A Dissertation Report on

"MODIFICATION AND DEVELOPMENT OF PRESS TOOL FOR COMBINING SHEET METAL OPERATIONS FOR REDUCTION IN HUMAN EFFORT AND COST"

By

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C E R T I F I C A T E

This is to certify that the following students have successfully completed the Dissertation entitled "**Modification and Development of press tool for combining sheet metal operations for reduction in human effort and cost**" under my supervision, in the partial fulfillment of Bachelor of Engineering – Mechanical Engineering, of Savitribai Phule Pune University, Pune.

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NOMENCLATURE

Symbol	Meaning
A	Shear Area
L	Length
S	Material Thickness
Tb	Shear Strength
σt	Tensile Strength
a	Length Of Legs
x’	Bend Angle
q	Correction Factor
R	Bend Radius
S	Material Thickness
E	Center Distance
D	Center Distance Between Two Operating Radius
FG260	Grey Cast Iron
D2	Steel
MS	Mild Steel
20MN	Alloy Steel
OHNS	Oil Hardening Non-Shrinking Die Steel

CONTENTS

ABSTRACT

Press tools are used to produce a component in large quantity, out of sheet metals where component achieved depends upon press tool construction and its configuration. The different types of press tool constructions lead to different operations namely blanking, bending, piercing, forming, drawing, cutting off, parting off, embossing, coining, notching, shaving, lancing, dinking, perforating, trimming, curling etc. The application of press operations is widely used in many industries like food processing, packing, defense, textile, automobile, aircraft and many apart from manufacturing industry.

Press tools are mainly used for increasing productivity of the system. This project mainly deals with the modification needed in the earlier press tool to reduce human effort and cost which in turn increases productivity. The already available large bed of press tool facilitates the use of a increased size combined press tool.

The earlier tool had few complications in its on-going processes and time required to make one product was more than the rate of demand of the product. The project has proposed a combination of different operations on the same press tool to meet with the demands and reduce cost.

1. INTRODUCTION

A press is a sheet metal working tool with a stationary bed and a powered ram can be driven towards the bed or away from the bed to apply force or required pressure for various metal forming operations. High rate production industries generally use press machines. Thickness can vary significantly, although extremely small thicknesses are considered as sheet and above 6mm are considered as plate. Thickness of the sheet metal fed in between is called its gauge. Sheet metal is simply fed in between the dies of press tool for any press operation to perform. The reciprocating movement of punch is caused due to the ram movement of press machine.

In the sheet metal forming process, a blank sheet experiences a wide range of strain rates during the forming process since the punch progresses with the velocity of several m/s to form the product. The tension/compression hardening behavior of steel sheets changes sensitively with the variation of the strain rate. The different types of press tool constructions lead to different cutting and non-cutting operations namely blanking, bending, piercing, forming, drawing, cutting off, parting off, embossing, coining, notching, shaving, lancing, dinking, perforating, trimming, curling etc. All these operations require more period if not done efficiently.

The project focuses on modification in the existing press tool to increase the productivity and reduce human effort and cost. The earlier Press tool consisted of eight operations to produce one part of Honda Activa 4G muffler. As the demand increases so should the productivity. The eight operations took more time and man power to just produce one muffler. To increase the productivity, project has proposed the combination of the processes on one tool. Eight operations can be reduced to five by combining the processes. [2]

1.1 Problem statement

To modify the design of existing press tool and develop a new combined one to reduce number of strikes and save cost and human labor.

The Muffler of active scooter mainly has two sections

- Inner body
- Outer Body

For production of one complete muffler (outer and inner body) following operations are required:

- Muffler outer Body:
  1. Blanking and Piercing
  2. First forming
  3. Final forming
  4. Restrike

- Muffler inner Body:
  1. Blanking and Piercing
  2. First forming
  3. Final forming
  4. Restrike

Total eight operations are required in total to complete one muffler. This leads to:

1. More manufacturing time
2. Less productivity
3. More human effort
4. High cost

The tool to be developed has capacity to perform both operations which are first and second forming in one strike.

1.2 Objectives

The operations on the press tool are combined to achieve following objectives:

- To increase the productivity
- To reduce human effort
- To reduce cost of production

1.3 Scope

This press tool combination is efficient to be implemented in the company to reduce human effort, cost of production and manufacturing time to increase the supply over demand.

2. LITERATURE REVIEW

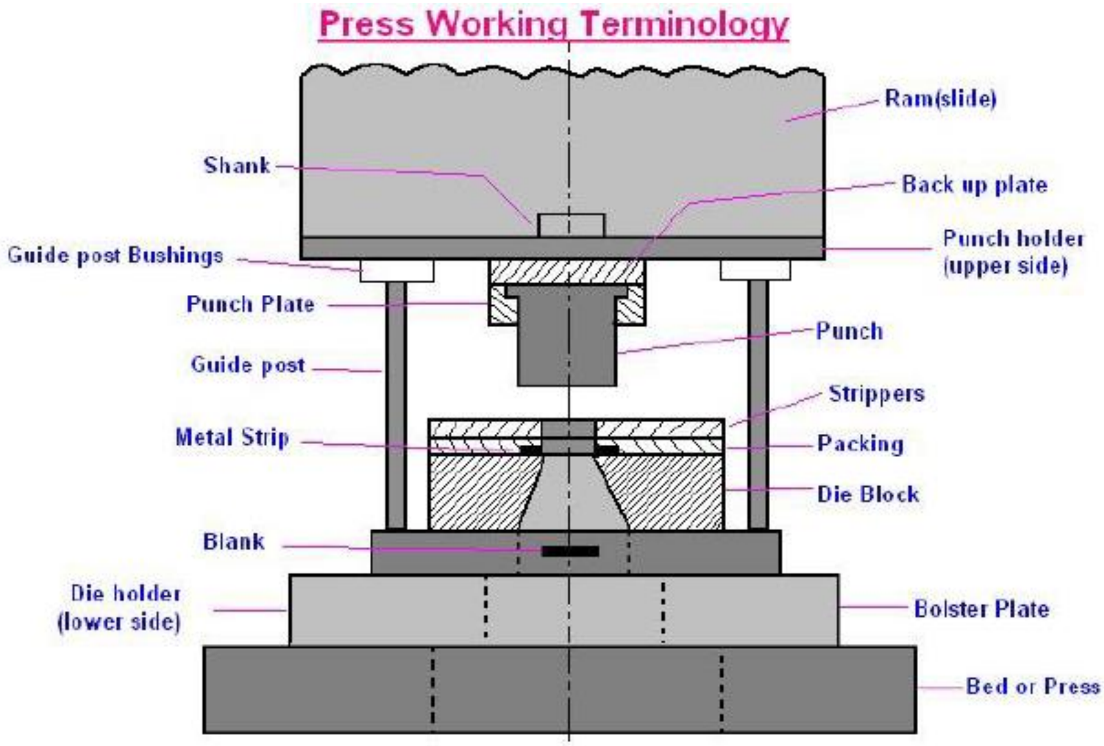


Fig .1 Press tool working terminology

2.1 Press:

A press is a sheet metal working tool with a stationary bed and a powered ram can be driven towards the bed or away from the bed to apply force or required pressure for various metal forming operations. The relative positions of bed and ram in the press are decided by the structure of its frame. The punch is generally gripped into the punch. holder and punch holder is attached to ram. A blaster steel plate is attached to the bed of the press and die is mounted on the blaster steel plate. [2]

2.2 Press Tool:

Commonly used tools which are major components of press working are punches and dies. Punch is an important part of the system which is fastened to the ram and forced into the die where workpiece to be processed is supported. Die is a work holding device, designed specifically for a particular design of a product. Die is rigidly held on the base of the press. Die carries an opening which is perfectly aligned with the punch and its movement. Both die and punch work together as a unit and this is called a die set. Punch and die both are made of high speed steel. Die is the part where strength and wear resistant both properties are required. So normally working surface of the die is made of satellite or cemented carbide. Details of the die set are described below. Punch Lower end of the ram holds punch holder which is equipped with the punch plate. Punch plate is generally made of stainless steel or HSS. The punch plate holds the punch rigidly and accurately. [2]

2.3 Different ways of holding the punch are described below:

a) Punch can be fastened by forcing it to punch plate, top end of the punch is flattened to fit in the countersunk recess as shown in figure
b) Punch can be clamped to the punch plate by a set screw. The correct position of the punch is located by cutting a slot into the punch plate as shown in figure
c) Shank of the punch is forced into the punch plate top end of the punch is made flat to fit into the countersunk recess as shown in Figure
d) Punch can be tightly secured to the punch plate with the help of grubs screws as shown in figure
e) Punch can be fastened by forcing it to punch plate, top end of the punch is flattened to fit in the countersunk recess as shown in figure
f) Punch can be tightly secured to the punch plate with the help of grubs' screws as shown in figure

g) Flange end of the punch is secured to the punch plate by set screws from the punch end as shown in figure.

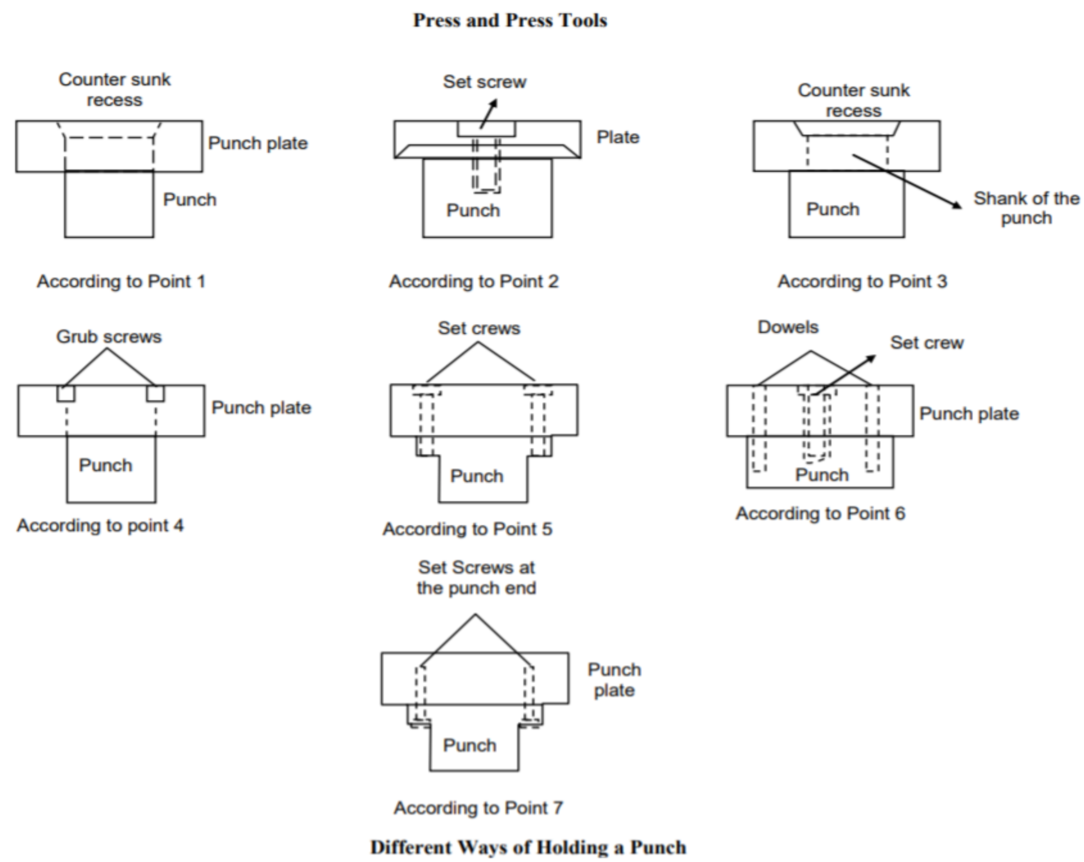


Fig .2 Different ways of holding a punch

2.4 Die:

The complete die set consists of a punch, die and some other accessories which are described in this section later. Perfect alignment of punch and die is most important for satisfactory working of punch. Accessories of die set provides the require alignment and rigidity to the system and improves accuracy of the system performance. These accessories are the finished parts, removal of waste.

a) **Punch Holder** It is also known by its other name upper shoe of die set. Punch holder is clamped to the ram of press. It holds the punch below it.

b) **Punch** It is the main tool of die assembly which directly comes in contact of workpiece during its processing, its detail have already been described.

c) **Die Holder** It is also called die shoe. Its work as a support for the die block and it is rigidly fastened to the balster plate of the press.

d) **Stops** are used for maintaining correct spacing of the sheet metal when it is fed below the punch to maintain the quality of output. These restrict the feed of stock (workpiece) to a pre-determined length each time without doing any precise measurements. Normally two types of stops are used

e) **Pilot** it is used for correct location of blank when it is fed by mechanical means. The pilot enters into the previously pierced hole and moves the blank to the correct position to be finally spaced by the stops. Normally pilots are fitted to the punch holders.

f) **Stripper** is used to discard the workpiece out side the press after the completion of cutting or forming operation. After the cutting when punch follows upward stroke the blank is stripped off from the punch cutting edge and prevents it from being lifted along with the punch. This action of prevention is performed by the stripper.

g) **Pressure Pads:** Pressure pads are plates which grip the workpiece very tightly at the ends when it plastically flows between the punch and the die. This tight griping eliminates the chances of wrinkling in the process of metal forming. A spring-loaded plunger acting on the bottom of workpiece plate also serve the same function. The pressure pads do a type of ironing on the sheet metal workpiece.

h) **Guide Posts**: Accurate alignment between die opening and punch movement is very important. Guide posts are used for correct alignment of punch and die shoe.

i) **Punch Plate:** Punch plate is also known as punch retainer. This is fixed to the punch holder. Punch plate serves as a guide way to hold the punch in right position and properly aligned. This makes the replacement of punch quick and correct.

