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Centrifugal Orienting Feeder

N.Mahesh Babu
B.Tech (Mechanical Engineering), Hyderabad Institute of Technology and Management y, Hyderabad, Telangana, India.

P.Naveen Reddy
B.Tech (Mechanical Engineering), Hyderabad Institute of Technology and Management y, Hyderabad, Telangana, India.

R.Sreevardhan Reddy
B.Tech (Mechanical Engineering), Hyderabad Institute of Technology and Management y, Hyderabad, Telangana, India.

R.L.Krishna Sagar
B.Tech (Mechanical Engineering), Hyderabad Institute of Technology and Management y, Hyderabad, Telangana, India.

Venkata Phani Babu.V
Assistant Professor, Department of Mechanical Engineering, Hyderabad Institute of Technology and Management y, Hyderabad, Telangana, India.

Abstract:

Centrifugal feeders also referred as 'rotary feeders', have a conical central driven rotor surrounded by a circular bowl wall. The feeder separate component parts utilizing rotary force and the parts revolve with high speed and are pulled to the outside of the bowl. A rotary orienting feeder is configured for singulating/orienting bulk volumes of articles. The feeder includes a rotatable driven feed disc, and a rotatable driven orienting bowl assembly which is positioned generally about the feed disc.

The feed disc is driven about an axis which angularly intersects an axis about which the bowl is driven, whereby during operation articles are transferred from the feed disc to an upper flange portion of the bowl assembly. An outer guide fence, which may be provided with suitable tooling, cooperates with the bowl and the articles carried thereby to effect singulation/orientation.

INTRODUCTION:

A prominent problem in manufacturing automation is the accurate and reliable presentation of small parts, in a desired orientation, to a work cell. This is often referred to as the parts feeding problem. A part feeding system is the proverbial black box with the parts entering the system in arbitrary orientations and exiting the system in a single specified final orientation. These part feeing systems implement a plan: a sequence of filters or gates that push, rotate and even drop parts until they reach the desired orientations. An efficient part feeding planner has the filters sequenced so that most of the entering parts, exit the system in the desired orientation. Methodologies to develop efficient manufacturing assembly lines include sophisticated computer vision based been picking, manual loading of pallets, trays or magazines and the design of the specialized feeding machines- all seemingly necessary components of the automated manufacturing assembly lines. For many types of automated manufacturing equipment, there is a requirement to supply them with parts which invariably need to be presented in a single orientation.

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Parts feeders are used for this purpose. A part feeder, which singulate and orient the part prior to packing and insertion, are critical component of an assembly line and one of the biggest obstacles to flexible assembly. The methods and technologies of moving component parts of an assembly into the transfer and insertion station on the assembly machine. While in motion, parts encounter various orienting devices such as wipers, scallops, narrow track, air jets, etc., in a centrifugal bowl feeder. Parts that are moving in undesired orientations will be rejected by these orienting devices and re-circulated, whilst those moving in the desired orientation are allowed to reach the output section of the parts feeder. In mass production, when the volume of a particular part is high, the most common method employed is to use centrifugal bowl feeders.

It is a device that receives a number of random oriented parts at its input and delivers them in a desired orientation at its output. The fabricated part arrives at the assembly site in a multitude of ways. A most common condition is to have component arrived at the assembly areas in boxes or other container in bulk disoriented condition. Storage density is usually excellent and shipping cost minimal. Other parts because of fragility, cosmetic considerations, war page or shipping cost are shipped in specific orientation-retention containers, such as trays, tubes or mandrels. It means by which these component are extracted from these storage device and placed in an altitude proper for insertion is the heart of automatic assembly. It should come as no shock, therefore to pinpoint that the most versatile of all part feeder remains the human assembly worker.

CENTRIFUGAL ORIENTING FEEDER:

The Centrifugal bowl feeder is the most common mechanism for feeding industrial parts. The bowl has a helical track climbing the inside wall. By giving the bowl a circular vibratory motion, parts dumped into the bowl will climb the helical track in single file. As parts climb the track, they encounter a sequence of obstacles which either re-orient the parts, or deflect disoriented parts back into the center of the bowl. Instead of welded passive orienting devices such as wiper blades and permanently constructed orienting devices on the track, stepper motor controlled wiper blades and adjustable track width are incorporated into the bowl feeder to make it flexible and programmable to suit parts of different sizes.

