Design and Fabrication of Multi Process Machine

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Abstarct: In industries materials needs to undergo various manufacturing process during its manufacturing. The material needs to go to various stations throughout the workshop for its machining. The transportation of material requires both energy and resources, if all the manufacturing process are in a single machine then it saves lot of energy and resources which can be used for other functions. So, Multi Process Machine is a combination of various mechanisms in a single machine in which various manufacturing processes (shaping, slotting, drilling) can be executed simultaneous or independently. This project is done as the prototype which is used in the manufacturing industries. In this we can perform three operations at a time.

Keywords: Shaping, Slotting, Drilling, Multi process machine.

1. Introduction

Every material needs to undergo various manufacturing process during its manufacturing. The material needs to go to various stations throughout the workshop for its machining. The transportation of material requires both energy and resources, if all the manufacturing process are in a single machine then it saves lot of energy and resources which can be used for other functions.

So, Multi Process Machine is a combination of various mechanisms in a single machine in which manufacturing process can be executed simultaneous or independently.

As these machines are capable of doing multiple processes, these are desirable in industries. These machines save lot of time and effort for both the workman and the industry. These help improve the efficiency of the industry by both saving time and effort. With the increase in the demand and complexities of the work-pieces the Multi Process Machine helps in reaching the demands and the model requirements with lesser cost, in smaller area, less effort.

Any material normally undergoes shaping, drilling, threading, slotting, welding and various other processes in a workshop during its manufacturing. To perform desired operations power is required which is generated by power source and actuators. The sensors are introduced to monitor the performance of the machines.

Of those shaping is the first process that a material undergoes to remove shape errors in the work-piece. It removes material in large quantities. It helps to make work-piece with only those allowances required for further machining. The shaper is generally used for machining flat surfaces in horizontal, vertical and angular directions.

Drilling is one of the most performed and well known manufacturing process. Drilling is used to make cavities which are used to join various parts together with help of screws, rivets, nut and bolts. Almost all work-pieces coming out of a workshop have undergone drilling. It is estimated that out of all the machining operations carried out, about 20% are hole making operations.

In Slotter the work-pieces which cannot be conveniently held in shaper, can be machined in this. Generally keyways, splines, rectangular grooves are machined in a slotting machine. The stroke of ram is smaller in slotting machine than in shapers to account for the type of work that is handled is them.

These three machining process i.e., Drilling, Shaping, Slotting are important manufacturing process, they are regularly used in industries. A Multi Process Machine having these three manufacturing process seems ideal and desirable for industries. These process are achieved in this machine through Quick Return Mechanism and Stock Yoke Mechanism.

This machine can be modified to satisfy the requirements of manufacturing industries. Body the machine can be made of cast iron to improve strength, and to improve damping capacity. The machine can be made to make each process run independently with a gear arrangement.

2. Background

The operations that the machine can perform depend on different mechanism and principles. Drilling operation is carried out by the rotating of the motor attached to it. Shaping operation requires a fast forward motion and the time for return should be as minimum as possible. Slotting ram should be vertical.

Understanding of the process and tools involved is crucial part to determine what mechanism to implement in the machine.

Drill bit: The drill bit is also called Twist Drill. These drill bits has two cutting edges and spiral flutes which provide clearance to remove chips that are produced by cutting edges and also to allow cutting fluid to reach these cutting edges.

Single point cutting tool: The tool used for shaper is single point cutting tool. The geometry of single point cutting tool is crucial. It consist of face, shank, side cutting edge, end cutting edge, nose, nose radius, end cutting edge angle, side cutting edge angle, back rack angle, side relief angle, end relief angle.

Quick return mechanism: This is also known as Whit-worth Mechanism which is the third inversion. This mechanism is attained by setting the crank i.e. link 2 as a fixed link and the link OQ rotates about O. In the slotted link as shown in figure, the slider slides and leads to generate a circle of radius CP. The rotary motion of P helps to generate reciprocatory motion of ram. The angle covered in cutting stroke is α and in return stroke is β. The mechanism is shown in Figure 1.

$$\frac{Time\ of\ cutting}{Time\ of\ return} = \frac{\alpha}{\beta} = \frac{\alpha}{360-\alpha} = \frac{360-\beta}{\beta}$$