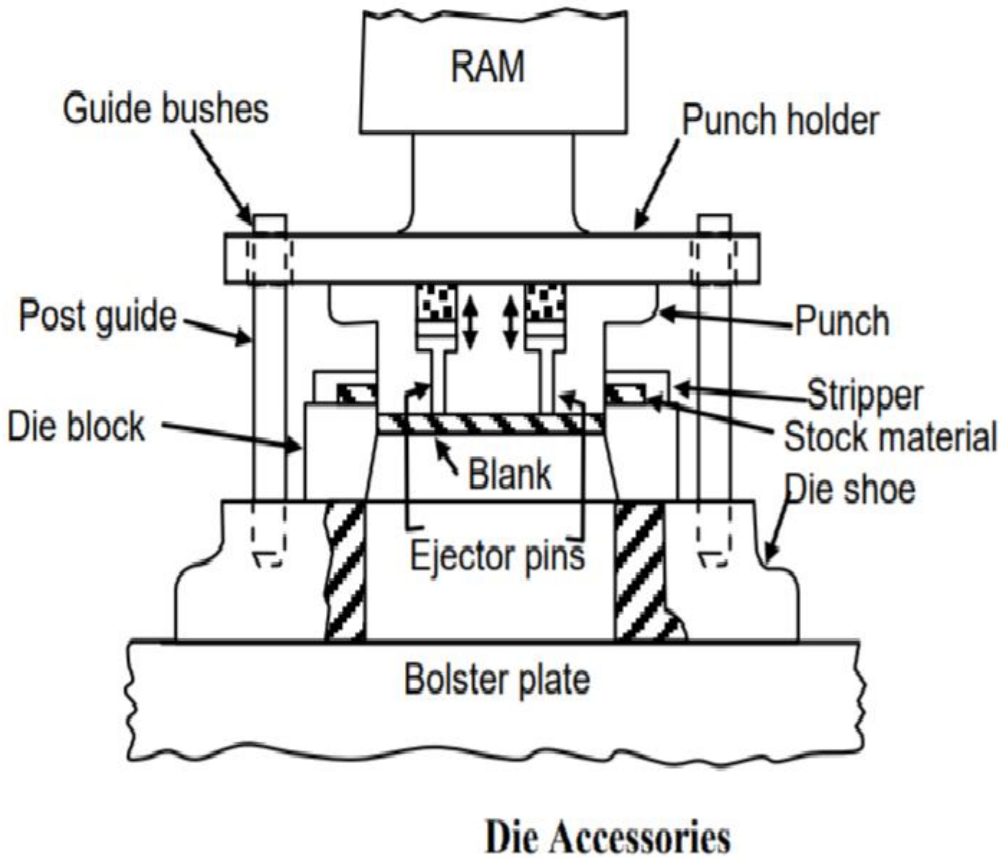


Fig .3 Die Accessories

3. METHODOLOGY

To understand the press tool or die mechanism we first need to know the basics.

Classification of Dies:

I. Single operation dies are designed to perform only a single operation in each stroke of ram.

II. Multi operation dies are designed to perform more than one operation in each stroke of ram.

Single operation dies are further classified as described below:

a) Cutting Dies These dies are meant to cut sheet metal into blanks. The operation performed so is named as blanking operation. These dies and concerned punches are given specific angles to their edges. These are used for operation based on cutting of metal by shearing action.

b) Forming Dies These dies are used to change two shape of workpiece material by deforming action. No cutting takes place in these dies. These dies are used to change the shape and size related configuration of metal blanks.

Multi-operation dies are can also be classified (further) as described below.

a) Compound Dies: In these dies two or more cutting actions (operations) can be executed in a single stroke of the ram.

b) Combination Dies: As indicated by their names these dies are meant to do combination of two or more operations simultaneously. This may be cutting action followed by forming operation. All the operations are done in a single action of ram.

c) Progressing Dies: These dies are able to do progressive actions (operations) on the workpiece like one operation followed by another operation and so on. An operation is performed at one point and then workpiece is shifted to another working point in each stroke of ram.

Classification based on specific operations that can be performed on them:

a) **Shearing Operations:** These belong to the category of cutting dies. These are used for operations involving shearing action on the workpiece material like blanking, punching, perforating, notch making, slitting, etc.

b) **Drawing Operations:** All dies designed for flanging, embossing, bulging and cupping operations fall in the category of drawing operation dies.

c) **Bending Operations:** Some of the dies designed for angle bending, curling, forming, folding, plunging, etc. operations fall in the category of dies based on bending operations.

d) **Squeezing Operations:** Another category of dies based on squeezing operations are capable to do operations like flattening, planishing, swaging, coining, sizing, extruding and pressing operations.

Classification based on construction:

a) **Cut-off Die** The die designed for cutting off operation is called cut-off die. It provides a vertical surface along which punch slides to cut-off the workpiece by shearing action.

b) **Drop through Die**: As indicated by their names, these dies are made hollow where blank fall after being cut-off.

c) **Return Type Die:** In these dies a knockout plate is incorporated, by which the cut blank returns to the position at which it was cut before it ejected.

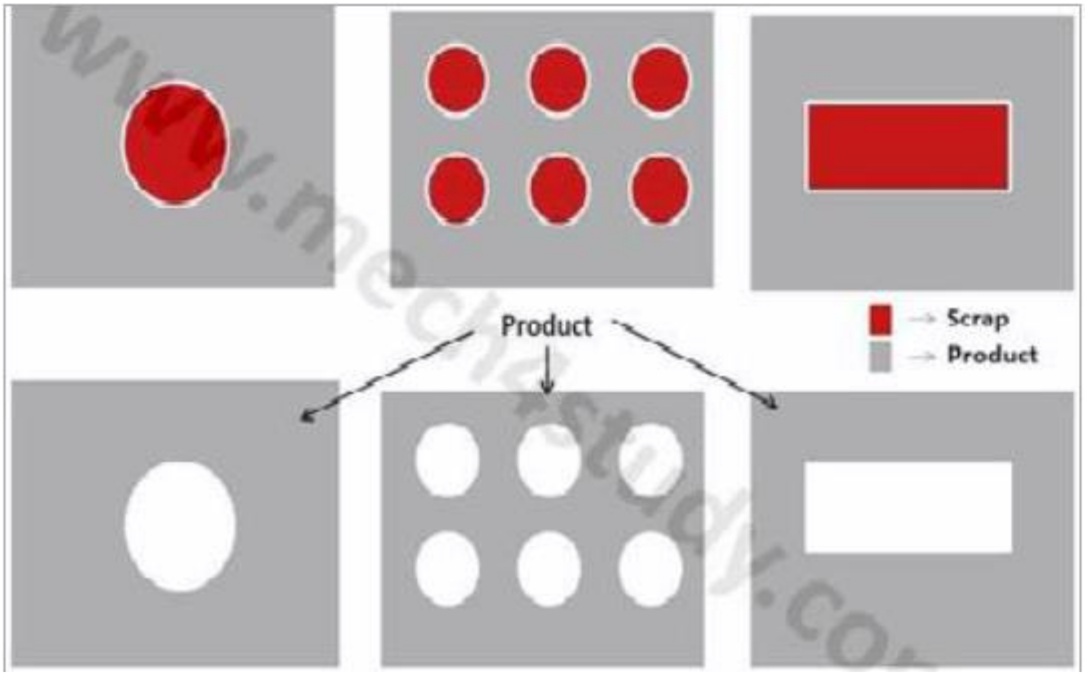
d) **Simple and Compound Dies:** Press and Press Tools These are two different dies, simple dies are those dies, used for single exclusive operation in each stroke of ram. These dies have already been discussed in earlier section.

In compound dies two or more operations can be done at a single working point. Initial cost of such dies is more due their complicated design and difficult manufacturing. Their low operating cost makes these very economical as a single compound die is equivalent to two or three simple dies. There is also reduction of cost of using of two or three presses because multiple operations are accomplished in a single press by a single operator.

a) **Continental Dies:** These are similar to other dies but the conceptual difference is, these are meant to do research and development work. These cannot do mass production as they may not be very robust.
b) **Transfer Die:** It is also like a progressive die having more than one working points. It is different form progressive die as it has feeding fingers in the die which transfer the workpiece from one work station to other. In some cases, feeding fingers are attached to press, then the press is called transfer press.

Different Operations performed on sheet metal working:

a) **Blanking:** Blanking is an operation of removing a piece of metal from a large sheet by punching with a predefine shaped punch. The removed part is called blank and it is the useful part and rest sheet is scrap. This process is used to cut gears, jewelry and complex parts.
b) **Punching:** It is similar operation like blanking except, the desire part is sheet and the blank is scrap. This process takes place on punching press. The negative allowance is provided on the punch which gives positive tolerance on sheet.
c) **Fine Blanking:** This process is used to produce very smooth and square edges blank. In this process sheet is locked tightly at accurate place. It involves clearances of the order of 0.5 – 10 mm and dimension tolerances are order of 0.025 - 0.05 mm in most cases.



(1) (2) (3)

Fig .4 Operations of piercing (1), perforating (2) and slotting (3)

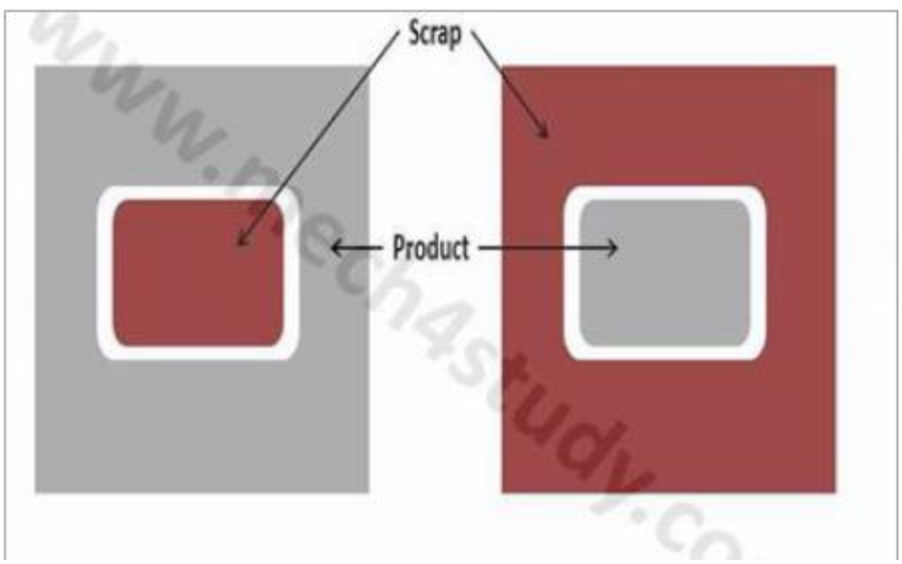


Fig 5 Operations of Punching (a) and blanking (b)

Basics of operations to be performed for manufacturing of press tool:

a) **Milling:** Milling is the machining process of using rotary cutters to remove material from a workpiece by advancing (or feeding) in a direction at an angle with the axis of the tool

b) **Turning:** Turning is a form of machining, a material removal process, which is used to create rotational parts by cutting away unwanted material. The turning process requires a turning machine or lathe, workpiece, fixture, and cutting tool.

c) **Shaping:** shaping is a manufacturing process of material removal in which the tool reciprocates across the stationary workpiece.

d) **Grinding:** A grinding machine, often shortened to grinder, is any of various power tools or machine tools used for grinding, which is a type of machining using an abrasive wheel as the cutting tool. Each grain of abrasive on the wheel's surface cuts a small chip from the workpiece via shear deformation.

e) **Counter drilling:** V-drill in an opposite direction. Type of: bore, drill. make a hole, especially with a pointed power or hand tool.

f) **Tapping:** A tap is used to cut or form the female portion of the mating pair. The process of cutting or forming threads using a tap is called tapping,

g) **Drilling:** Drilling is a cutting process that uses a drill bit to cut a hole of circular cross-section in solid materials. The drill bit is usually a rotary cutting tool, often multipoint.

Specifications of existing tool:

Table No. 1 Dimensions of old tool

PROCESS	PART	SIZE (mm)
Forming 1	Inner Body	550x800
Forming 2	Inner Body	530x630
Forming 1	Outer Body	600x800
Forming 2	Outer Body	550x650

4. DESIGN AND CALCULATIONS

4.1 Cutting force:

The Force Required to penetrate the stock material with the punch is the cutting force. If the die contains more than one punch that penetrates the stock material simultaneously, the cutting force for that die is the sum of the forces for each punch. Knowledge of cutting forces is important in order to prevent overloading the press or failure to use it to capacity.

The maximum force F in Newton needed to cut a material is equal to the area to be shredded times the shearing strength, Tb in N/mm^2 for the material. For the rectangular blank A will be the area in N/mm^2.

