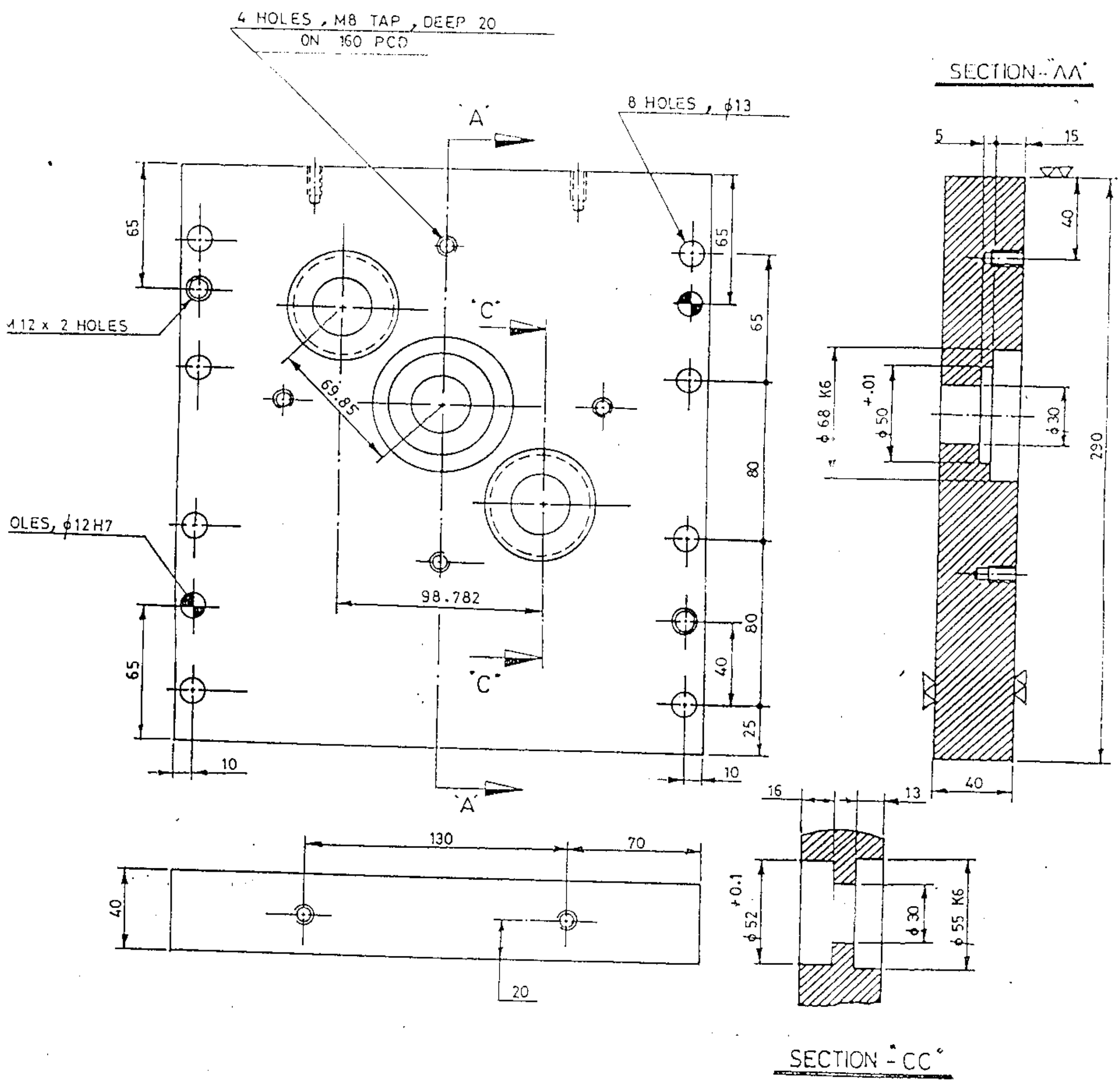
MAT'L :-	DRN :-	CHD :-	APD :-
PROJECTION	SCALE NTS	QTY	PART NAME :- GEAR BOX ASSY

