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Design & Manufacturing of Feeding Mechanism for Horizontal Grinding Machine

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***Abstract* - This paper intend to focus on the replacement existing feeding mechanism of horizontal grinding machine used for rough grinding of piston rings of various dimensions also increase in productivity , introducing to easier mechanism and more economical. For this purpose studied various mechanisms, among of these magnetic wheel feeding mechanism is selected for the operation. This paper also focuses on designing and modeling is of the same using CATIA V5 software.**

Keywords: Feeding Mechanism, Rough Grinding M/C.

1.1 INTRODUCTION-

In operation, old feed mechanism type of grinding machine desirable that the feed mechanism should be organized so that it brings the grinding wheel & the work rapidly into close proximity and thereafter to permit a relative feeding movement of work and wheel, slowly and with great precision for perfection the grinding operation. After this has been completed, it is desirable to effect a rapid separation of the work and the wheel to permit the removal of the ground work piece.

For the above purpose different types of feeding mechanisms being used in various kinds of machines. From the study of the mechanisms have selected best suited for the needs of the machine. The older chain feeding mechanism proved to be outdated & costly. So, magnetic wheel feeding mechanism is selected for designing & manufacturing.

1.2 Grinding-

Grinding is the process of removing metal by the application of abrasives which are bonded to form a rotating wheel. When the moving abrasive particles contact the work piece, they act as tiny cutting tools, each particle cutting a tiny chip from the work piece. It is a common error to believe that grinding abrasive wheels remove material by a rubbing action; actually, the process is as much a cutting action as drilling, milling, and lathe turning.

Surface Grinding-

Surface grinding or grinding flat surfaces, is characterized by a large contact area of the wheel with the work piece, as opposed to cylindrical grinding where a relatively small area of contact is present. As a result, the force of each abrasive grain against the work piece is smaller than that applied to each grain in cylindrical grinding. In surface grinding the grinding wheel should be generally softer in grade and wider in structure than for cylindrical grinding.

Standard types of grinding wheels:- Grinding wheels come in many different sizes, shapes, and abrasives.

1. Straight- Straight wheels are commonly applied to internal, cylindrical, horizontal spindle, surface, tool, and offhand grinding and snagging.
2. Cylinder- Cylinder wheels, type number 2, may be arranged for grinding on either the periphery or side of the wheel.
3. Tapered- Tapered wheels, type number 4, take tapered safety flanges to keep pieces from flying if the wheel is broken while snagging.
4. Straight Cup- The straight cup wheel, type number 6, is used primarily for surface grinding, but can also be used for offhand grinding of flat surfaces. Plain or beveled faces are available.

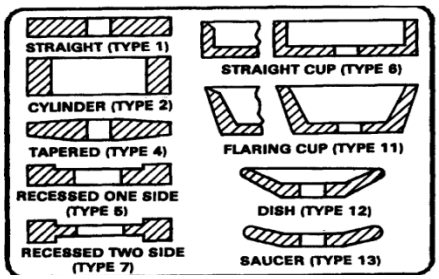


Fig 1. Types Of Grinding Wheels

5. Flaring Cup- The flaring cup wheel, type number 11, is commonly used for tool grinding. With a resinoid bond, it is useful for snagging.
6. Dish- The chief use of the dish wheel, type number 12, is in tool work. Its thin edge can be inserted into narrow places, and it is convenient for grinding.
7. Saucer- The saucer wheel is also known as a saw gummer because it is used for sharpening saws.