F_c= A × Tb

Where,

A= Shear Area = L×S

L= Length

S= Material thickness

Tb= Shear strength = 0.8 × σt

Area of required sheet is considered.

Thickness being considerably small, only thickness and breadth of sheet is considered. Hence,

A= 800×1 = 800 sq. mm

FG260 material is used.

Hence,

σt= 260 N/mm^2

$$\boxed{F_c = 0.8 \times 260 = 166400\ N}$$

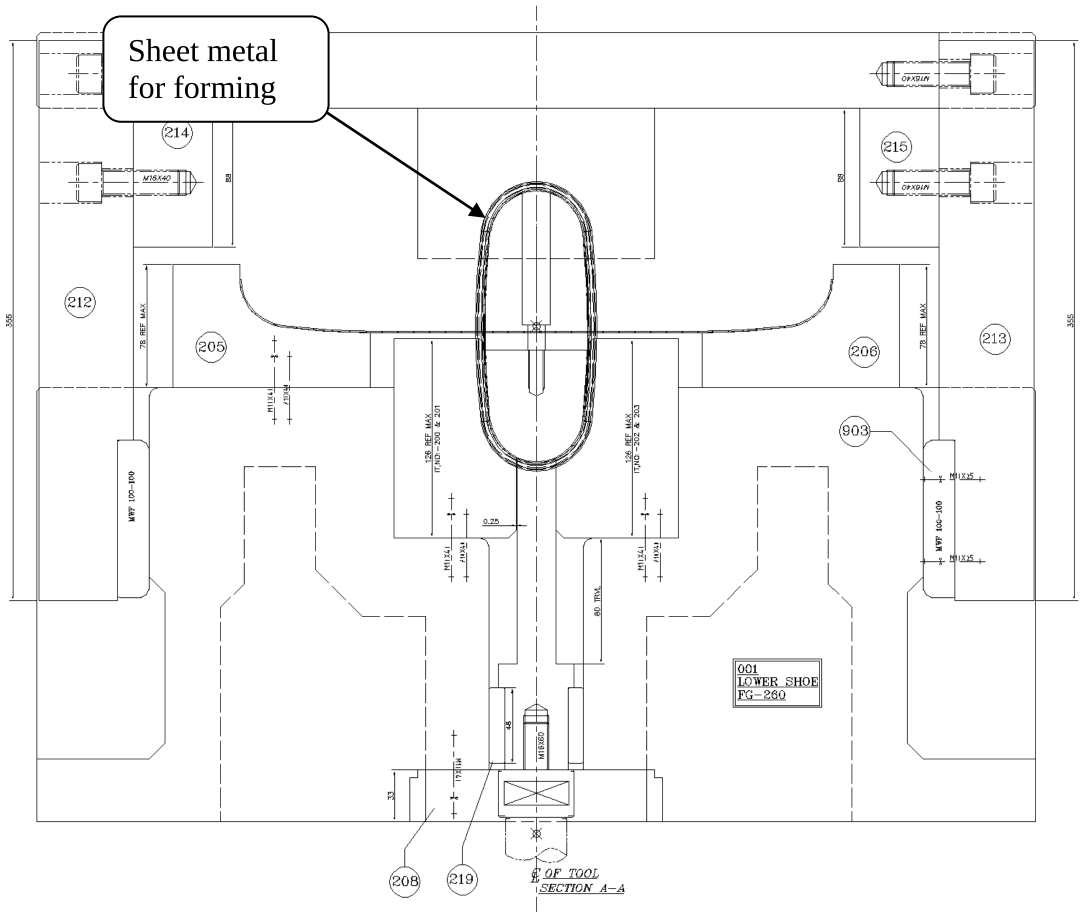


Fig 6 Figure of Sheet metal inside the tool

4.2 Stripping force:

The force that causes blank to grip inside the die walls also causes the stock material to grip around the punch. The stock material will rise as the press ram is raised unless some means of stripping the stock material from the punch is provided.

The amount of pressure required to stock material from the punch varies from 5% to 20% of the cutting force requirements. Thicker materials require more stripping force because more material is in the contact with the punch, Holes punched close to the strip edge do not require as much stripping force as there is less backing and the metal can give. Punches with polished walls tend to strip easier than rough ones.

Stripping force can be given as

$F_s = S \times P \times T$

Where,

S = Stripping constant

P = perimeter of cutting edge in mm

t = Stock thickness in mm

here

S = 0.0105 …………….(Badve engineering data book)

P = 119.71mm (length of stock material)

t = 0.8 mm

therefore,

$F_s = 0.0105 \times 119.71 \times 0.8$

$$\boxed{F_s = 1.005564 \text{ KN}}$$

4.3 Stretched Length

Stretched length is the length of the stock material which will be after the operation of press. It is given by the following formula below

$$\mathbf{L_s = a + (R + q + S/2)\,(\Pi x'/180)}$$

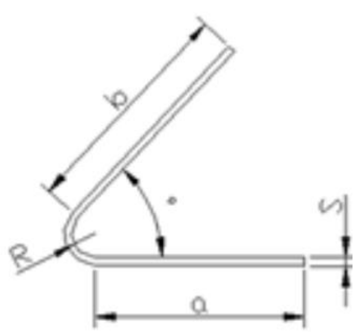


Fig 7 Stretched length

Where,

a= length of legs

L= blank length

q= correction factor

x'= bend angle

R= bend radius = 30.03 mm S= material thickness = 1mm

R/S=30.03/1 = 30.03

q= 1……………. (correction factor table from Badve engineering data book)

L_s = 119.71 + (30.03 + 1× (2/2)) (Π× 60/180)

= 119.71+ (31.03) × (Π/3)

$\boxed{= 152.205 \text{ mm}}$

(Tolerance is 152 ± 2)

L_s = It is the stretching length that occurs during the bending. It must be accounted to determine length of blank.

4.4 Dowel Pins:

Dowel pins are used for alignment purpose. They are usually located near diagonally opposite corners of die block, for maximum locating effect. The diameter of the dowel pins is taken to be equal to the outside diameter of fastening screws. Most dowels are used in the constructions are hardened and ground steel pins.