Item No.	Description	Material	Quantity
1.	Gear Box Body	M.S.	1
2.	Gear Box Cover	M.S.	1
3.	Top cover	M.S.	1
4.	Spindle shaft	M.S.	2
5.	Main shaft	EN 8	1
6.	Drive shaft	EN 8	1
7.	Driven gear	EN 8	2
8.	Front cover plate	M.S.	1
9.	Back cover plate	M.S.	1
10.	Spacer	M.S.	6
11.	Ring nut	STD	4
12.	Locking washer	STD	2
13.	Key	STD	3
14.	Deep groove ball bearing	STD	2
15.	Thrust bearing	STD	2
16.	Deep groove ball bearing	STD	4
17.	Gasket	STD	1
18.	Oil seal (40x55x7)	STD	1
19.	Oil seal (30x42x7)	STD	2
20.	Machine base	CI	1



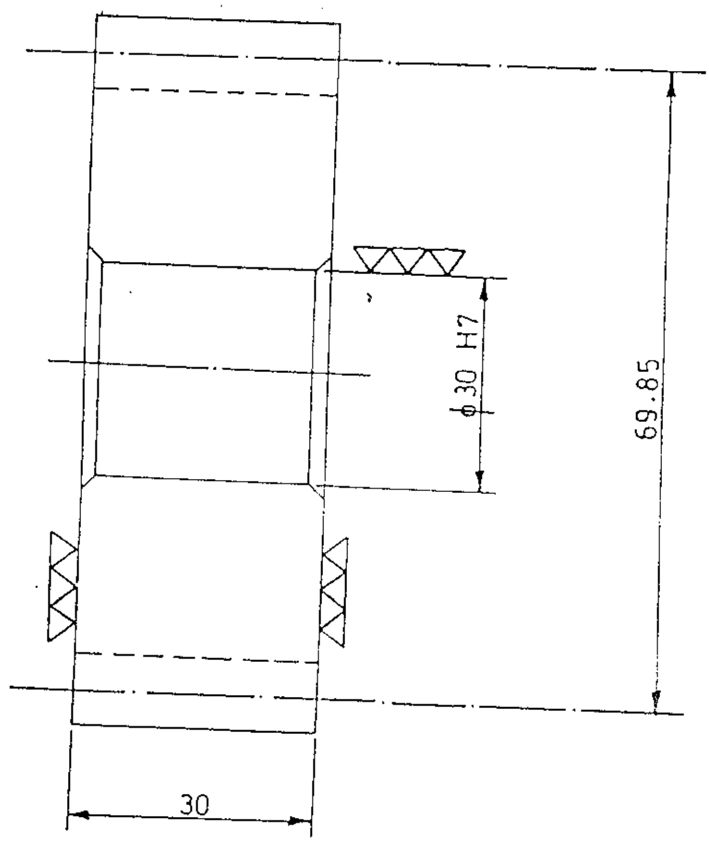
ALL DIMENSIONS ARE IN MM

MATL :- M . S	DRN :-	CHD :-	APD :-
PROJECTION	SCALE NTS	QTY 1	PART NAME :- GEAR BOX BODY
KUMARAGURU COLLEGE OF TECH COIMBATORE			DRG NO :- SPM 005/GR2/1



ALL DIMENSIONS ARE IN MM

TL :- M . S	DRN :-	CHD :-	APD :-
PROJECTION	SCALE NTS	QTY 1	PART NAME :- GEAR BOX COVER
UMARAGURU COLLEGE OF TECH COIMBATORE			DRG NO :- SPM 005/GR 2/2