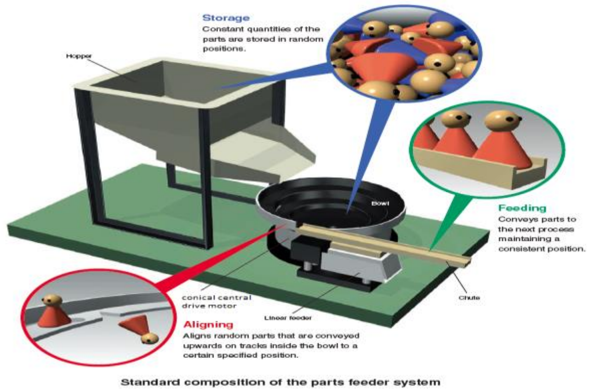

Fig 1: Centrifugal Orienting Feeder

The centrifugal bowl feeder consists of nine specially designed stations along its track for feeding of non-rotational parts. These stations are controlled by both the computer sub-system and the PLC sub-system.

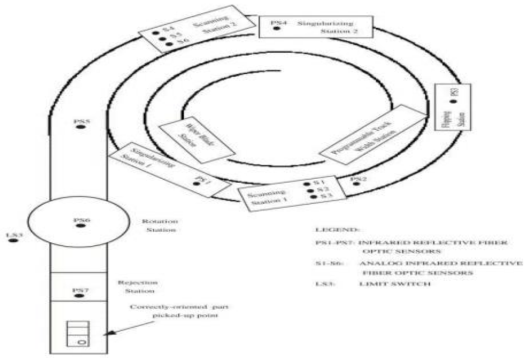

Fig 2: Symmetric Diagram of Feeding System

Typical Orienting System:

Of all the various types of feeding devices, centrifugal-bowl feeders allow by farthe greatest flexibility in the design of orienting devices. Figure shows theorienting system commonly employed to orient screws in a centrifugal-bowl feeder. In this arrangement, the first device, a wiper blade, rejects all the screws not lying flat on the track. The gap below the blade is adjusted so that a screw standing on its head or a screw resting

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on the top of others is either deflected back into the bowl or made to lie flat on the track. Clearly, the wiper blade can be applied here only if the length of the screw is greater than the diameter of its head. The next device, a pressure break, allows screws to pass only in single file and only with either head or shank leading. Screws being fed in any other attitude will fall off the narrow track and back into the bowl at this point. The pressure break also performs another function: If the delivery chute becomes full, excess parts are returned to the bottom of the bowl at the pressure break, and congestion in the chute is therefore avoided. The last device consists of a slot in the track that is sufficiently wide to allow the shank of the screw to fall through while retaining the screw head. Screws arriving at the slot either with the shank leading or with the head leading are therefore delivered with the shank down, supported by the head. In this system for orienting screws, the first two devices are passive and the last is active.

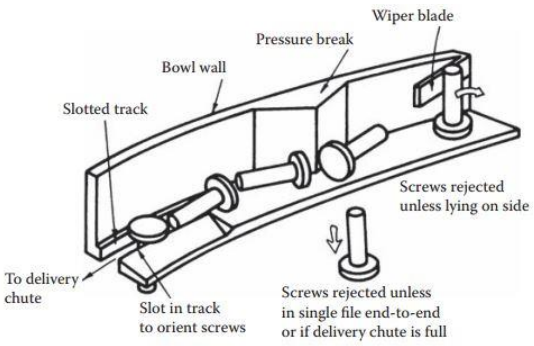

Fig 3: Typical Orienting System

Although the devices described above are designed for parts of a certain shape, two of them have wide application in centrifugal-bowl feeding. First, a pressure break is usually necessary because most feeders are adjusted to overfeeds lightly in order to ensure that the work head is never “starved” of parts. In this situation, unless a level-sensing device controlling the feeder output is attached to the delivery chute, the delivery chute is always full, and a pressure break provides a means of preventing congestion at its entrance. Figure illustrates a common type of orienting device known as a cut-out, where a portion of the track has been cut away.