Diameter of dowel pins = outer diameter of fastening screws

$\boxed{\text{Diameter of dowel pins = 16mm}}$

4.5 2D design of existing tool

a) For forming 1 inner body

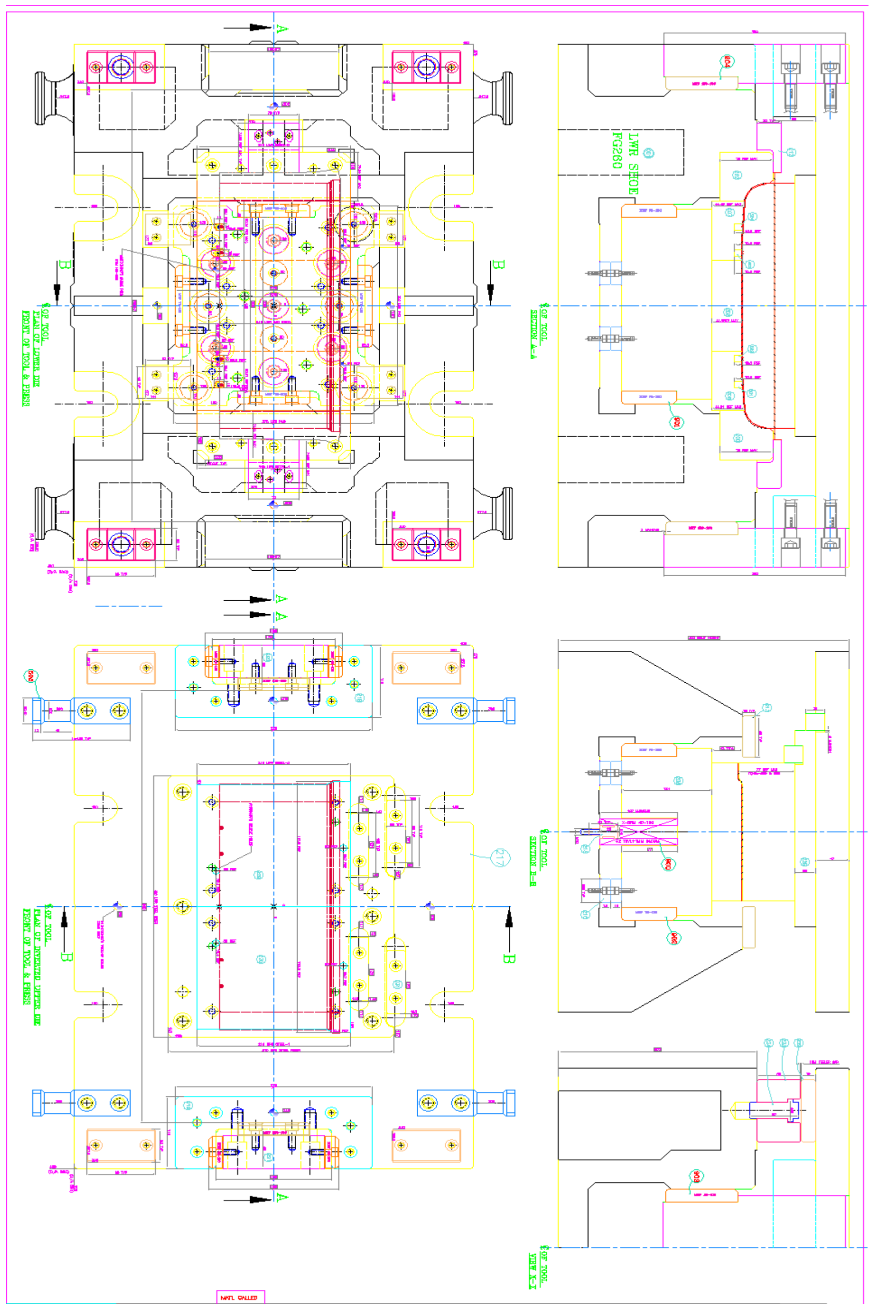


Fig 8 Forming 1 Inner Body

b) Forming 2 inner body

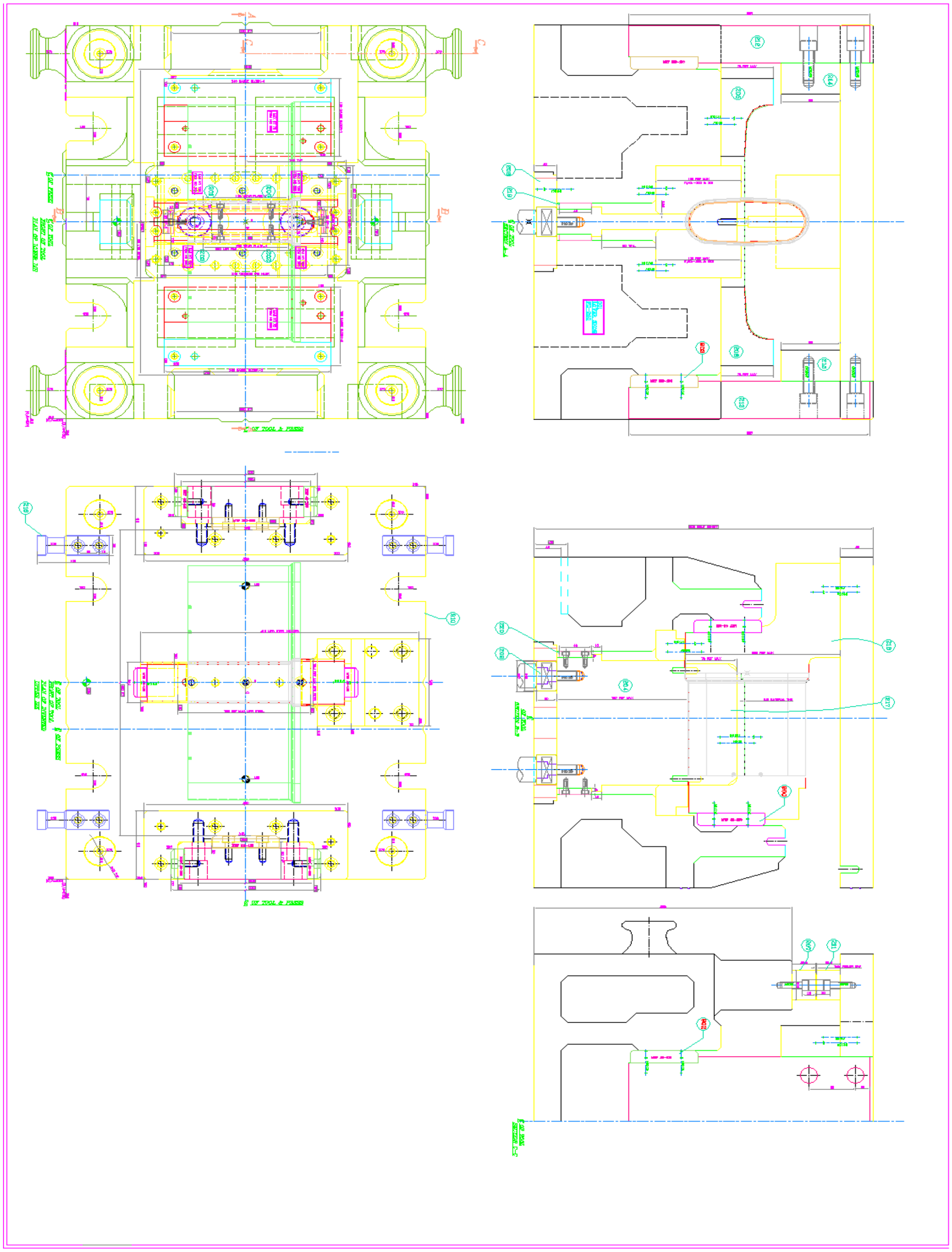


Fig 9 Forming 2 Inner Body

c) Form 1 outer body

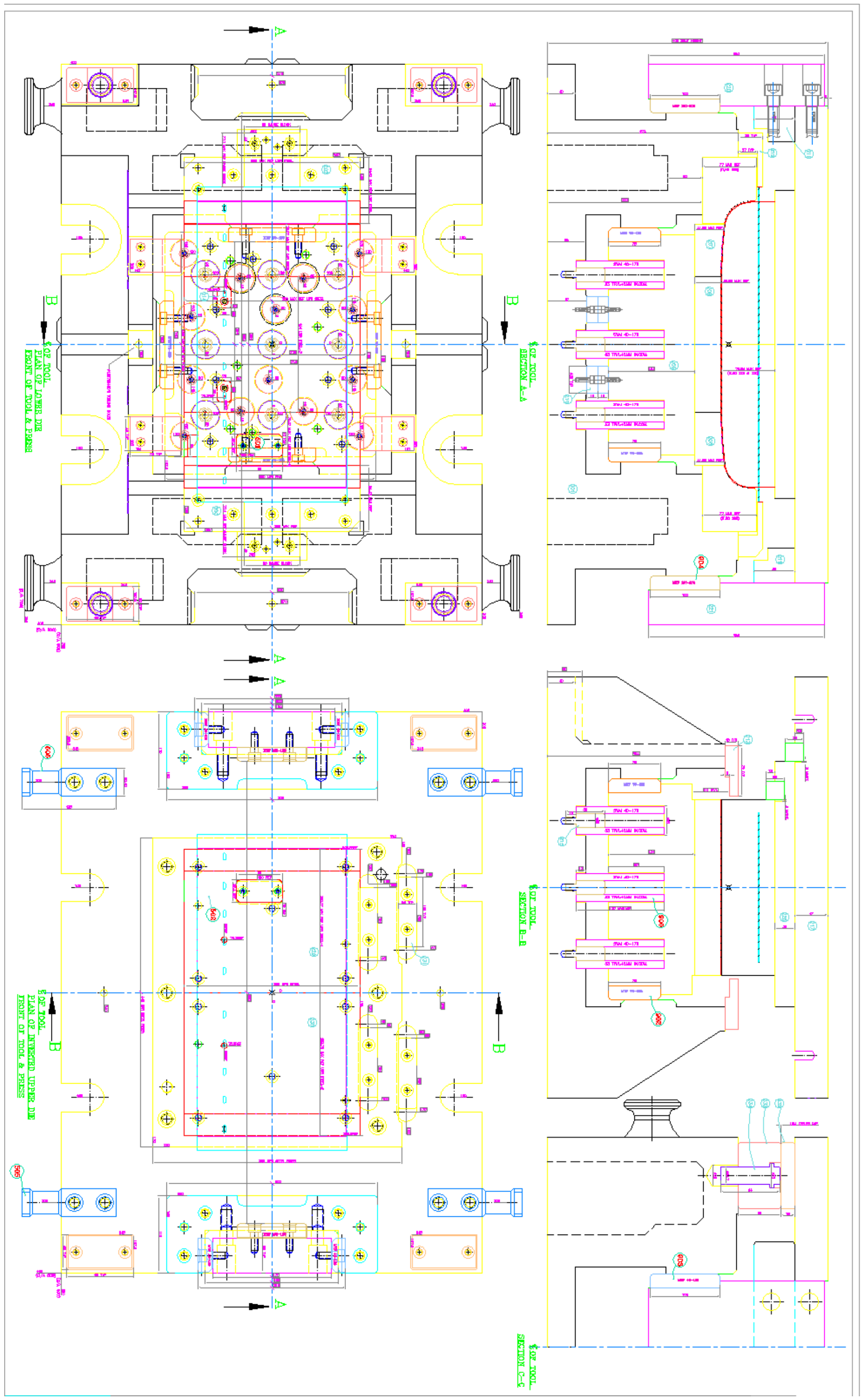


Fig 10 Forming 1 Outer Body

d) Form 2 outer body

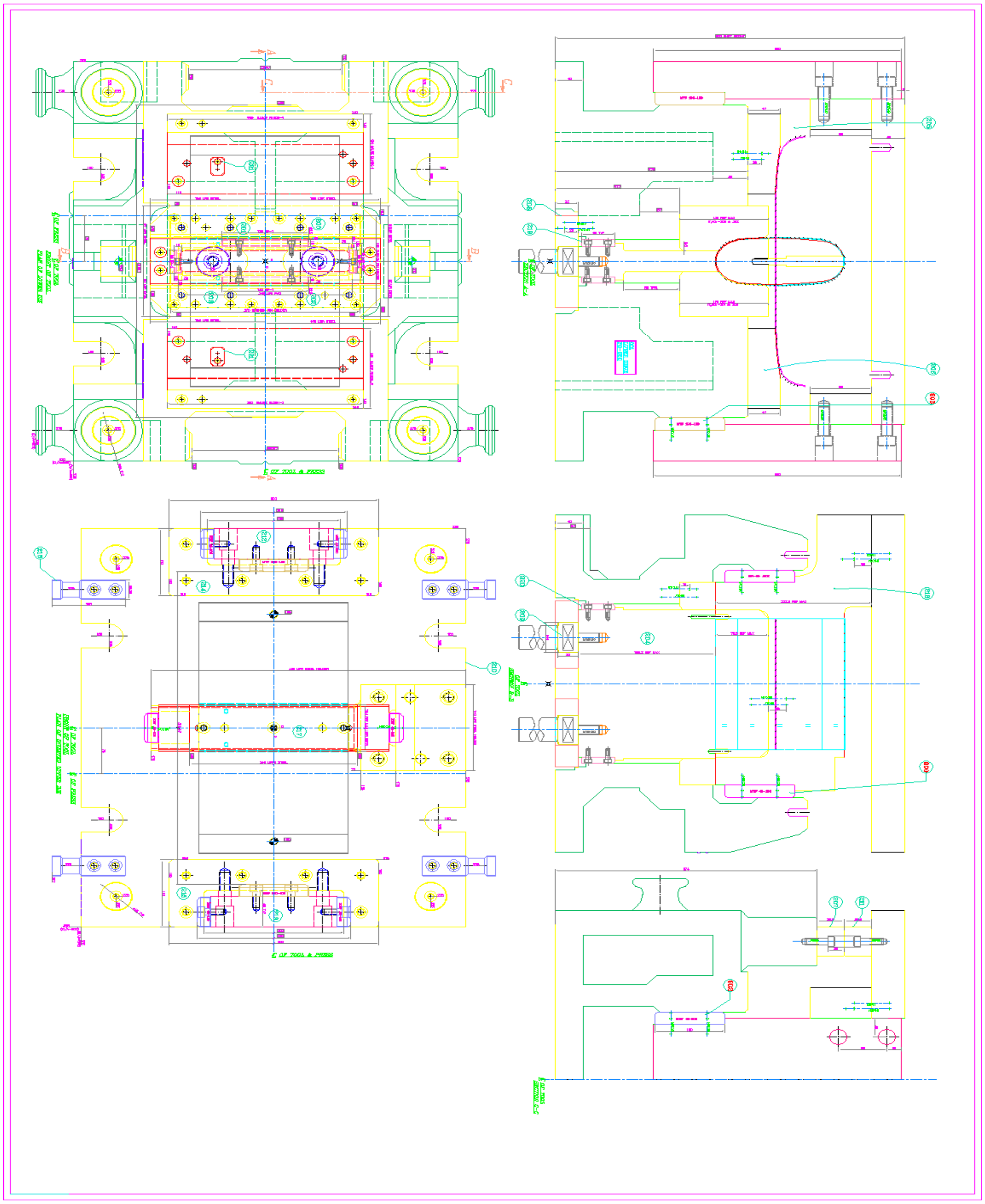


Fig 11 Forming 2 Outer Body

4.6 2D design of new combined tool

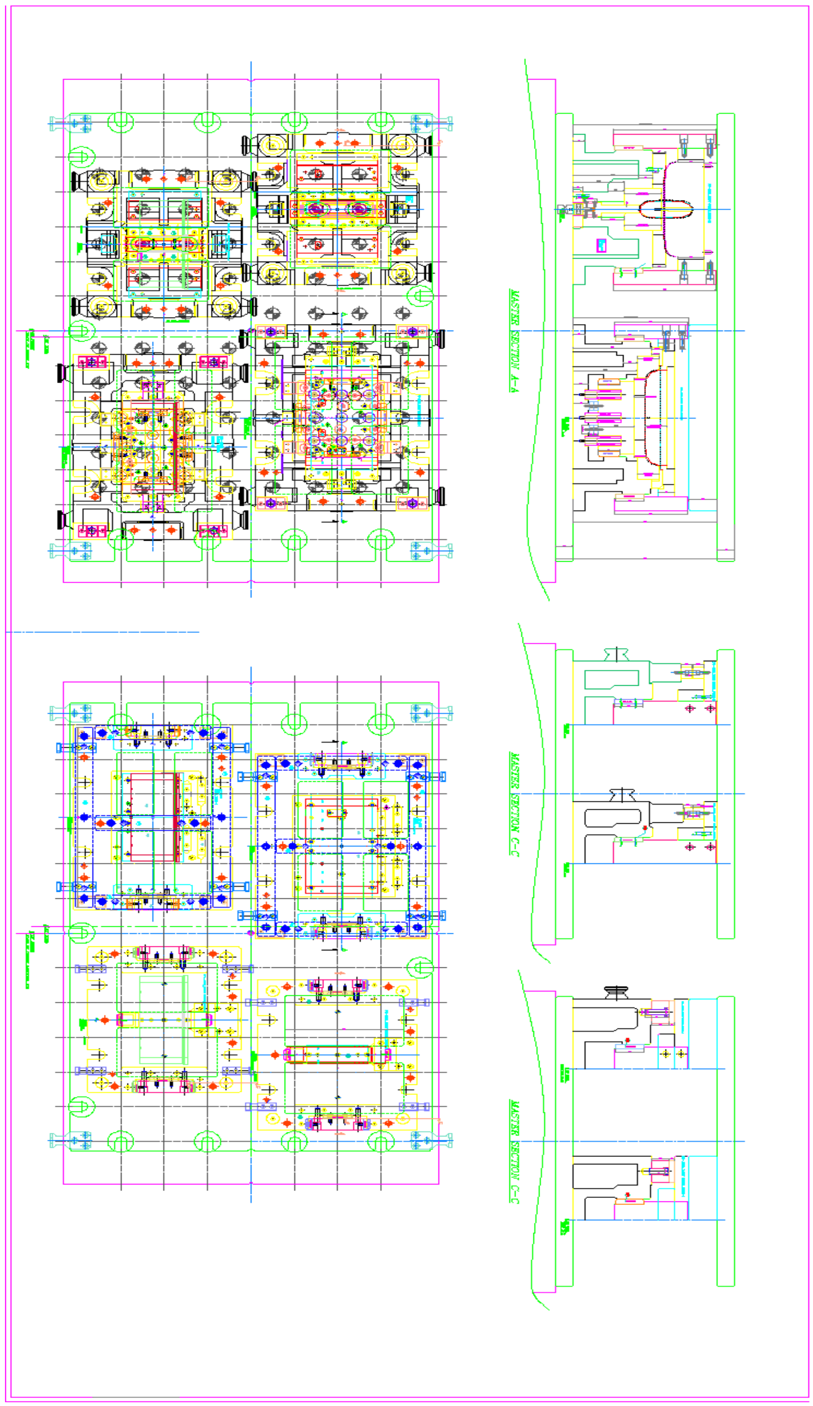


Fig 12 Combined Tool

5. MATERIALS USED FOR TOOL MANUFACTURING

The materials used for manufacturing of new tool are similar to old one as the job material is same and the material properties of tool matches the requirement.