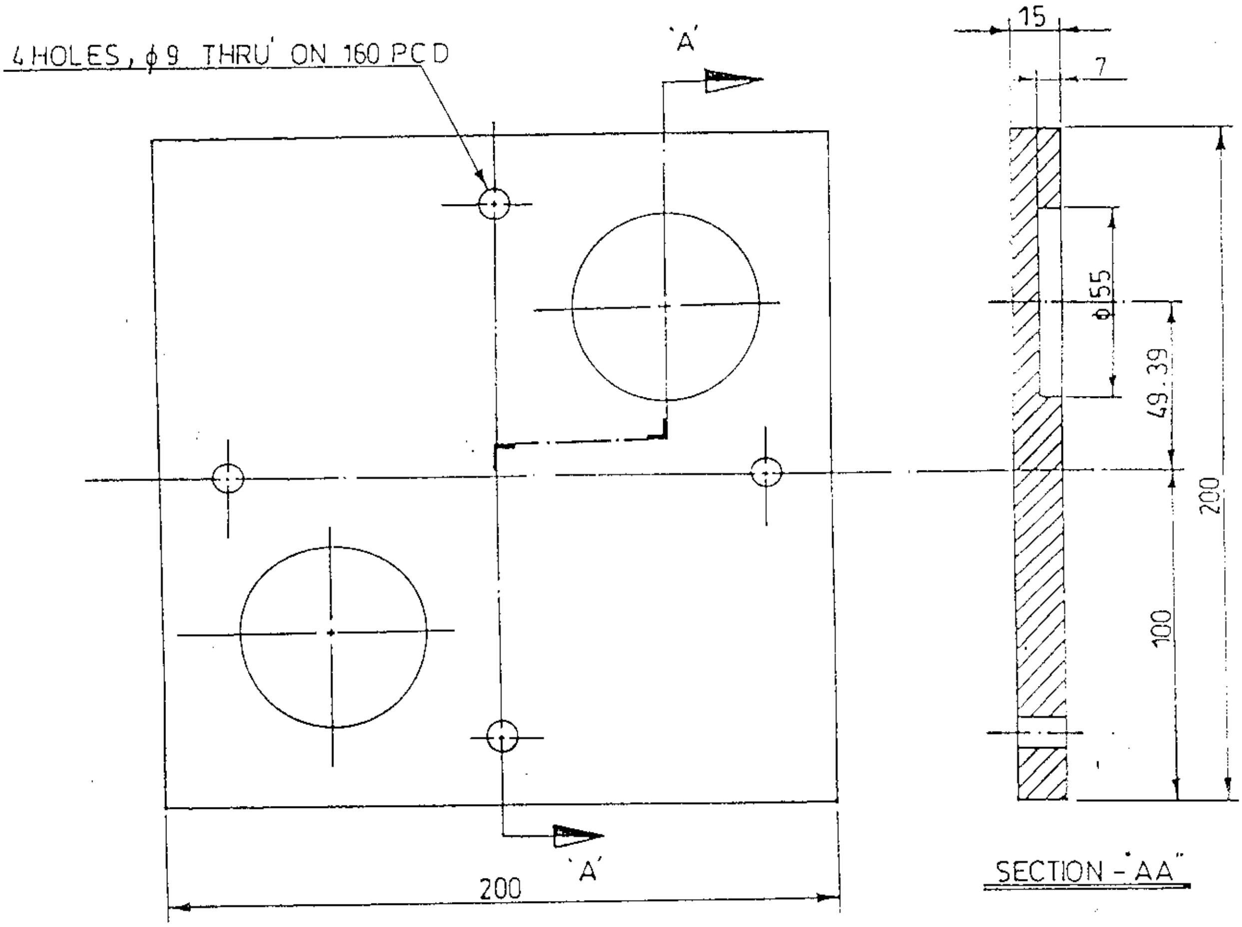


MODULE :- 3

NO OF TEETH :- 24

ALL DIMENSIONS ARE IN MM

MATL :- EN 8D	DRN :-	CHD :-	APD :-
PROJECTION	SCALE NTS	QTY 3	PART NAME :- GEAR
KUMARAGURU COLLEGE OF TECH COIMBATORE			DRG NO :- SPM 005/GR2/7