1.3 Relevance-

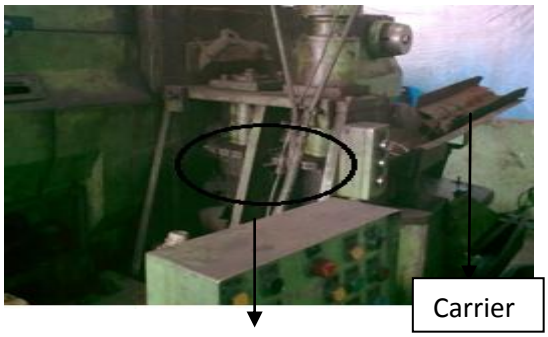
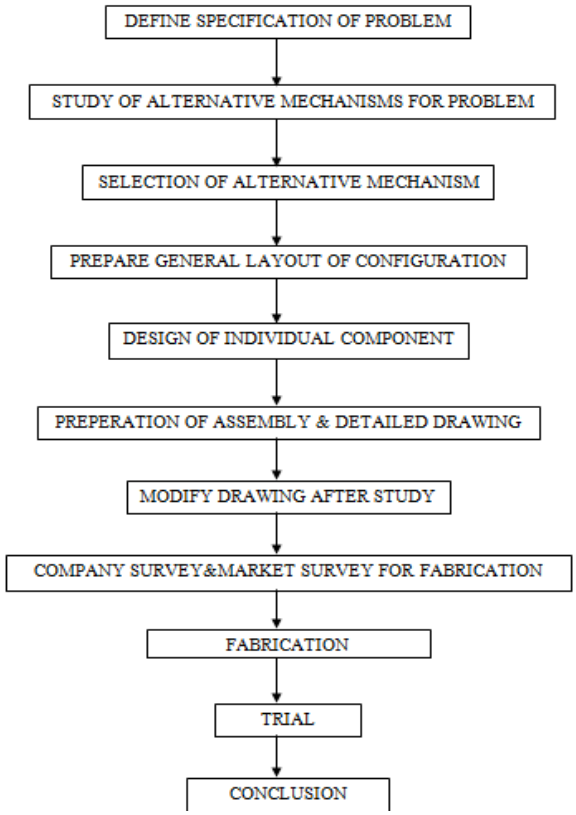


Fig2. Chain Feeding Mechanism

There is horizontal rough grinding machine which is used to grind varieties of piston ring. The piston ring diameter ranges from 70 mm to 160 mm. In this machine chain feeding mechanism is used to transmit the rings for carrier to grinding wheels but due to chain feeding mechanism various difficulties was occurred and it is not possible to pass the maximum nos. of ring through grinding wheels hence it reflect on productivity and output, also there is numbers of disadvantages like low feed rate, difficult to feed, low efficiency, less effective, high power consumption, high cost of production, higher breakage of piston rings, high maintenance cost, more time required to complete the operation.

1.4 New feeding mechanism (Flow chart)-



i) Define specification of problem- Define what is the problem associated with old mechanism. i.e. machine is horizontal grinding machine having chain feeding mechanism.

ii) Study of alternative mechanisms for problem- Study of different types of feeding mechanism like through feed, swing arm etc.

iii) Selection of alternative mechanism-
Selection of possible alternatives i.e. magnetic feeding mechanism is best suitable alternative for the machine from all aspects.

iv) Prepare general layout of configuration:
Selection of appropriate mechanism for the machine supposed to prepare a general layout for the whole grinding machine.

v) Design of individual component:

vi) Manufacturing of mechanism as per the design.

vii) Assembly of component and Trial is done on mechanism studying by various parameters like speed of magnetic wheel, speed of grinding wheel, coolant rate, coolant concentration etc.

1.5 Survey, Study & Selection Of Different Mechanism-

1) Through-feed (thru-feed) Mechanism-The mechanism is simplest of all. The piston rings are supposed to feed manually to the machine by a continuous force. The system actually suits simple shaped work pieces. The feeding system has high efficiency for mass production.

Fig 3. Through-Feed

2) Rotary Carrier Mechanism-The mechanism is designed for irregular shaped work pieces. The component is to be fed to the rotating carrier which in turn feeds the components to the grinding machine. The mechanism comprises of a carrier that momentarily carries the component to the grinding machine. The efficiency is moderately high.

Fig 4. Rotary Carrier

3. Gun-feed Mechanism-The mechanism is in itself a special mechanism usually used for feeding oddly-shaped work pieces and work pieces which require partial-surface grinding. The efficiency is lower than the above mechanisms. The mechanism comprises of a ‘gun’ as shown in the adjoining figure. The gun is supposed to feed the component to the grinding machine. The components are fed manually to the gun.

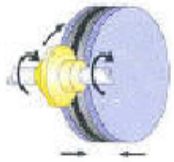


Fig 5. Gun Feed

4. Swing-arm Mechanism-This mechanism is very rarely used. The mechanism is used for feeding for intricate work pieces and those which require end face grinding. The efficiency of this mechanism is the least. Also the cost of this system tops the charts. As shown in the figure, there exists a swing arm to feed components to the grinding machine at a required rate. The swing arm reciprocates between the two end positions to feed the component.