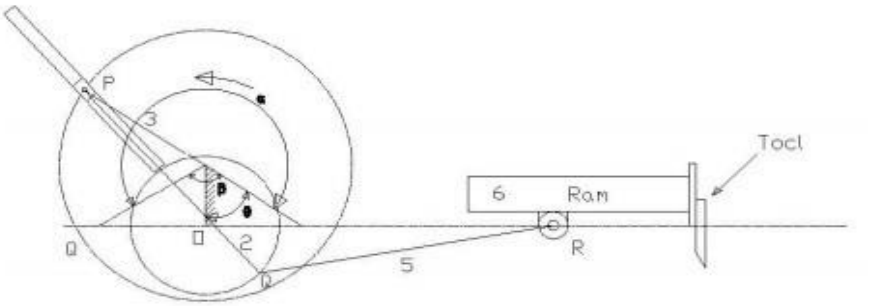

Figure 1: Quick Return Mechanism

Scotch yoke mechanism: The crank and yoke is connected with a pin. The yoke is fitted with bars which act as ram which is the output. When the crank is given rotational motion in clockwise direction, the yoke moves in the forward direction because of the pin which slides in the yoke. The length of the forward stroke is equal to the crank length. In one complete rotation of crank, yoke moves equally in forward stroke and backward stroke. The displacement can be controlled with the variation of the crank length.

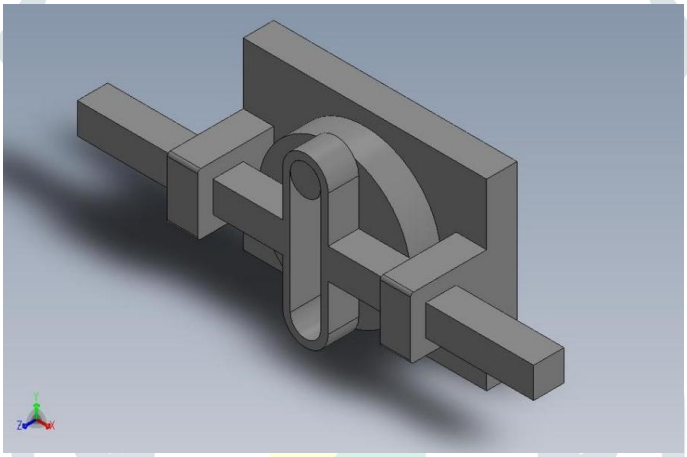

Figure 2: Stock Yoke Mechanism

The reciprocating part is directly attached to a yoke with a slot that engages a pin on the rotating part. The tool is directly coupled with the sliding yoke. The motion obtained over time is pure sine wave when rotated with constant rotational speed. The scotch yoke mechanism is shown in Figure 2.

3. Experimentation

Material: The material used in the machining process is cast iron and mild steel. The DC motor is used to perform the various operations of capacity 0.5HP and 1440rpm. For the shaping operation quick return mechanism is used for the forward and backward strokes. The slider attached to this mechanism will have less velocity and high acceleration, during the time of cutting. This is desirable as more force is required during the time of cutting. A specific pulley arrangement has been introduced into this machine at the input. The necessity arised due to the input rpm, which is high for all the mechanism that are in the machine. The rpm has to be reduced, so a two pulley arrangement has been introduced into the machine. A flywheel is also being used mainly for the slotting mechanism. The forces in this mechanism will suddenly become high during the impact. Flywheel store energy in the form of rotational inertia, the energy will be utilized during the cutting action of slotter.

Figure 3 and 4 represents the arrangement of the mechanism and gears of the Multi Process Machine. The machine is able to perform Drilling, Shaping and Slotting. The machine has a body made of mild steel angles. Power required to perform the processes is given by a 0.5 HP motor. The power is transmitted to the main shaft through a pulley and flywheel arrangement to alter the rpm provided by the motor. Shaper and Slotter require less rpm