This device makes use of thedifference in shape between the top and the base of the part being fed. Because of the width of the track and the wiper blade, the cup-shaped part can only arriveat the cut-out resting on its base or on its top.

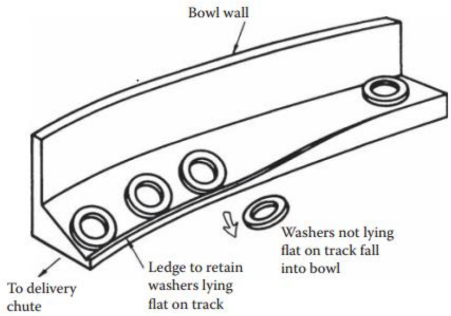

Fig 4: Typical Orienting System

Figure shows another application of a cut-out, in which the area coveredby the top of a part is very much smaller than the area covered by its base. Inthis case, a V-shaped cutout rejects any part resting on its top.

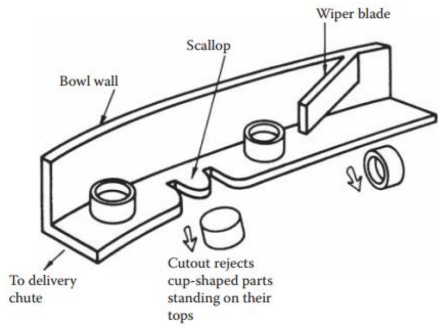

Fig 5: Typical Orienting System

Above Figure shows an example in which U-shaped parts are oriented. Withparts of this type, it is convenient to feed them supported on a rail. In this case,some of the parts climb onto the rail and pass to the delivery chute. The remainderfalls into the bowl, either directly or through a slot between the rail and the bowlwall.

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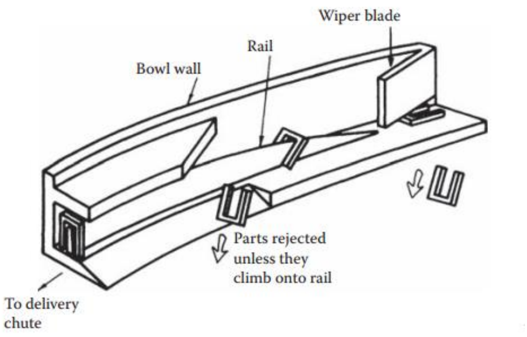

Fig 6: Typical Orienting System

Figure shows a narrowed-track orienting device that is generally employed to orient parts lengthwise end to end while permitting only one row to pass. Finally, Figure shows a wall projection and narrowed-track device used to feed and orient parts with steps or grooves, such as short, headed parts.

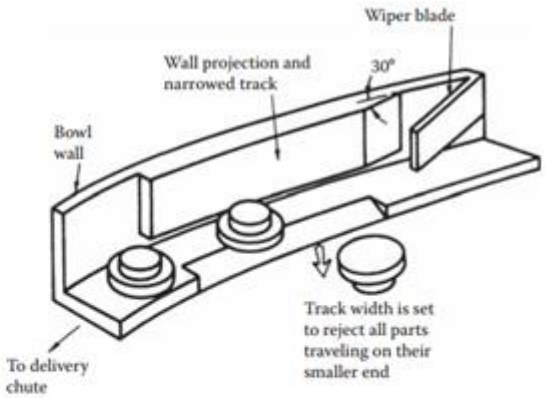

Fig 7: Typical Orienting System

EFFECT OF ACTIVE ORIENTING DEVICES ON FEED RATE:

Sometimes, a part used on an assembly machine can have only a single orientation but, more often, the number of possible orientations is considerably greater. If, for example, a part had eight possible orientations and the probabilities of the various orientations were equal and, further, if only passive orienting devices were used to orient the parts, the feed rate of oriented parts would be only one-eighth of the feed rate of un oriented parts. It is clear that if active orienting devices could be utilized, the feed rate of oriented parts could be considerably increased.