Fig 6. Swing Feed

5. Carrier Plate Feed Mechanism:-In this type of feeding system, the component to be grinded is fed to the machine using a circular shaped carrier plate (i.e a disk). The disk has pockets of the shape of the component to be grind. The plate while rotating goes into the grinding machine & gets the component grinded. The thickness of the carrier plate is less than the finished product width by 0.5 mm, so that there should not be any contact between the carrier plate and the grinding wheels.

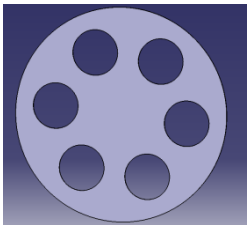


Fig. 7 Carrier Plate

6. Belt Drive- The component to be grind is fed to the grinding machine with the help of a mechanism that is driven with the help of belt drive. The efficiency of this mechanism is very low. & it is very less used these days.

7. Magnetic Wheel- The component to be fed is stuck on the magnetic wheel that rotates & feeds the component to the grinding machine. The mechanism is pretty simple & also has proved to give high production rate. The wheel is driven by a motor &the speed is adjusted with help of a gearbox.

2. DESIGN OF FEEDING MECHANISM:

2.1 Design of Magnetic Wheel-The wheel should be thick enough to carry magnetic studs of dimensions D12 x 18 mm. So, Thickness of magnetic wheel = length of magnetic stud + back clearance= 18 + 10= 28 mm.

Now, Diameter of the magnetic wheel = 2 (Dia. Of ring + shaft radius + space consumed by guide plate + lower supporting plate width + clearance)

= 2 (158 + 25 + 30 + 60 + 20)

= 2 x 285 = 570 mm

But, in market, we are not available with the wheel of dimensions, D570 x 28 mm thick. The standard closest size available is D600 x 33 mm thick. The material of the wheel is Stainless Steel.

Specifications of the Magnetic Stud-

1. Permanent Magnet
2. Dia. = 12 mm
3. Length = 18 mm
4. Magnetic Power = 2 kg/ mm^2
5. No of studs = 200

2.2 Designing of RPM of Magnetic wheel condition-Time required for grinding machine operation is 1.5 seconds as per machine the specifications. So we have to design mechanism in which ring remains in contact with grinding wheel about 1.5 sec. So we have to take 20 RPM of magnetic wheel which gives near about 1.5 seconds feed, illustrated as below.

To keep continuous feeding the travel of ring on magnetic wheel should be for 1.5 sec. in figure let the ring is stickled at point 'S' on magnetic wheel & is feed at point 'F' which is at diametrically opposite position..

This implies that half rotation of wheel should take 1.5 sec.

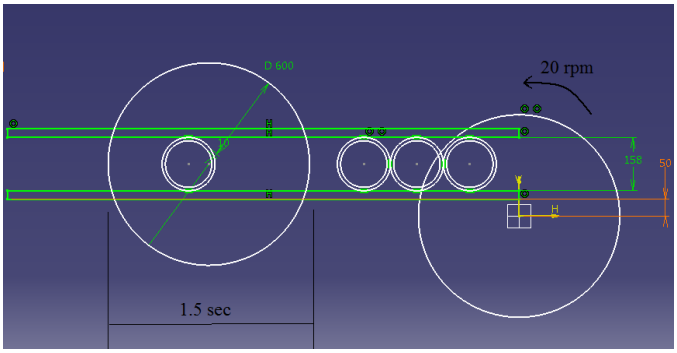


Fig.8 (A) Feeding Mechanism

Hence, Revolution = 0.5 / 1.5 sec.

Revolution / second = (1/3) sec.

Revolution / minute = (60 / 3) = 20 rev / min.

2.3 Designing of No. of passes per shift -

Calculate the no. of rings passes by mechanism i.e. time required to travelling of ring from A to B as shown in the figure below.

Time for travel between A & B =

(Time required for A to C) + (time required for C to B)

$2\pi \rightarrow 3$ sec.