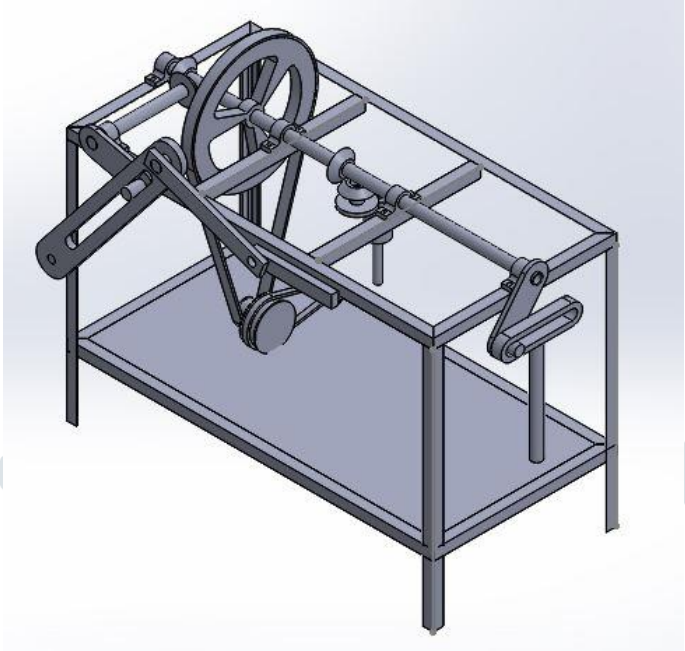

Figure 3: Multi Process machine

Whereas drilling requires relatively high speed so a gear train has been added to increase the rpm of drill bit. The machine also includes vices to hold the work-pieces.

The ball bearings are arranged to attach the shafts to the frame and this are bolted to the frame. The motor is connected to the main shaft with the belt drive arranged to reduce the rpm of the motor. This main shaft is connected to the two sub shafts helps to drive the drilling and shaping mechanism. From the main shaft, the torque is transmitted to the drilling shaft and shaping machine shaft. The slotting machine is directly connected to the main shaft.

The gear ratio is arranged accordingly that it increase the drilling shafts rpm. At the end of the main shaft slotting mechanism is arranged and two sub shafts are attached with the shaping mechanism and drill bit. And to hold the job we are using two bench vices and one fixed die for the machine. At the slotting machining we are using the die to hold the job. The single axis bench vice is using at the drilling machine that helps to move the fixed job up and down below the drill bit. Fixed bench vice is using to hold the job at the shaping machine.