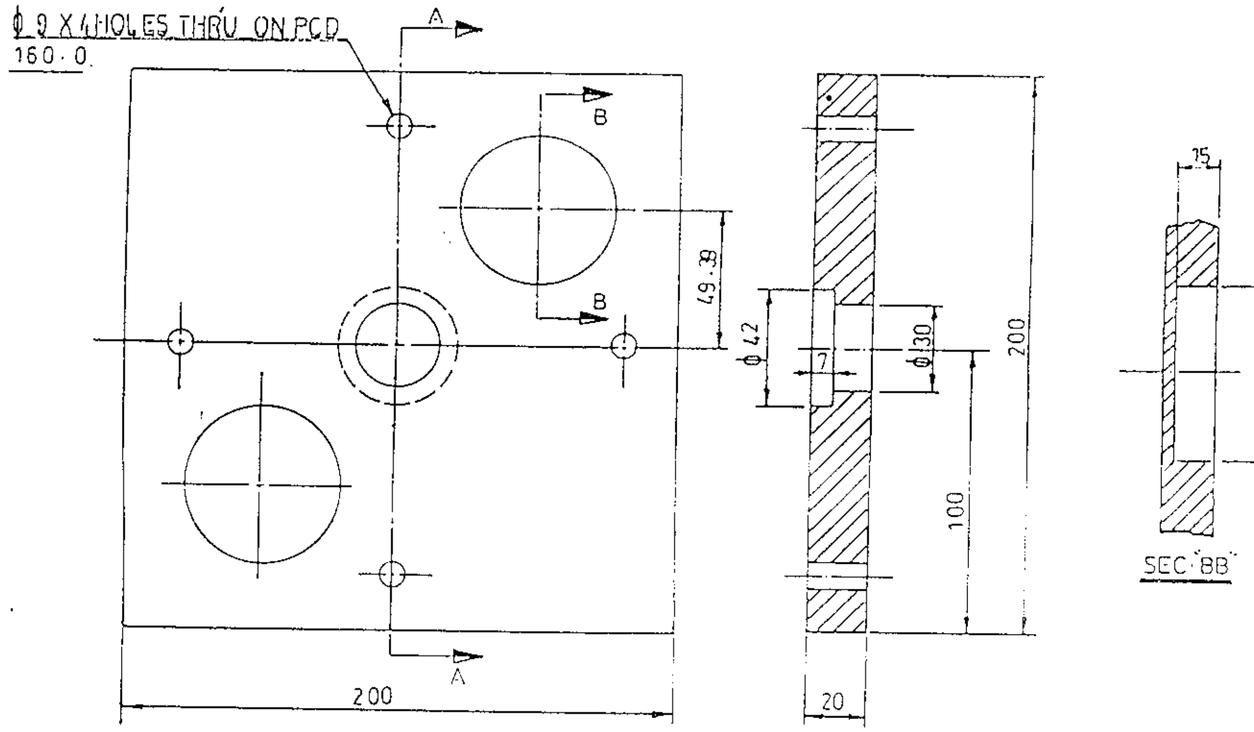


ALL DIMENSIONS ARE IN MM

MATL :-	DRN :-	CHD :-	APD :-
M . S			

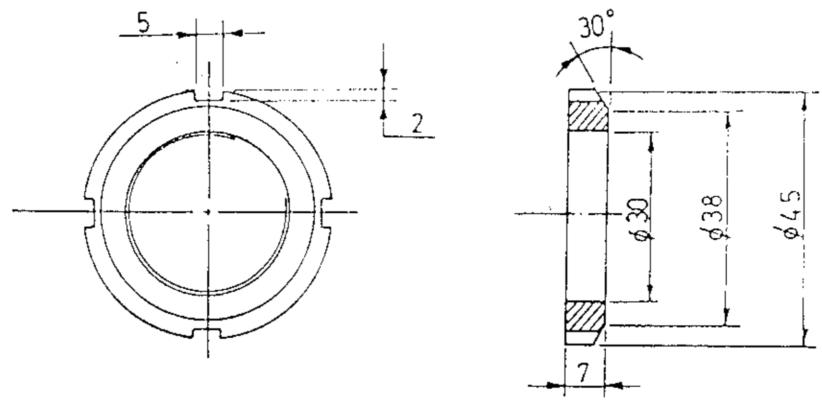
PROJECTION	SCALE	QTY	PART NAME :-
	NTS	1	FRONT COVER PLATE

KUMARAGURU COLLEGE OF TECH COIMBATORE	DRG NO :- SPM 005/GR 2/8



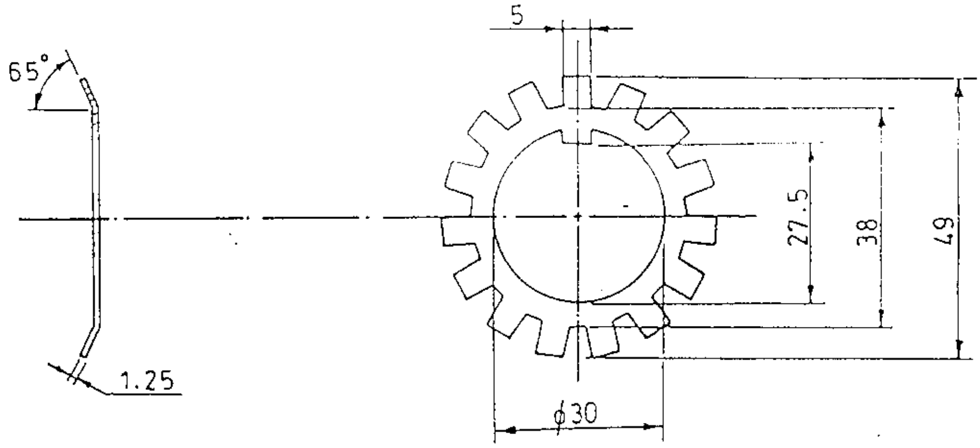
ALL DIMENSIONS ARE IN MM

TL :- M . S	DRN :-	CHD :-	APD :-
PROJECTION	SCALE NTS	QTY 1	PART NAME :- BACK COVER
UMARAGURU COLLEGE OF TECH COIMBATORE			DRG NO :- SPM 005 / GR 2 / 9

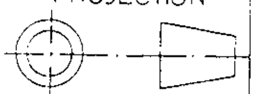


ALL DIMENSIONS ARE IN MM

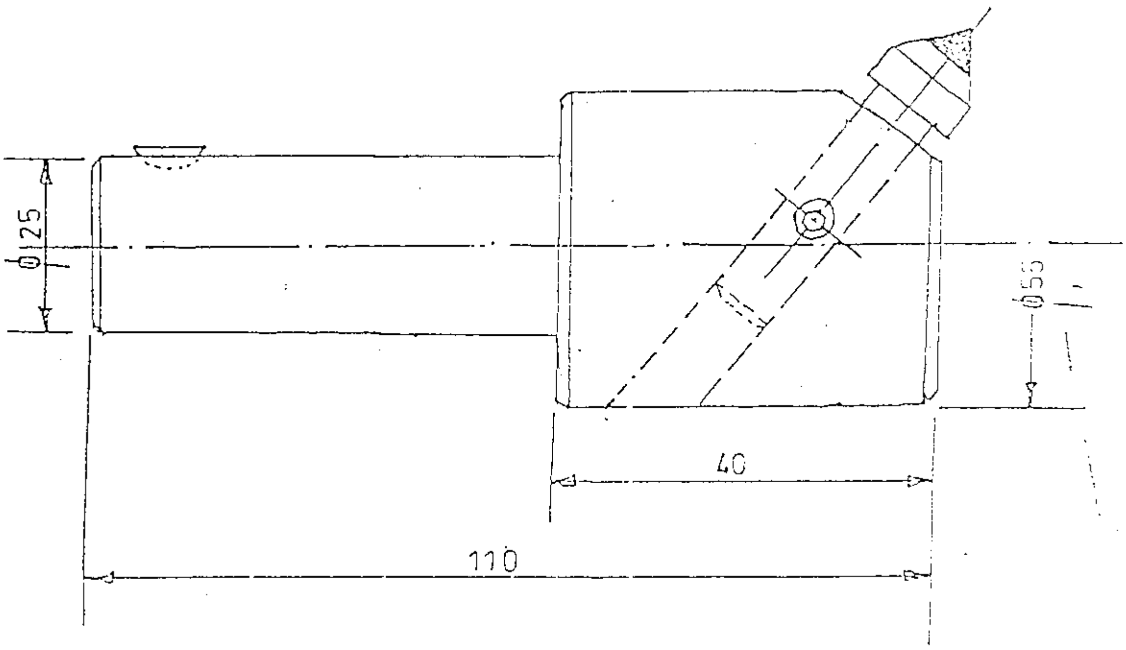
MATL :- M . S	DRN :-	CHD :-	APD :-
PROJECTION	SCALE NTS	QTY 2	PART NAME :- RING NUT
KUMARAGURU COLLEGE OF TECH COIMBATORE			DRG NO :- SPM 005 / GR2 / 11



ALL DIMENSIONS ARE IN MM

MATL :- M . S	DRN :-	CHD :-	APD :-
PROJECTION 	SCALE NTS	QTY 2	PART NAME :- LOCKING WASHER
KUMARAGURU COLLEGE OF TECH COIMBATORE			DRG NO :- SPM 005/GR 2/12

KUMARAGURU COLLEGE OF TECH
DRG NO :-
COIMBATORE
SPM 005/GR2



ALL DIMENSIONS ARE IN MM

MATL :- M . S	DRN :-	CHD :-	APD :-
PROJECTION	SCALE NTS	QTY 1	PART NAME :- TOOL HOLDER
KUMARAGURU COLLEGE OF TECH COIMBATORE			DRG NO :- SPM 005 GR2