(angles in radian)

$\frac{11\pi}{18} \rightarrow t_1$ sec.

$$\frac{2\pi}{11\pi/18} = \frac{3}{t_1 \text{sec.}}$$

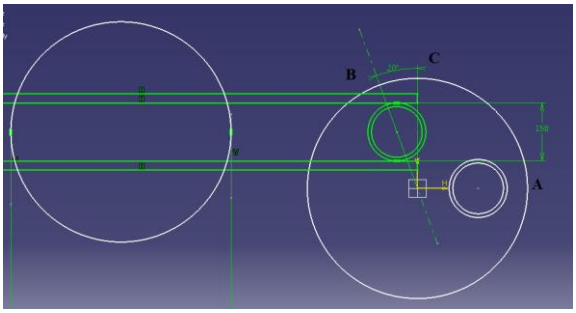


Fig.8 (B) Feeding Mechanism

Therefore, $t_1 = 0.916666$ sec.

This is the time required by ring from sticking point to feeding point.

So, No. of rings passed in one shift(8 hrs shift)

= (no. of sec available in a shift) / (time required for one ring)

$= \frac{3800 \times 8}{t_1} = \frac{28800}{0.91667} = 31418$ rings / shift.

2.4 Calculation of Power Requirement- The magnetic wheel is rotated by using the motor. The motor has to work against the mass moment of inertia of the magnetic wheel. Thus the power requirement can be estimated as described below.

We know that the torque required to rotate the wheel is given by, $\tau = I * \alpha$ ----- (1)

For wheel rotations about axis through center

$I = \frac{MR^2}{2}$ ----- (2), $I = \frac{63 * 0.3^2}{2}$

The wheel is rotated from rest to maximum speed of $N_{max.} = 20$ rev/ sec.

As the wheel is to be rotated instantly the time required for this speed change is assumed as 0.01 sec.

So, Angular Acceleration (α) = $\frac{W_{max} - W_0}{Time}$

$\alpha = \frac{2\pi N_{max}}{60 * Time}$, $\alpha = \frac{2\pi * 60}{60 * 0.01} = 209.49$ rad/sec^2

Torque = $I * \alpha = 2.835 * 209.49 = 593.904$ Nm

Power = $\tau * \omega = \frac{\tau * 2\pi}{60} = 1243.8699$ watt = 1.66 HP

Motor power = 2.37 HP

Selecting the nearest possible value we have,

Motor capacity = 3HP, (The surplus power will accommodate the frictional and maximum load conditions).

2.5 Design of Guiding Plate

Here we are going to use four guide plates. For its dimensions we have to consider following criteria:

1. It should have thickness more than the thickness of unfinished ring.
2. Its inner diameter is equal or less than magnetic wheel.
3. It cannot use more space of magnetic wheel.

- Thickness of the guide plate = $T_G = T_{ring} + 0.7$ mm.
- Diameter of the guide plate $\leq$ (diameter$_{mag.wheel}$ - 20) mm.
- Angle of the guide plate = 40^0.

The material used will be C.I. of Sut = 100 N/mm^2

2.6 Determination of Central Distance between Magnetic & Grinding Wheel

Central distance between the magnetic wheel & grinding wheel = Grinding Wheel radius+ Magnetic Wheel radius + hand wheel width + clearance =

300 + 300 + 300 + 25= 925 mm

2.7 Design of Supporting Plate-

The supporting plate is the plate that supports the piston ring through the machine till the end of the grinding machine. As the piston ring is in contact with the supporting plate at the time of grinding also, the thickness of the supporting plate cannot be equal or greater than that of the finished piston ring. Otherwise there will be contact between the supporting plate and the grinding wheels of the grinding machine, affecting the grinding operation of piston ring.

Thickness = Finished ring thickness – 0.5 mm.

Width = 60 mm.

Length = Center of magnetic wheel to end of outlet.

= Centre dist bet^n MW & GW + GW Radius + outlet length from GW end

= 925 + 300 + 300 = 1525 mm.

The material to be used for the supporting plate is Steel 30 C8 of Syt = 400 N/mm$^{2.}$

2.8 Determination of MW Height from Shop Floor

The height of the magnetic wheel should be so adjusted that the ring when passed from the magnetic wheel should go to the centre of the Grinding wheel. So the vertical distance between the centers of the two wheels (i.e. MW & GW) is calculated as follows.

Height of GW from shop floor = 1110 mm (i.e. measured)

Height of MW from shop floor = Height of GW centre from shop floor – (X) = 1110 – X (mm)

Where, X = Radius of ring + (Width of guide plate) + shaft radius & clearance = 79 + 60 + 45 + 10 = 194 mm.