Table No. 2 Material used and properties [5]

PART	MATERIAL	PROPERTIES
Lower Shoe	FG260 (Grey cast Iron)	This specification governs the quality requirements of Grey Iron Castings having a tensile strength of 260 N/mm2. As cast or cast and stress relieved or rough machined or rough machined and stress relieved as specified in BHEL order/drawing. Castings shall comply with the following national standards and also meet the requirements of this specification. IS: 210-1993 (RA-2004): Grey Iron Castings Gr: FG 260. Castings shall be artificially aged (stress relieving) by heating in a furnace to a temperature of 520 to 580°C (recommended), whenever specified. Test pieces shall also be heat treated along with the castings they represent.
Lower and Upper Steel	D2 (Steel)	D2 steel is an air hardening, high-carbon, high-chromium tool steel. It has high wear and abrasion resistant properties. It is heat treatable and will offer a hardness in the range 55-62 HRC and is machinable in the annealed condition. D2 steel shows little distortion on correct hardening. D2 steel’s high chromium content gives it mild corrosion resisting

		properties in the hardened condition. For Forging Heat slowly and uniformly to 700°C then more rapidly to 900/1040°C. Do not continue to forge D2 below 925°C. Reheat as often as necessary to maintain proper forging temperature. After forging cool slowly. This is not an annealing process. After the forging is cold, it must be annealed as described below. D2 tool steel is extremely sensitive to overheating during hardening. Pre heat slowly to 750/780°C and soak. Continue heating to the final hardening temperature of 1000/1030°C and allow the component to equalize. Quench in oil or cool in air.
Heel Plate	MS	Mild steel contains - carbon 0.16 to 0.18 % (maximum 0.25% is allowable) Manganese 0.70 to 0.90%Silicon maximum 0.40%, Sulfur maximum 0.04% Phosphorous maximum 0.04%. The modulus of elasticity calculated for the industry grade mild steel is 210,000 Mpa. It has an average density of about 7860 kg/m3. Mild steel is a great conductor of electricity. So, it can be used easily in the welding process. Because of its malleability, mild steel can be used for constructing pipelines and other construction materials. Even domestic cookware is made of mild steel. It is ductile and not brittle but hard. Mild steel can be easily machined in the lathe, shaper, drilling or milling machine. Its hardness can be increased by the application of carbon.
Wear Plate	20MN (Alloy Steel)	20MnCr5 steel are low alloyed engineering case hardening steel for parts which require core tensile strength of 1000 – 1300 N/mm² and good wearing

		resistance. It is used in boxes, piston bolts, spindles, camshafts, gears, shafts and other mechanical controlling parts. It consists of carbon, silicon, phosphorous, manganese, Sulphur and chromium. Core hardening 850 – 880 ^{o}C. Case hardening: 810 - 8400C. Quenching media: water, oil, air, thermal bath. Hot Forming temperature: 1100-850 ^{o}C.
Holder	SS400, S50C (S55C), FC250, SKS3, and A7075	The punch and die holder are not only for fixing the die to the press machine but also for supporting the rigidity of the die. They also have the role of adjusting the die height and providing the space for springs, etc. Usually, the materials used are SS400 or S50C. There is no big difference between the two. Among cast iron types, FC250 is used. This is the material used when cast iron die sets are used. When high rigidity is required for purposes such as high volume production, etc., SKS3 is used after heat treatment (to a hardness of about 56 HRC). When low weight is required, the aluminum alloy A7075 may be used.
Backing Plate	SK3, SK5, SKS3, and S50C	Backing plates are used at three locations in a die. They are used for the purpose of backing up so as to prevent components such as small diameter punches, etc., from getting too deep inside the holder due to the force of press operation. Apart from that, backing plates are used for preventing the parts from getting detached (stripper backing plate) and for adjusting the height of the die. For backing up, an SK material is used after heat treatment (to a hardness of about 56 HRC). The SKS material is

		used when high rigidity is required. Materials such as S50C, which is used without heat treatment, is used for backing up or preventing the detachment of parts such as a large-sized punch with a large pressure receiving area, or for adjusting the height.
Gauge Plate	OHNS	It is Oil Hardening Non-Shrinking Die Steel. All press cutting tools & punching tools for thinner materials. Small tools of complicated design for reforming, bending & drawing. Small plastic & rubber molds. Toughness of a material determines whether it can be subjected to shock conditions, and the extent to which it may undergo deformity in shape but still not snap. If subjected to a proper treatment process, O1 Tool Steel tends to be very tough. As opposed to toughness, brittleness measures whether a material will snap instead of getting deformed, when load is applied. Alloy steels like O1 Tool Steel are less brittle than cast or pig iron because of the presence of magnesium. Strength of a metal determines the extent to which it may deform when load is applied on it. Strength can be measured based on various parameters, such as the maximum ability to take strain, resistance to wear and tear, impact handling, or how the material performs when subjected to frequently changing load conditions. Strength generally increases as the carbon and manganese content increases. Given the high percentage of both of those, O1 Tool Steel is strong. Hardness of a material indicates its resistance to get indented that is not temporary (i.e.; it persists even

		after the load conditions are removed, as opposed to the strength that is an indication of its performance only when the load is applied), and carbon is also the primary hardening element in steel. The Rockwell method measures the hardness of O1 Tool Steel to be in the range of 64 RC to 58 RC (this is the most commonly used measurement technique).

6. MANUFACTURING PROCESSES FOR THE TOOL

6.1 Raw material ordering

Table No. 3 Raw Material Size

For	Dimensions for raw material (W x L x B)		
Upper Plate	61	1250	1935
Lower Plate	61	1250	1935
Liner Inner body 1	61	105	750
Liner Inner body 2	61	105	400
Liner Outer body 1	61	105	780
Liner Outer body 2	61	105	450

The raw material ordered according to above specifications and the material for it is mild steel. The process after raw material ordering is to machine the raw material and make it clean from indentations which occur from various reasons like weather, transportation, human factors, etc.

Post the work of raw material organizing is stage of pre-machining of the tool, it includes light machining of the surface.

After this the machining operations like milling, grinding, tapping etc. starts.

6.2 Machining processes

Machining is the broad term used to describe removal of material from a workpiece, it covers several processes, which we usually divide into the following categories:

a) Cutting, generally involving single-point or multipoint cutting tools, each with a clearly defined geometry.
b) Abrasive processes, such as grinding.
c) Nontraditional machining processes, utilizing electrical, chemical, and optimal sources of energy.

The three principal machining processes are classified as turning, drilling and milling. Other operations falling into miscellaneous categories include shaping, planning, boring, broaching and sawing.

a) Turning operations are operations that rotate the workpiece as the primary method of moving metal against the cutting tool. Lathes are the principal machine tool used in turning.
b) Milling operations are operations in which the cutting tool rotates to bring cutting edges to bear against the workpiece. Milling machines are the principal machine tool used in milling.
c) Drilling operations are operations in which holes are produced or refined by bringing rotating cutter with cutting edges at the lower extremity into contact with the workpiece. Drilling operations are done primarily in drill presses but sometimes on lathes or mills.
d) Miscellaneous operations are operations that strictly speaking may not be machining operations in that they may not be swarf producing operations but these operations are performed at a typical machine tool. Burnishing is an example of a miscellaneous operation. Burnishing produces no swarf but can be performed at a lathe, mill, or drill press.

The machining operations are performed on VMC (Vertical Milling Machine) CNC is a type of motion control system. It basically means that instead of using cams or templates to cut a part, it is controlled by a computer. A VMC is a type of CNC machine, typically enclosed and most often used for cutting metal. They are usually very precise and very expensive. Here is a pic of a popular VMC, built by Haas, that uses CNC controls.

As opposed to the machining with a horizontal machining center (HMC), CNC machines with the vertical machining centers (VMC) have vertically oriented spindles. VMC workpieces are usually mounted on top of their table and perform standard 2.5 or 3 axis machining operations. VMC are useful for creating the parts, die or molds with precision, accuracy, repeat-ability and surface finishes. The term ‘machining center’ almost always describes the CNC (Computer Numerical Control) milling and drilling machines that have an automatic tool changer and a table that clamps the work-piece in one place. CNC machining is a process that is used in the manufacturing sector, it involves the use of computers to control machine tools.

Benefits of Machining with Vertical Machining Center

Horizontal Machining Centers (HMC) usually come with 4th axis as compared to Vertical Machining Centers (VMC) where 3rdaxis is still considered as staple machinery in machine shops. It’s also possible to stick a tombstone in the 4th axis, enhancing the pallet changing, and add through spindle coolant as well. There are several advantages of machining that standard VMC and VMC with 4th axis have to offer such as:

a) In comparison to a HMC the VMC
b) Offers the operator access to its machine chamber, allowing one to easily observe processing conditions – which is an option in most HMC
c) Simpler Set-Up, Management and Functionality
d) Widely used in market, give its straightforward bugger
e) More Versatile in comparison and offers relatively simple CNC program controls
f) Most Economically efficient and effective method of machining metal and/or other substances
g) In a VMC, the debugger is easier hence why it’s widely used in the market.

Fig. No.13 Vertical Milling Machine

Fig. No. 14 Vertical Milling Machine II

6.2.1 Milling process

Milling is a process performed with a machine in which the cutters rotate to remove the material from the work piece present in the direction of the angle with the tool axis. With the help of the milling machines one can perform many operations and functions starting from small objects to large ones. There are a lot of cutting tools used in the milling process. The milling cutters named end mills have special cutting surfaces on their end surfaces so that they can be placed onto the work piece by drilling. These also have extended cutting surfaces on each side for peripheral milling. The milling cutters have small cutters at the end corners. The cutters are made from highly resistant materials that are durable and produce less friction. Any material put through the cutting area of the milling machine gets regular intervals. The side cutters have got regular ridges on them. The distance between the ridges depends on the feed rate, the diameter of the cutter and the quantity of cutting surfaces. These can be the significant variations in the height of the surfaces. This means that more than two milling cutters are involved in a setup like the horizontal milling. All the cutters perform a uniform operation, or it may also be possible that the cutter may perform distinct operations. This is an important operation for producing duplicate parts. The workpiece is holding on the worktable of the machine. The table movement controls the feed of workpiece against the rotating cutter. The cutter is mounted on a spindle or arbor and revolves at high speed. Except for rotation the cutter has no other motion. As the workpiece advances, the cutter teeth remove the metal from the surface of workpiece and the desired shape is produced. Milling is typically used to produce parts that are not axially symmetric and have many features, such as holes, slots, pockets, and even three-dimensional surface contours. Parts that are fabricated completely through milling often include components that are used in limited quantities, perhaps for prototypes, such as custom designed fasteners or brackets. Another application of milling is the fabrication of tooling for other processes. For example, three-dimensional molds are typically milled. Milling is also commonly used as a secondary process to add or refine features on parts that were manufactured using a different process. Due to the high tolerances and surface finishes that milling can offer, it is ideal for adding precision features to a part whose basic shape has already been formed. A face mill machines a flat surface of the workpiece in order to provide a smooth finish. [8] The depth of the face, typically very small, may be machined in a single pass or may be reached by machining at a smaller axial depth of cut and making multiple passes.

Fig 15 Surface for Milling (Yellow Colored)

6.2.2 Profile Milling

Profile milling covers multi-axis milling of convex and concave shapes in two and three dimensions. The larger the component and the more complicated the configuration to machine, the more important the process planning becomes. Super-finishing, often performed using high-speed machining techniques, is sometimes required. Milling of remaining stock, so called rest milling, is included in semi-finishing and finishing operations. For best accuracy and productivity, it is recommended to perform roughing and finishing in separate machines, and to use dedicated cutting tools for each operation. The finishing operation should be carried out in a 4/5-axis machine tool with advanced software and programming techniques. This can considerably reduce, or even completely eliminate, time consuming manual completion work. Profile milling is used to rough or finish mill vertical or slanted surfaces. The surfaces selected must allow for a continuous tool path. The depth of the cut can be specified using the step depth parameter. By default, the system will detect undercuts when derouging a 3-axis profiling tool path. If you want to be able to machine an undercut, set gouge avoid type to tip only. The following illustration shows machining an undercut. 3-axis profiling will clean up the top horizontal edges of selected surfaces, as shown in the following figure. If there is another surface bounding the top edge, select it as a check surface to avoid gouging. 5-axis surface profiling can be used for swarf cutting, as shown in the following illustration. The tool axis will stay tangent to the surface being machined. Use the axis shift parameter to shift the depth of the cut along the tool axis and set the parameter to a positive value. A positive axis shift is used to change the contact point to the side of the cutter.