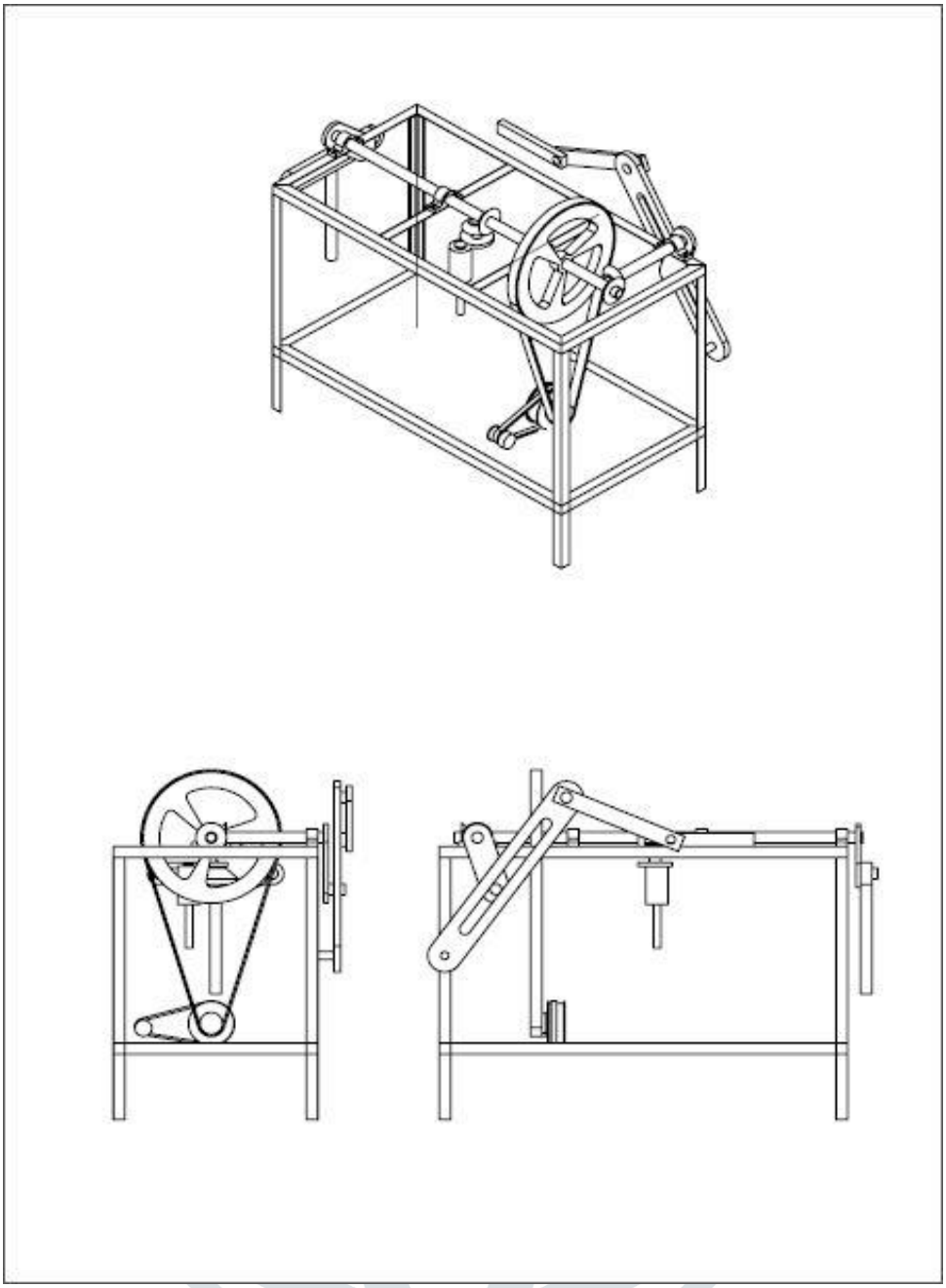

Figure 4: Draft View of Machine

We use L-beam for the frame making. It cut with the abrasive cutting blade with the size of 4 inch with the help of metal cutting machine. And this frame parts are joined by the nut and bolt at the ends. With the help of vertical axis drilling machine we drill the holes for the L-section. And this are bolted to make a frame. For the frame the ball baring are attached with the shafts and then this shafts are continued with their respective mechanism. Figure 5 shows shafts and mechanisms used in the machine.

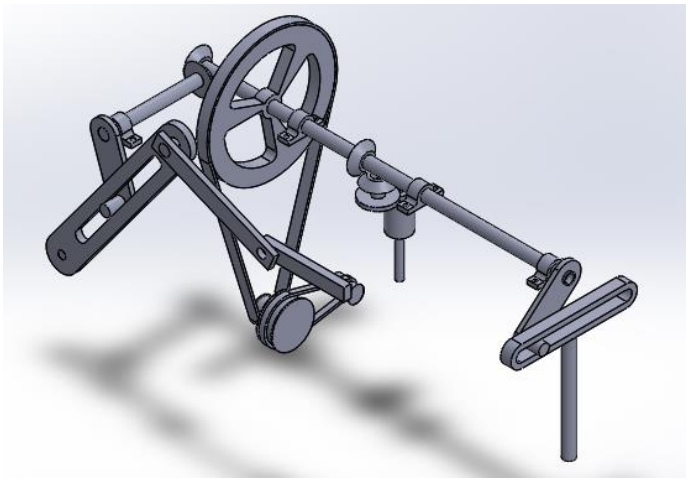

Figure 5: Shafts and mechanisms

Machine body: The body of the machine shown in Figure 6 is the most important structure of any machine. All the parts of the machine are to be mounted on the body. Body will be taking all the weight load of all the parts in the machine, loads during the working i.e., dynamic loads, vibrations during the working of the process and a few kinds of loads. The body of the machine can be formed in two ways.

Figure 6: Machine Body

First method is to make the whole body of one piece, so that there is no unnecessary stress in the body because of welds or joints. The other method is to use bars or angles and join them. The second method of making a body is prone to less vibrational strength and it may residual stresses present in it even before its first use. In second method those disadvantages can be overcome by increasing the factor of safety.

In this project of Multi process machine we are using the second method i.e., joining the individual iron angles into a frame to support the mechanisms, The angles used in this are of Mild Steel and with dimensions 1”x1”x0.625”.