Hence, Height of MW from shop floor = 1110 – 194 = 916 mm.

3. NEW MAGNETIC WHEEL FEEDING MECHANISM INCLUDES FOLLOWING PARTS:

A) Magnetic Wheel B) Guide Plate C) Motor & Gear Box D) Tray To Carry Rings Towards The Magnetic Wheel E) Frame F) Supporting Plate G) Hand wheel Mechanism.

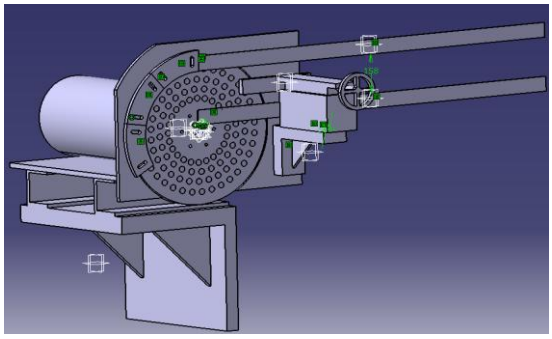


Fig.9 Assembly of Magnetic Wheel Mechanism]

3.1 Construction-

*1) Magnetic Wheel:-*The Magnetic wheel is circular in shape having 600 mm diameter and thickness of 88 mm. The Magnetic wheel is made up of M.S. On the M.S. plate the shoe magnets are attached at regular intervals. The diameter of shoe magnets is 16 mm and thickness is 20 mm. The flux of single shoe magnet is 2 kg/mm^2. There are 200 such shoe magnets are inserted in the M.S. circular plate.

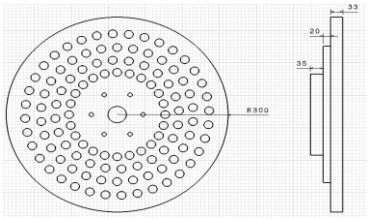


Fig.10 Magnetic Wheel

2) Frame:

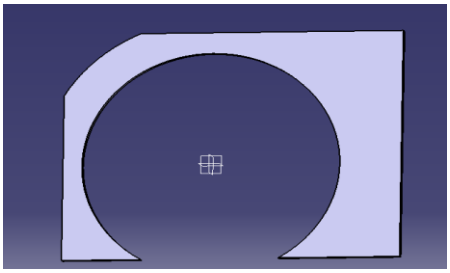


Fig.11 Frame

It is important component in construction of overall mechanism. The frame supports the magnetic wheel, guide plate. It is directly welded on the machine body. The frame is cut into shape from a metal sheet. The guide plate is attached on the frame only with the help of adjustable screws.

3) Guide plate: - It is a plate having circular shape fixed to frame. Its function is to guide the piston rings properly to the Grinding wheels. The piston rings being attached on the magnetic wheel are guided in angular direction by these guide plates. Here 3-4 such guide plates to guide the rings to the grinding machine. As these plates are adjustable, it is easy to compensate for the ring diameter variation.

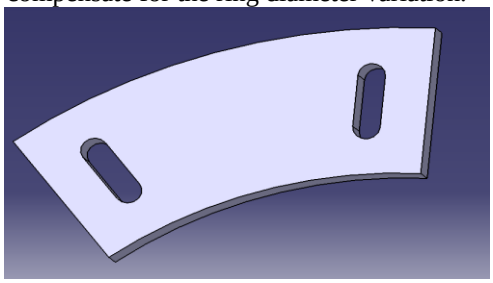


Fig. 12 Guide Plate

4) Supporting Plate: There are two supporting plates between the two grinding wheels. These plates are extended from the centre of the Magnetic wheel through to the end of the machine. Its function is to support the piston ring between the Grinding Wheels at the time of operation. The length of support plate is 1525 mm. with 25 mm width. Thickness of support plate is 0.5 mm less than the thickness of piston rings.