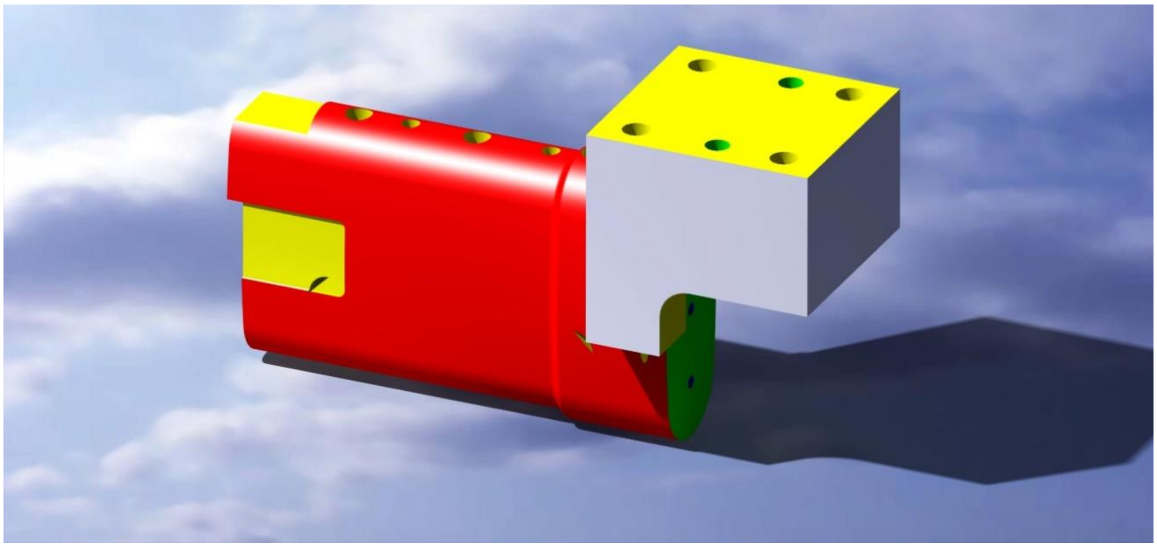


Fig 16 Surface to be Profile Milled (Edges of red colored part)

6.2.3 Shaping operation

Dove tail joint is machined on two separate pieces of work as male and female elements. The required shape is marked on the face of the work and the unwanted metal is first removed by the round nose tool. A special form tool is used to finish the machining. The required shape of a ‘V’ block is marked on the face of the work and machining is done by any suitable method of angular machining. It is a manufacturing process of material removal in which the workpiece reciprocates against a stationary cutting tool producing a plane or sculpted surface. Planning is analogous to shaping. The main difference between these two processes is that in shaping the tool reciprocates across the stationary workpiece. Planning motion is the opposite of shaping. Both planning and shaping are rapidly being replaced by milling. In shaping, the tool is brought into position with the workpiece. The tool then repeatedly moves in a straight line while the workpiece is incrementally fed into the line of motion of the tool, this produces a flat, smooth, and sculpted surface. For shaped pieces the tool reciprocates across the stationary workpiece. The tools are usually tilted or lifted after each stroke. This is done hydraulically or manually to prevent the tool surface from chipping when the workpiece travels back across. can be used to produce flat surfaces, as well as cross-sections with grooves and notches, are produced along the length of workpiece. Shaping is basically the same as planning, except the workpiece is usually smaller, and it is the tool that moves and not the workpiece. It can be used to produce horizontal, vertical, or inclined flat surfaces on workpieces usually too large for shaping. Shaping is used not only for flat surfaces, but also for external or internal surfaces (either horizontal or inclined). Curved and irregular surfaces can also be produced by using special attachments. Flat, angular, and contoured surfaces are made by horizontal shapers. Concerning shaping, the device that holds the piece being worked on has a very heavy movable jaw to withstand cutting forces. The size of the planer needed is determined by the workpiece. Depending on the size of the workpiece many clamps and supporting devices may be used to hold it on the planer.

Machining external keyways refers to the cutting of long slots along the length of cylindrical rods. Initially a round nose tool is used and then a square nose tool is used to finish the operation. A hole of depth equal to the depth of the keyway is made at the blind end to leave a clearance to the tool at the end of the stroke. When a keyway is cut at the middle of the shaft, holes are drilled at both ends of the keyway. The shape of the T-slot is marked on the face of the work. A parting off tool is fitted on the tool post and a rectangular slot is machined at the middle for the required depth. The broad base of the ‘T’ slot is machined by a T-slot cutting tool. Rack gear cutting is a process of cutting teeth elements at linear pitch on a flat piece of work. Firstly, the groove is machined with a square nose parting tool. Then, the groove is further machined with a form tool conforming the shape of the teeth. A shaper can also produce a contoured surface using a round nose tool. To produce a small contoured surface a forming tool is used. If the curve is sufficiently large, powered crossed along with manual down feed is so adjusted that the tool will trace the required contour.

The most common use is to machine straight, flat surfaces, but with ingenuity and some accessories a wide range of work can be done. Other examples of its use are:

a) Keyways in the boss of a pulley or gear can be machined without resorting to a dedicated broaching setup.
b) Dovetail slides
c) Internal splines and gear teeth.
d) Keyway, spline, and gear tooth cutting in blind holes
e) Cam drums with toolpaths of the type that in CNC milling terms would require 4- or 5-axis contouring or turn-mill cylindrical interpolation
f) It is even possible to obviate wire EDM work in some cases. Starting from a drilled or cored hole, a shaper with a boring-bar type tool can cut internal features that don't lend themselves to milling or boring (such as irregularly shaped holes with tight corners).

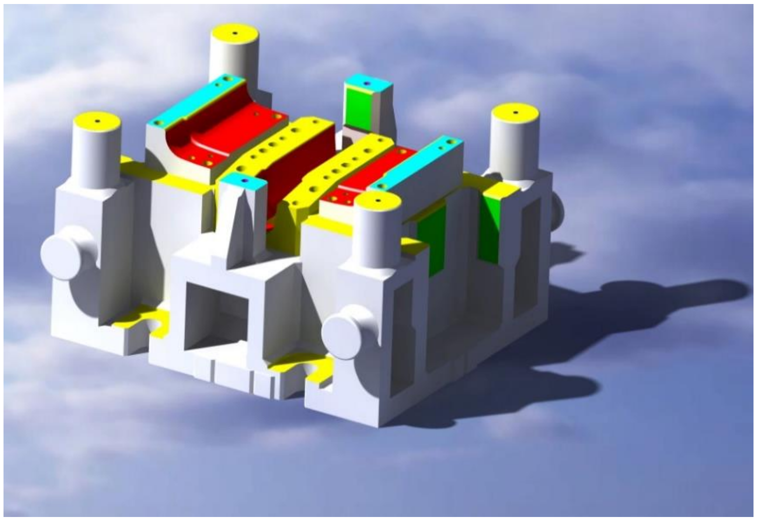


Fig 17 Part for Shaping (Colored part)

6.2.4 Drilling operation

Drilling is a cutting process that uses a drill bit to cut a hole of circular cross-section in solid materials. The drill bit is usually a rotary cutting tool, often multi-point. The bit is pressed against the work-piece and rotated at rates from hundreds to thousands of revolutions per minute. This forces the cutting edge against the work-piece, cutting off chips (swarf) from the hole as it is drilled. Drilling is a cutting process that uses a drill bit to cut a hole of circular cross-section in solid materials. The drill bit is usually a rotary cutting tool, often multi-point. The bit is pressed against the work-piece and rotated at rates from hundreds to thousands of revolutions per minute. This forces the cutting edge against the work-piece, cutting off chips (swarf) from the hole as it is drilled. Drilled holes are characterized by their sharp edge on the entrance side and the presence of burrs on the exit side (unless they have been removed). Also, the inside of the hole usually has helical feed marks. Drilling may affect the mechanical properties of the workpiece by creating low residual stresses around the hole opening and a very thin layer of highly stressed and disturbed material on the newly formed surface. This causes the workpiece to become more susceptible to corrosion and crack propagation at the stressed surface. A finish operation may be done to avoid these detrimental conditions. For fluted drill bits, any chips are removed via the flutes. Chips may form long spirals or small flakes, depending on the material, and process parameters. The type of chips formed can be an indicator of the machinability of the material, with long chips suggesting good material machinability. When possible drilled holes should be located perpendicular to the workpiece surface. This minimizes the drill bit's tendency to "walk", that is, to be deflected from the intended center-line of the bore, causing the hole to be misplaced. Speed refers to the revolutions per minute (RPM) of the drilling machine spindle. For drilling, the spindle should rotate at a set speed that is selected for the material being drilled. Correct speeds are essential for satisfactory drilling. The speed at which a drill turns and cuts is called the peripheral speed. Peripheral speed is the speed of a drill at its circumference expressed in surface feet per minute (SFPM). This speed is related to the distance a drill would travel if rolled on its side. For example, a peripheral speed of 30 feet per minute means the drill would roll 30 feet in 1 minute if rolled on its side. It has been determined through experience and experiment that various metals machine best at certain speeds; this best speed for any given metal is what is known as its cutting speed (CS). If the cutting speed of a material is known, then a simple formula can be used to find the recommended RPM of the twist drill. Feed is the distance a drill travels into the workpiece during each revolution of the spindle. It is expressed in thousandths of an inch or in millimeters. Hand-feed drilling machines have the feed regulated by the hand pressure of the operator; thus, the skill of the operator will determine the best feeds for drilling. Feed should increase as the size of the drill increases. After starting the drill into the workpiece by hand, a lever on the power-feed drilling machine can be activated, which will then feed the drill into the work until stopped or disengaged. Too much feed will cause the drill to split; too little feed will cause chatter, dull the drill, and possibly harden the workpiece so it becomes more difficult to drill. Drills 1/2 inch or smaller can generally be hand-fed, while the larger drills require more downward torque. [4]

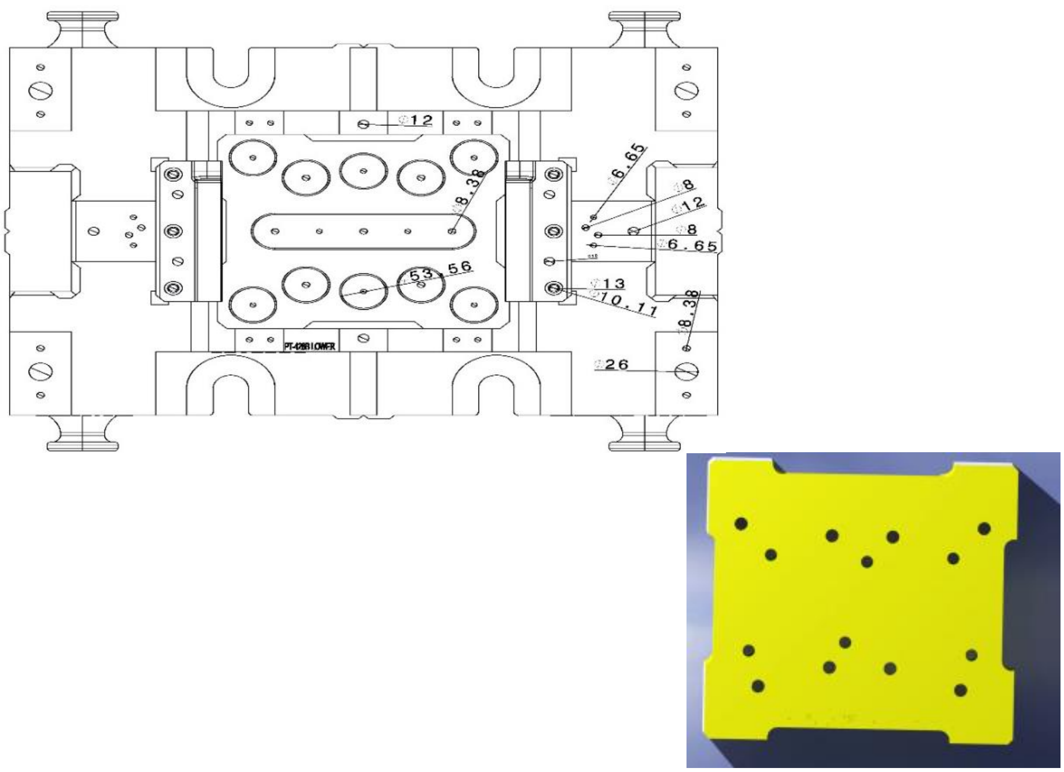


Fig 18 Drilling operation

6.2.5 Tapping operation

Taps and dies are tools used to create screw threads, which is called threading. Many are cutting tools; others are forming tools. A tap is used to cut or form the female portion of the mating pair (e.g. a nut). A die is used to cut or form the male portion of the mating pair (e.g. a bolt). The process of cutting or forming threads using a tap is called tapping, whereas the process using a die is called threading. Both tools can be used to clean up a thread, which is called chasing. However, using an ordinary tap or die to clean threads will generally result in the removal of some material, which will result in looser and weaker threads. Because of this, threads are typically cleaned using special taps and dies made for this purpose, which are known as chasers. Chasers are made of softer materials and are not capable of cutting new threads, however they are still tighter fitting than actual fasteners and are fluted like regular taps and dies (to provide a means for debris like dirt and rust to escape). One particularly common use is for automotive spark plug threads, which often suffer from corrosion and a buildup of carbon. Metalworking taps and dies were often made by their users during the 18th and 19th centuries (especially if the user was skilled in toolmaking), using such tools as lathes and files for the shaping, and the smithy for hardening and tempering. Thus, builders of, for example, locomotives, firearms, or textile machinery were likely to make their own taps and dies. During the 19th century the machining industries evolved greatly, and the practice of buying taps and dies from suppliers specializing in them gradually supplanted most such in-house work. Joseph Clement was one such early vendor of taps and dies, starting in 1828. With the introduction of more advanced milling practice in the 1860s and 1870s, tasks such as cutting a tap's flutes with a hand file became a thing of the past. In the early 20th century, thread-grinding practice went through significant evolution, further advancing the state of the art (and applied science) of cutting screw threads, including those of taps and dies.