Dimensions are 3’x1.2’x2’ (length x breadth x height)

Flywheel arrangement: The dimensions of the input shaft is 1.5 inch, the diameter of the flywheel is 12 inch. The power transmitted to the main shaft is 0.5 Hp which is equivalent to 373W. The motor which is used as input provides an rpm of about 1440. The output rpm is 90 i.e., rpm of main shaft.

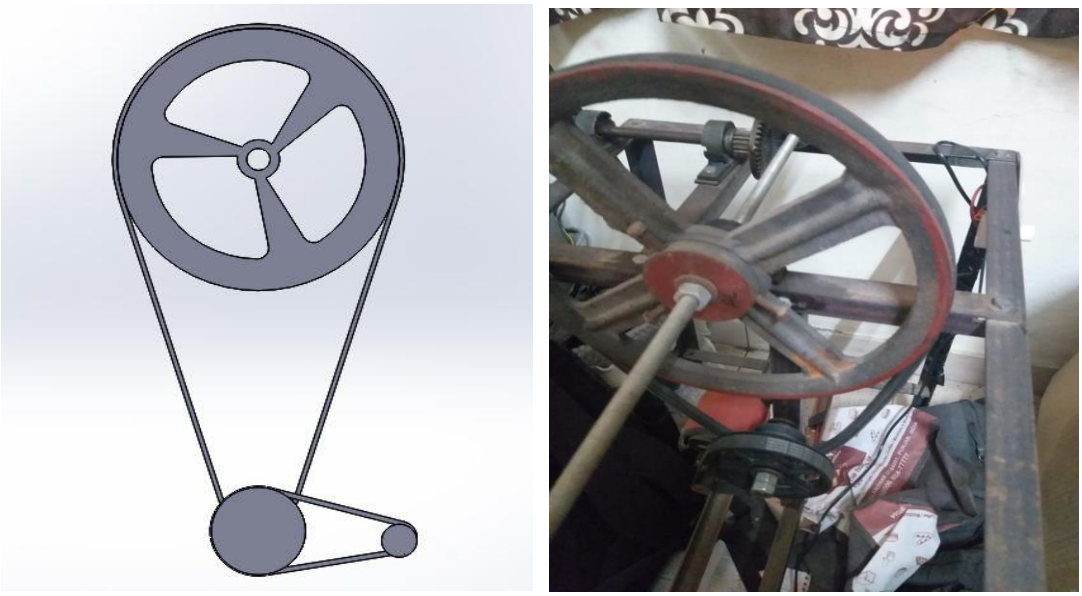

Figure 7: Flywheel Arrangement

The rpm provided is very high for any mechanism present. It must be reduced so as to put to use. This arrangement uses a two pulley arrangement, where one of the pulley is replaced with Flywheel. Flywheels act as a bank of energy .The Slotter process has to produce large force suddenly, this resisting force has the ability to causes a sudden pause in the rotation. With the help of flywheel, the stored energy is utilized at that time and to help to have a smooth rotation of the main shaft and to reduce fluctuations. The flywheel arrangement is shown in Figure 7.

The energy is stored in the flywheel in the form of rotational energy.

$$W = \frac{1}{2} \mathrm{I_m} \omega^2 \quad \text{Where,}$$

$$I_m = \int_m r^2 dm$$

$$\omega = 2\pi n_m$$

Here 'm' is the mass of the flywheel, 'n_m' is the rpm of the flywheel, W is the energy stored in the flywheel.

Drilling arrangement: Drilling arrangement (shown in Figure 8) here is an 8mm drill bit which rotates with a rpm of nearly 315. A gear arrangement has been used so as to increase the rpm of drill as it cannot work at small rpm.

Figure 8: Drilling Arrangement

The main shaft is connected to a bevel gear pair. Bevel gear pair is selected because the motion is required perpendicular to the shaft. The bevel gear which is vertical is connected to a spur gear pair to increase the rpm of the drill bit.

The spur gear pair has one gear of 3 inch diameter and the other gear is 1 inch diameter, gear ratio of the pair is 3.5.

Gear Ratio (G) = 3.5

Rpm of the shaft (N_1) = 90 rpm

Rpm of second shaft (N_2) = N_1 x G

N_2 = 3.5 x 90

N_2 = 315 rpm.