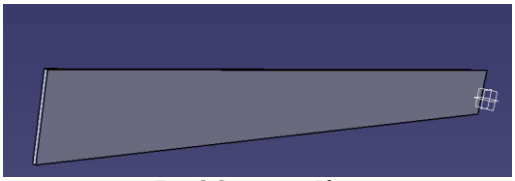


Fig.13 Supporting Plate

5) Hand wheel:

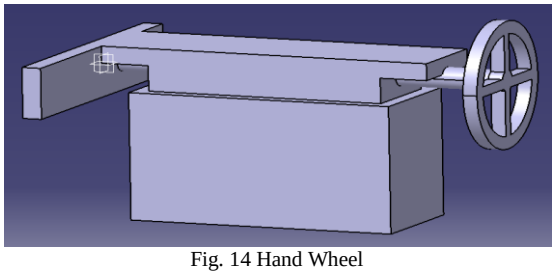


Fig. 14 Hand Wheel

It is very important component in feeding mechanism which is used to compensate width of ring as per requirement .Instead of going for a new Hand wheel mechanism we have to use pre-existing mechanism. It is made up of cast iron material. The hand wheel mechanism consists of a lead screw. So, by revolving hand wheel we adjust the width of ring. That mechanism avoids overlapping of piston ring by which failure of machine is avoided. It also provides lateral support to the piston ring to keep the piston rings in track. The hand wheel guide is closely fitted to the machine opening.

Tray: Tray is in 'V' shaped. The rings are placed in the tray, and then rings are manually pushed towards the magnetic wheel.

Working: - As we start the machine, the electric motor starts rotating. The gearbox coupled to the motor transmits the rotations to the shaft connected to the gearbox. As the speed of motor is much higher so we used worm and worm wheel for higher speed reduction. The magnetic wheel mounted on the shaft also rotates. The direction of rotation of magnetic wheel is towards the grinding wheel. The rings placed in the tray are manually pushed towards the magnetic wheel. As the M.S. circular plate is magnetized due to magnetic flux of number of shoe magnets, the piston rings of C.I. is stuck to the magnetic wheel which is rotating. These rings are then passed towards the grinding wheel with the help of guide plate & support plate. Then these rings are ground by the grinding wheels in the double disk horizontal grinding machine.

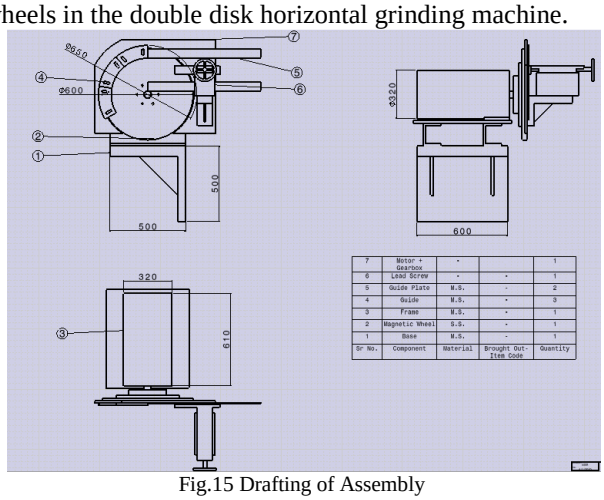


Fig.15 Drafting of Assembly

4. Manufacturing, assembly and Testing- So, as per the drawings of details and assembly, manufacturing with assembly is done. Nos. of trails is carried out on mechanism to check its functioning. For this purpose we took a trial run and observed the various parameters. The results of the trial run are as discussed below.

i. Ring diameter = 158 mm.
ii. Motor Speed = 940 rpm.
iii. Magnetic Wheel Speed = 17 rpm.
iv. Coolant = Starmax.
v. Time required for feeding a single ring = 1.05 sec
vi. Cycle time for single piston ring = 1.05+1.5= 2.55 sec.
vii. No. of damaged piston rings = 37 per shift.
viii. Output rate = 27,428 rings per shift.

For magnetic Wheel speed of 17 rpm, the total no of passes per shift was observed to be 27,428. This was due to the fact that though the theoretical speed of magnetic wheel was calculated to be 20 rpm, we were not able to get the speed above 17 rpm. Because heat generation rate is found very high for speeds above 17 rpm, which require more coolant & causes more damaging of rings.

Conclusion-

This paper attempts to give an overview of the new FEEDING MECHANISM for Horizontal Grinding machine to increase production rate. The mechanism giving very efficient solution for physical problem is presented here. New feeding mechanism is more efficient than the old mechanism. This paper also intends to develop design skills using CATIA V5 and an opportunity to face the problems that occur during designing & manufacturing a component or a machine.

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