The tap illustrated in the top of the image has a continuous cutting edge with almost no taper — between 1 and 1.5 threads of taper is typical. This feature enables a bottoming tap to cut threads to the bottom of a blind hole. A bottoming tap is usually used to cut threads in a hole that has already been partially threaded using one of the more tapered types of tap; the tapered end ("tap chamfer") of a bottoming tap is too short to successfully start into an unthreaded hole. In the US, they are commonly known as bottoming taps, but in Australia and Britain they are also known as plug taps. The tap illustrated in the middle of the image has tapered cutting edges, which assist in aligning and starting the tap into an untapped hole. The number of tapered threads typically ranges from 3 to 5. Plug taps are the most commonly used type of tap. In the US, they are commonly known as plug taps, whereas in Australia and Britain they are commonly known as second taps. The small tap illustrated at the bottom of the image is similar to an intermediate tap but has a more pronounced taper to the cutting edges. This feature gives the taper tap a very gradual cutting action that is less aggressive than that of the plug tap. The number of tapered threads typically ranges from 8 to 10. A taper tap is most often used when the material to be tapped is difficult to work (e.g., alloy steel) or the tap is of a very small diameter and thus prone to breakage. The above taps are generally referred to as hand taps, since they are, by design, intended to be manually operated. During operation, it is necessary to periodically reverse rotation of a hand tap to break the chip (also known as swarf) formed during the cutting process, thus preventing an effect called "crowding" that may cause tap breakage. The most common type of power driven tap is the "spiral point" plug tap, also referred to as a "gun" tap, whose cutting edges are angularly displaced relative to the tap centerline. This feature causes the tap to continuously break the chip and eject it forward into the hole, preventing crowding. Spiral point taps are usually used in holes that go all the way through the material, so that the chips can escape. Another version of the spiral point plug tap is the spiral flute tap, whose flutes resemble those of a twist drill. Spiral flute taps are widely used in high speed, automatic tapping operations due to their ability to work well in blind holes.[9]

A quite different kind of tap is a Forming Tap. A forming tap, aka a fluteless tap or roll tap, simply forcefully displaces the metal into a thread shape upon being turned into the hole, instead of cutting metal from the sides of the hole as cutting taps do. A forming tap closely resembles a cutting tap without the flutes, or very nearly just like a plain thread. There are lobes periodically spaced around the tap that actually do the thread forming as the tap is advanced into a properly sized hole. The threads behind the lobes are slightly recessed to reduce contact friction. Since the tap does not produce chips, there is no need to periodically back out the tap to clear away chips, which, in a cutting tap, can jam and break the tap. Thus, thread forming is particularly suited to tapping blind holes, which are tougher to tap with a cutting tap due to the chip build-up in the hole. Forming taps only work in malleable materials such as mild steel or aluminum. Formed threads are typically stronger than cut threads. Note that the tap drill size differs from that used for a cutting tap as shown in most tap drill tables, and that an accurate hole size is required because a slightly undersized hole can break the tap. Proper lubrication is essential because of the frictional forces involved, therefore a lubricating oil is used instead of cutting oil.

6.2.6 Grinding operation

Grinding is an abrasive machining process that uses a grinding wheel as the cutting tool. Grinding practice is a large and diverse area of manufacturing and toolmaking. It can produce very fine finishes and very accurate dimensions; yet in mass production contexts it can also rough out large volumes of metal quite rapidly. It is usually better suited to the machining of very hard materials than is "regular" machining (that is, cutting larger chips with cutting tools such as tool bits or milling cutters), and until recent decades it was the only practical way to machine such materials as hardened steels. Compared to "regular" machining, it is usually better suited to taking very shallow cuts, such as reducing a shaft’s diameter by half a thousandth of an inch or 12.7 μm. Grinding is a subset of cutting, as grinding is a true metal-cutting process. Each grain of abrasive functions as a microscopic single-point cutting edge (although of high negative rake angle), and shears a tiny chip that is analogous to what would conventionally be called a "cut" chip (turning, milling, drilling, tapping, etc.) However, among people who work in the machining fields, the term *cutting* is often understood to refer to the macroscopic cutting operations, and *grinding* is often mentally categorized as a "separate" process. This is why the terms are usually used separately in shop-floor practice.[8]

Cylindrical grinding (also called center-type grinding) is used to grind the cylindrical surfaces and shoulders of the workpiece. The workpiece is mounted on centers and rotated by a device known as a drive dog or center driver. The abrasive wheel and the workpiece are rotated by separate motors and at different speeds. The table can be adjusted to produce tapers. The wheel head can be swiveled. The five types of cylindrical grinding are: outside diameter (OD) grinding, inside diameter (ID) grinding, plunge grinding, creep feed grinding, and centerless grinding. Creep-feed grinding (CFG) was invented in Germany in the late 1950s by Edmund and Gerhard Lang. Unlike normal grinding, which is used primarily to finish surfaces, CFG is used for high rates of material removal, competing with milling and turning as a manufacturing process choice. Depths of cut of up to 6 mm (0.25 inches) are used along with low workpiece speed. Surfaces with a softer-grade resin bond are used to keep workpiece temperature low and an improved surface finish up to 1.6 μm Rmax. Centerless grinding is when the workpiece is supported by a blade instead of by centers or chucks. Two wheels are used. The larger one is used to grind the surface of the workpiece and the smaller wheel is used to regulate the axial movement of the workpiece. Types of centerless grinding include through-feed grinding, in-feed/plunge grinding, and internal centerless grinding.

6.2.7 Heat treatment

Heat treating (or heat treatment) is a group of industrial and metalworking processes used to alter the physical, and sometimes chemical, properties of a material. The most common application is metallurgical. Heat treatments are also used in the manufacture of many other materials, such as glass. The temperature was around 580°C for the red part to be heated. Heat treatment involves the use of heating or chilling, normally to extreme temperatures, to achieve a desired result such as hardening or softening of a material. The tool is heat treated only on the surface which cuts or bends the stock material so as to harden the material.

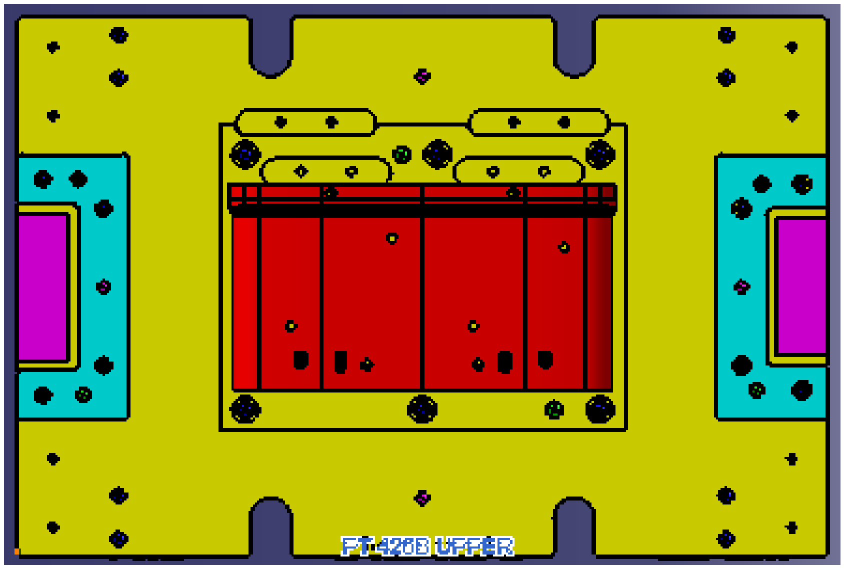


Fig 19 Heat treated part in red color

Heat treatment techniques include annealing, case hardening, precipitation strengthening, tempering, normalizing and quenching. It is noteworthy that while the term *heat treatment* applies only to processes where the heating and cooling are done for the specific purpose of altering properties intentionally, heating and cooling often occur incidentally during other manufacturing processes such as hot forming or welding.

Metallic materials consist of a microstructure of small crystals called "grains" or crystallites. The nature of the grains (i.e. grain size and composition) is one of the most effective factors that can determine the overall mechanical behavior of the metal. Heat treatment provides an efficient way to manipulate the properties of the metal by controlling the rate of diffusion and the rate of cooling within the microstructure. Heat treating is often used to alter the mechanical properties of a metallic alloy, manipulating properties such as the hardness, strength, toughness, ductility, and elasticity. The crystal structure consists of atoms that are grouped in a very specific arrangement, called a lattice. In most elements, this order will rearrange itself, depending on conditions like temperature and pressure. This rearrangement, called allotropy or polymorphism, may occur several times, at many different temperatures for a particular metal. In alloys, this rearrangement may cause an element that will not normally dissolve into the base metal to suddenly become soluble, while a reversal of the allotropy will make the elements either partially or completely insoluble. When in the soluble state, the process of diffusion causes the atoms of the dissolved element to spread out, attempting to form a homogenous distribution within the crystals of the base metal. If the alloy is cooled to an insoluble state, the atoms of the dissolved constituents (solutes) may migrate out of the solution. This type of diffusion, called precipitation, leads to nucleation, where the migrating atoms group together at the grain-boundaries. This forms a microstructure generally consisting of two or more distinct phases. Steel that has been cooled slowly, for instance, forms a laminated structure composed of alternating layers of ferrite and cementite, becoming soft pearlite. After heating the steel to the austenite phase and then quenching it in water, the microstructure will be in the martensitic phase. This is due to the fact that the steel will change from the austenite phase to the martensite phase after quenching. It should be noted that some pearlite or ferrite may be present if the quench did not rapidly cool off all the steel. Unlike iron-based alloys, most heat treatable alloys do not experience a ferrite transformation. In these alloys, the nucleation at the grain-boundaries often reinforces the structure of the crystal matrix. These metals harden by precipitation. Typically, a slow process, depending on temperature, this is often referred to as "age hardening". Many metals and non-metals exhibit a martensite transformation when cooled quickly(with external media like oil, polymer, water etc.). When a metal is cooled very quickly, the insoluble atoms may not be able to migrate out of the solution in time. This is called a "diffusion less." When the crystal matrix changes to its low temperature arrangement, the atoms of the solute become trapped within the lattice. The trapped atoms prevent the crystal matrix from completely changing into its low temperature allotrope, creating shearing stresses within the lattice. When some alloys are cooled quickly, such as steel, the martensite transformation hardens the metal, while in others, like aluminum, the alloy becomes softer.

The specific composition of an alloy system will usually have a great effect on the results of heat treating. If the percentage of each constituent is just right, the alloy will form a single, continuous microstructure upon cooling. Such a mixture is said to be eutectoid. However, If the percentage of the solutes varies from the eutectoid mixture, two or more different microstructures will usually form simultaneously. A hypo eutectoid solution contains less of the solute than the eutectoid mix, while a hypereutectoid solution contains more. With the exception of stress-relieving, tempering, and aging, most heat treatments begin by heating an alloy beyond the upper transformation temperature. This temperature is referred to as an "arrest" because at the A_3 temperature the metal experiences a period of hysteresis. At this point, all of the heat energy is used to cause the crystal change, so the temperature stops rising for a short time (arrests) and then continues climbing once the change is complete. Therefore, the alloy must be heated above the critical temperature for a transformation to occur. The alloy will usually be held at this temperature long enough for the heat to completely penetrate the alloy, thereby bringing it into a complete solid solution. Because a smaller grain size usually enhances mechanical properties, such as toughness, shear strength and tensile strength, these metals are often heated to a temperature that is just above the upper critical-temperature, in order to prevent the grains of solution from growing too large. For instance, when steel is heated above the upper critical-temperature, small grains of austenite form. These grow larger as temperature is increased. When cooled very quickly, during a martensite transformation, the austenite grain-size directly affects the martensitic grain-size. Larger grains have large grain-boundaries, which serve as weak spots in the structure. The grain size is usually controlled to reduce the probability of breakage.[6]

6.2.8 Reaming operation
(Finishing Operation)

A reamer is a type of rotary cutting tool used in metalworking. Precision reamers are designed to enlarge the size of a previously formed hole by a small amount but with a high degree of accuracy to leave smooth sides. There are also non-precision reamers which are used for more basic enlargement of holes or for removing burrs. The process of enlarging the hole is called reaming. There are many different types of reamer and they may be designed for use as a hand tool or in a machine tool, such as a milling machine or drill press. The geometry of a hole drilled in metal by a twist drill may not be accurate enough (close enough to a true cylinder of a certain precise diameter) and may not have the required smooth surface finish for certain engineering applications. Although modern twist drills can perform excellently in many cases—usually producing sufficiently accurate holes for most applications—sometimes the stringency of the requirements for the hole's geometry and finish necessitate two operations: a drilling to slightly undersize, followed by reaming with a reamer. The planned difference between the drill diameter and the reamer diameter is called an *allowance*. (It allows for the removal of a certain small amount of material.) The allowance should be < 0.2 mm (.008 in) for soft materials and < 0.13 mm (.005 in) for hard materials. Larger allowances can damage the reamer. The drilled hole should not be enlarged by more than 5% of the drilled diameter. Drilling followed by reaming generally produces hole geometry and finish that is as close to theoretical perfection as possible. (The other methods of hole creation that approach nearest to perfection under certain conditions are boring [especially single-point boring] and internal cylindrical grinding.) An adjustable hand reamer can cover a small range of sizes. They are generally referenced by a letter which equates to a size range. The disposable blades slide along a tapered groove. The act of tightening and loosening the restraining nuts at each end varies the size that may be cut. The absence of any spiral in the flutes restricts them to light usage (minimal material removal per setting) as they have a tendency to chatter. They are also restricted to usage in unbroken holes. If a hole has an axial split along it, such as a split bush or a clamping hole, each straight tooth will in turn *drop* into the gap causing the other teeth to retract from their cutting position. This also gives rise to chatter marks and defeats the purpose of using the reamer to *size* a hole. A straight reamer is used to make only a minor enlargement to a hole. The entry end of the reamer will have a slight taper, the length of which will depend on its type. This produces a self-centering action as it enters the raw hole. The larger proportion of the length will be of a constant diameter.