Shaper arrangement: A single point cutting tool is fixed in the tool holder, which is attached to the ram. The work piece is clamped to the table. The tool is attached on the tool holder, the tool reciprocates, the material is cut in the forward stroke and idle in the return stroke. The arrangement is shown in Figure 9.

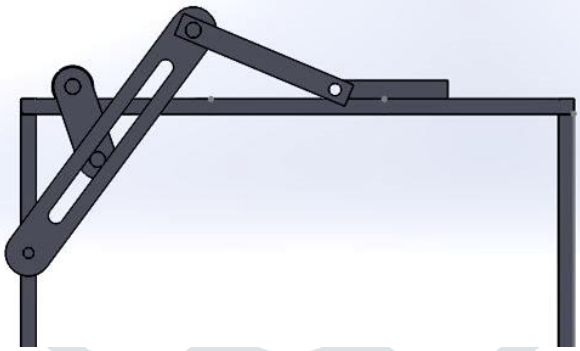

Figure 9: Shaper Arrangement

$$\frac{Time\ of\ cutting}{Time\ of\ return} = \frac{\alpha}{\beta} = \frac{\alpha}{360-\alpha} = \frac{360-\beta}{\beta}$$

Length of the ram is 9 inches. The mechanism will be made to produce 2 to 2.5 length of cut.

Slotter mechanism arrangement: In this mechanism arrangement the main shaft is directly attached to the crank which is connected to yoke. The yoke has a movement which is in the form of a sine wave. The yoke will require a high force during the slotting process. The energy is provided to it by the flywheel which has been introduced mainly to satisfy this function the length of the ram used is 10” long. The mechanism is shown in Figure 10.

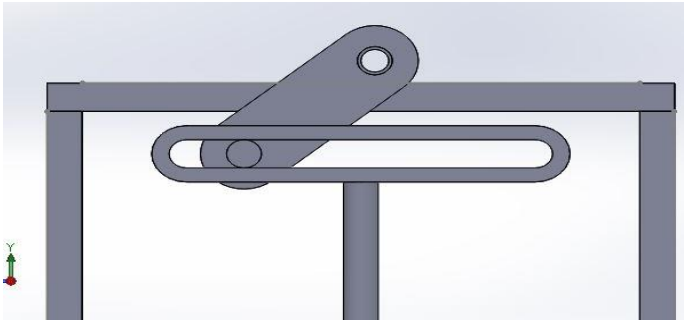

Figure 10: Slotting Mechanism arrangement

The form of output of the stock yoke mechanism i.e., the output of slotter machine is

$$x = A\sin\phi$$

$$x' = A\omega\cos\phi$$

$$x'' = -A\omega^2\sin\phi$$

Where ϕ is the angle of the crank, ω is the rpm of crank and A is the length of the crank.

4. Result and Discussion

The machine is expected to perform all the three manufacturing process Drilling, Shaping, Slotting simultaneously. The machine will run on Single Phase Motor of 0.5HP capacity. All the process are expected to receive power through the Gear Trains which are connected to the main shaft. The Flywheel is used to store and provide power to the slotter during the slotting process.

This machine will be able to perform Drilling, Slotting and Shaping using a motor as power source. The machine is designed so that it can reduce time and energy wasted during transportation of work-pieces during manufacturing. This machine is very useful for the industries where there is a frequent change in operation required. Multi Process Machine is desired by industries, as using them is cost effective and energy efficient.

5. Conclusion

The project focus on the principle of scotch yoke mechanism and Quick Return Mechanism, type of tooling with different type of equipment's which can run simultaneously and fabricate the work-piece. In multipurpose machine results can help to plan the machining of work piece with allowable tolerance.

The vital need for the fabrication of a multipurpose machine is significant. Also, multipurpose machine will helps to reduce the cost and consequently increase the rate of production and craftsman's skill.

Summarizing the project, it performs three manufacturing process Drilling, Shaping, Slotting in a single machine simultaneously. The whole body is made of mild steel because it is easily machinable. It is equipped with 0.5 HP Single Phase Motor to provide the power for all process. The power is first transmitted to flywheel through a belt. Flywheel is attached to a main shaft which is having bevel gears to transmit power to the mechanisms which perform the machining process. Drilling gets input directly, whereas to perform shaping and slotting, quick return mechanism and stock yoke mechanism are used.

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