Reamed holes are used to create holes of precise circularity and size, for example with tolerances of -0/+0.02 mm(.0008") This will allow the force fitting of locating dowel pins, which need not be otherwise retained in the body holding them. Other holes, reamed slightly larger in other parts, will fit these pins accurately, but not so tightly as to make disassembly difficult. This type of alignment is common in the joining of split crankcase halves such as are used in motorcycle motors and boxer type engines. After joining the halves, the assembled case may then be line bored (using what is in effect a large diameter reamer), and then disassembled for placement of bearings and other parts. The use of reamed dowel holes is typical in any machine design, where any two locating parts have to be located and mated accurately to one another - typically as indicated above, to within 0.02 mm or less than .001". A machine reamer only has a very slight lead in. Because the reamer and work piece are pre-aligned by the machine there is no risk of it wandering off course. In addition, the constant cutting force that can be applied by the machine ensures that it starts cutting immediately. Spiral flutes have the advantage of clearing the swarf automatically but are also available with straight flutes as the amount of swarf generated during a reaming operation should be very small. A morse taper reamer is used manually to finish morse taper sleeves. These sleeves are a tool used to hold machine cutting tools or holders in the spindles of machines such as a drill or milling machine. The reamer shown is a finishing reamer. A roughing reamer would have serrations along the flutes to break up the thicker chips produced by the heavier cutting action used for it.[7]

6.2.9 Dowel Operation

A dowel is a solid cylindrical rod, usually made from wood, plastic, or metal. In its original manufactured form, a dowel is called a dowel rod. Dowel rods are often cut into short lengths called dowel pins. The traditional tool for making dowels is a dowel plate, an iron (or better, hardened tool steel) plate with a hole having the size of the desired dowel. To make a dowel, a piece of wood is split or whittled to a size slightly bigger than desired and then driven through the hole in the dowel plate. The sharp edges of the hole shear off the excess wood. A second approach to cutting dowels is to rotate a piece of oversized stock past a fixed knife, or alternatively, to rotate the knife around the stock. Machines based on this principle emerged in the 19th century. For modest manufacturing volumes, wood dowels are typically manufactured on industrial dowel machines based on the same principles as the rotary cutters described above. Such machines may employ interchangeable cutting heads of varying diameters, thus enabling the machines to be quickly changed to manufacture different dowel diameters. Typically, the mechanism is open-ended, with material guides at the machine's entry and exit to enable fabrication of continuous dowel rod of unlimited length. Since the 19th century, some of these dowel machines have had power feed mechanisms to move the stock past the cutting mechanism. High-volume dowel manufacturing is done on a wood shaper, which simultaneously forms multiple dowels from a single piece of rectangular stock (i.e., wood). These machines employ two wide, rotating cutting heads, one above the stock and one below it. The heads have nearly identical cutting profiles so that each will form an array of adjoined, side-by-side "half dowels". The heads are aligned to each other and one head is shaped to make deeper cuts along the dowel edges so as to part the stock into individual dowel rods, resulting in a group of dowel rods emerging in parallel at the machine's output.

The wooden dowel rod used in woodworking applications is commonly cut into dowel pins, which are used to reinforce joints and support shelves and other components in cabinet making. Some woodworkers make their own dowel pins, while others purchase dowel pins precut to the required length and diameter.

When dowels are glued into blind holes, a very common case in dowel-based joinery, there must be a path for air and excess glue to escape when the dowel is pressed into place. If no provision is made to relieve the hydraulic pressure of air and glue, hammering the dowel home or clamping the joint can split the wood. An old solution to this problem is to plane a flat on the side of the dowel; some sources suggest planning the flat on the rough stock before the final shaping of the round dowel. Some dowel plates solve the problem by cutting a groove in the side of the dowel as it is forced through; this is done by a groove screw, a pointed screw intruding from the side into the dowel cutting opening. Some dowel pins are Fluted with multiple parallel grooves along their length to serve the same purpose. When two pieces of wood are to be joined by dowels embedded in blind holes, there are numerous methods for aligning the holes. For example, pieces of shot may be placed between the wood pieces to produce indentations when the pieces are clamped together; after the clamp is released, the indentations indicate the center points for drilling. Dowel centers are simple and inexpensive tools for aligning opposing blind holes. Various commercial systems, such as Dowel max, have been devised to solve this problem. Alternative joinery methods may be used in place of conventional dowel pins, such as Miller dowels, biscuit joiners, spline joints, and proprietary tools such as the Domino jointer. Dowel pins are often used as precise locating devices in machinery. Steel dowel pins are machined to tight tolerances, as are the corresponding holes, which are typically reamed. A dowel pin may have a smaller diameter than its hole so that it freely slips in, or a larger diameter so that it must be pressed into its hole.

7. FINAL INSPECTION

The Dowell Operation is last one for the tool manufacturing and the tool next goes for visual inspection. In visual inspection the tool is inspected for cracks, unevenness and any other unneeded on tool.

The Figure below shows the completed tool's processes. The tool completed OP 20 and 30 operations in one strike (refer below figure)

Fig 20 Muffler sheet metal manufactured by tool outer body

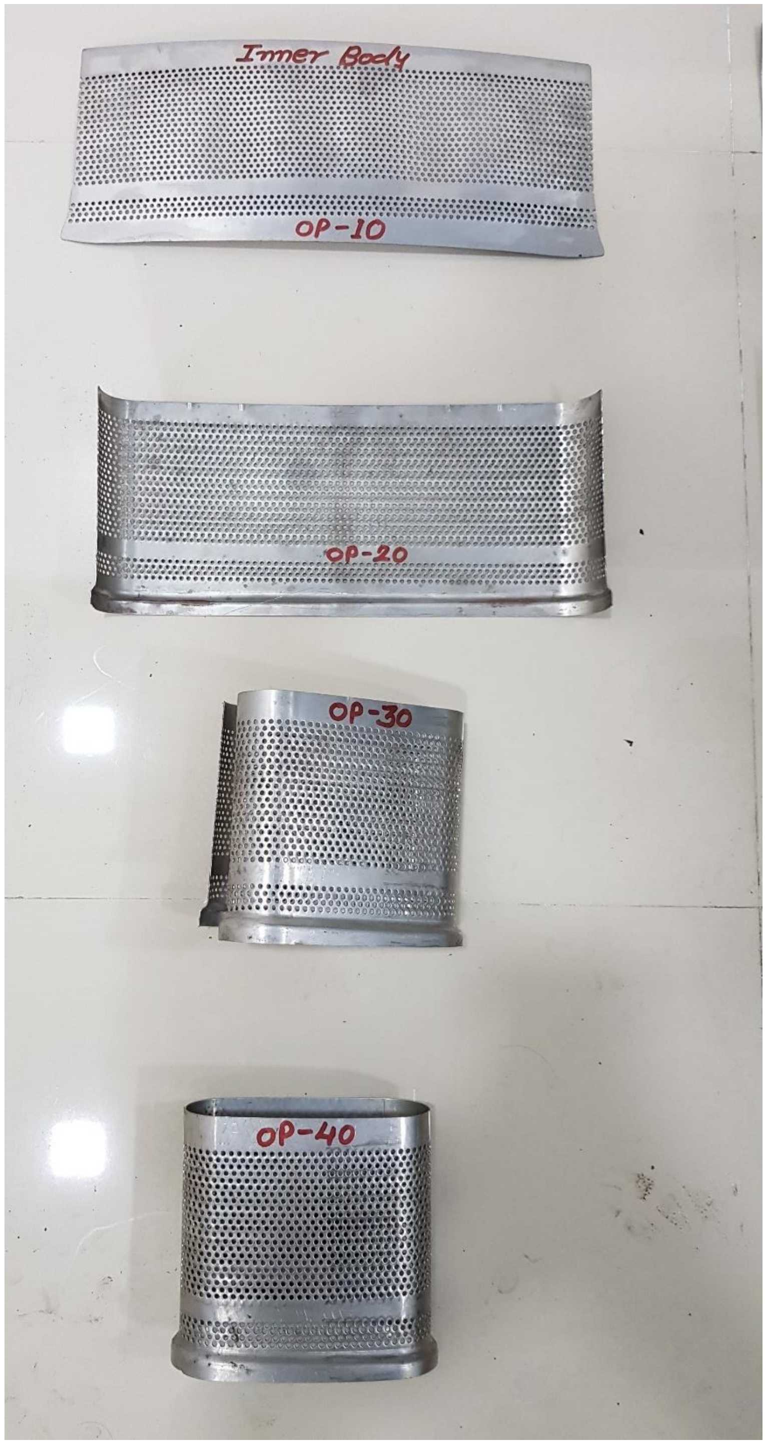


Figure 21 Muffler sheet metal manufactured by tool inner body

8. FINISHED TOOL

The new Dimention of the combined press tool is 1900 × 1200 mm

Fig 22 Finished Tool

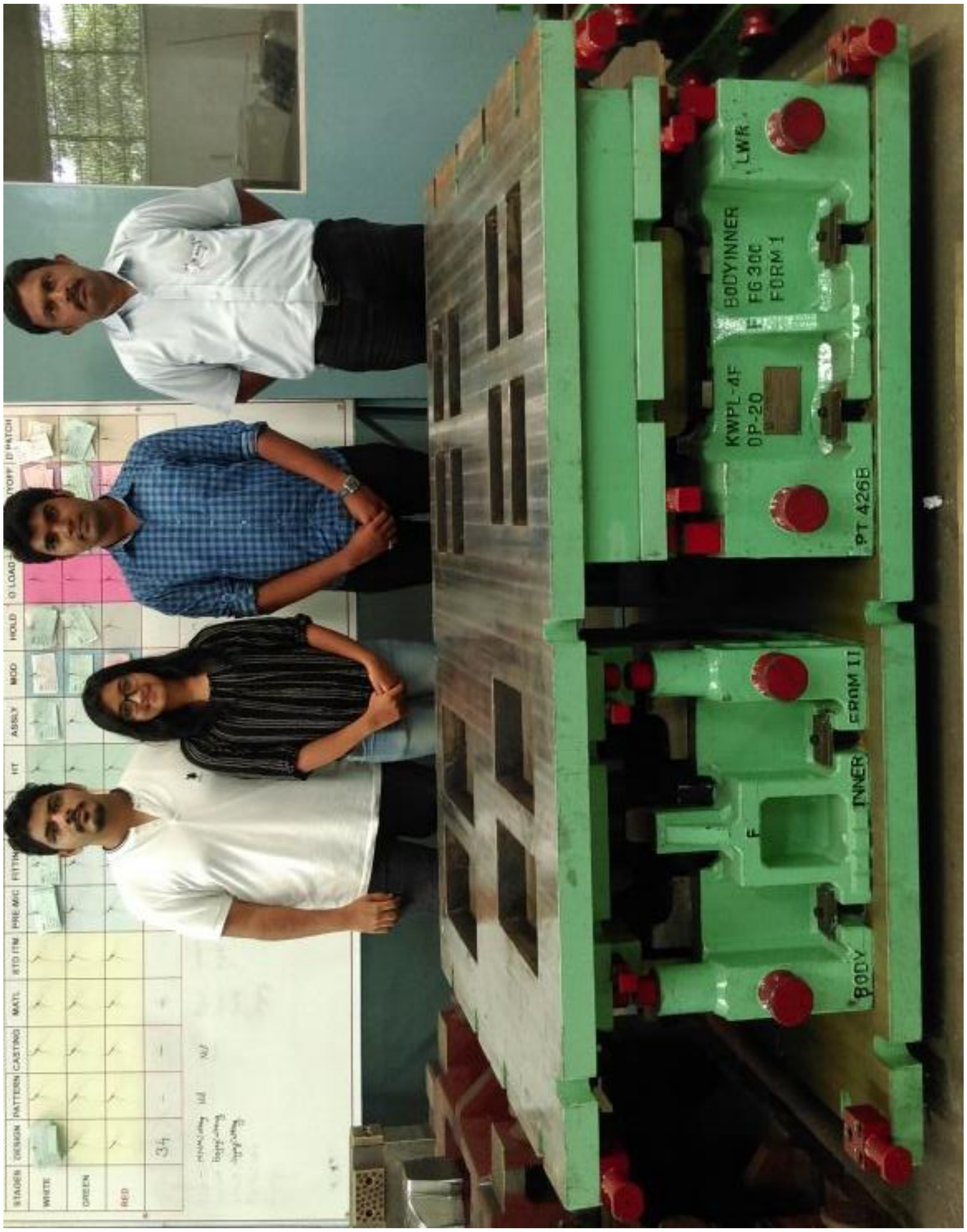


Fig 23 Post project completion photo with Industrial Guide

9. CONCLUSION

The report includes the modification done to the previous press tool to manufacture a new combined one. The operations of the muffler assembly were done on four different press tools and was heavily time consuming and also had an impact on the productivity of the company. The increase in demand of active scooter gave rise more and more order of the mufflers from the vendors, this gave rise to the idea of manufacturing more number of mufflers in less amount of time by manufacturing a new press tools by available designs with slight modifications.

The new press tool manufactured will be cutting time to one-fourth of the current time that is by combining the four strikes of forming one and forming two of inner and outer body respectively. We learned how trivial details like the slight misalignment of the two-combined press tool makes the process easier and does not interfere with the material as well as helps in manufacturing four sheet metals at once. The current manufactured press tool will give satisfactory result of reducing the operation time by 38% and making the muffler production quicker.

In the current design the worker must pick up the molded piece and insert in the next stage which can be eradicated in the future by installing a spring mechanism on the tool and making the sheet metal move with the spring force. This can save even more time and effort and will reduce the danger of hurting the worker while replacing the sheet metal.

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