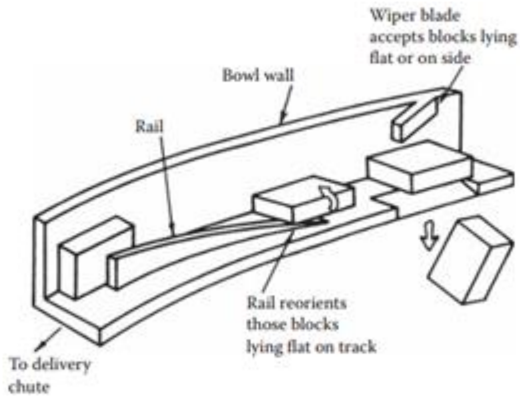

Fig 8: Typical Orienting System

Wiper blade station:

It is a passive orienting device commonly used in the vibratory bowl feeder to reject or wipe off parts that are stacked on top of one another and also those parts that are higher than the set height limit of the wiper blade. In this feeder, the wiper blade is attached to a ball-screw assembly that is driven by a stepper motor controlled by the computer, so that the height of the wiper blade can be programmed, thus parts with different heights can be fed in this feeder.

Programmable track width station:

This is also a passive orienting device commonly used in the bowl feeder to ensure that all the parts would travel in single file longitudinally on the track, rejecting parts that are traveling abreast to another part. In this feeder, the programmability of the track width is achieved by constructing a hinged wall pair that guides the parts into a narrowing track. The hinge will open up to widen the track and vice versa. A stepper motor that is similar to the one used in the wiper blade controls the width of track. Since the width of the track is controlled by the stepper motor, parts with different widths can be fed in this system.

Singularizing station 1:

Singularizing station 1 is used to control the flow of the part into the scanner. It consists of a door hinge that is integrated into the wall of the bowl feeder, a pneumatic cylinder which will control the hinge to extend to block a feeding part or retract to release a feeding part, an infrared reflective fibre optic sensor

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PS1 which is used to detect that a part is present. When a feeding part blocks the path of the infrared light from the sensor PS1, the presence of the part is acknowledged by the PLC. Then the initially closed hinge, which is controlled by the PLC, will open to block the next feeding part that comes along. Hence, only one part at a time is allowed to proceed to scanning station 1 for scanning.

Scanning station 1:

This station serves to determine the orientation of a feeding part with three analog infrared reflective fibre optic sensors. Each of the optical fiber sensors is connected to a sensor block, which will transform the light signals into the voltage signals and amplify the voltage signals. The output of the sensor block is connected to an A\D converter card, which will convert the voltage signals into the digital signals for the computer to process. The scanning station 1 is used to scan the surface profile of the part and send the data to the computer, so that the orientation of the part can be identified. The part identification process and the operation of the subsequent station are controlled by neutral network software in the computer. When the orientation of the feeding part has been determined, the computer would decide on one of the following:

(1) No action if the part is in the desired orientation or 180° reversed.

(2) Request flipping operation if the part is upside-down.

Flipping station:

This station is designed to flip the part which is identified to be upside-down by the scanning station 1. The orienting device consists of a 90° vee-track, and air-jet and a reflective fibre optic sensor PS3. The flipping operation is activated upon request by the computer, after determining that the part is upside-down. Therefore, as the feeding part arrived and is sensed by PS3, the air jet would blow the part to rest on the other side of the vee-track, and thereby flipping it 180°.

Singularizing station 2:

This station is used to control the flow of the part into the scanning station 2. The structure of singularizing station 2 and its working principle are exactly the same as that of singularizing station 1. They all ensure that just one feeding part at a time can pass through to the next scanning station. The reflective fibre optic sensor PS2 is used to detect that a part is proceeding to singularizing station 2, therefore open the singularizing station 2 to let the part pass through.

Scanning station 2:

This station would make a second identification to determine the orientation of the feeding part. The structure and the function of the scanning station 2 are the same as that of the scanning station 1. After the scanning, the computer would decide the appropriate actions to be taken after scanning such as:

(1) No action if the part is in the desired orientation.

(2) Request rotating operation if the part is 180° reversed.

(3) Reject the part if a poor scan or identification was encountered.

(4) Reject an upside-down part.

In addition, as a precautionary measure, it would compare the scanning result with that of the first scanning station and would also attempt to use the successful first scanning result whenever possible if a poor scan or identification is encountered.

Rotation station:

This station is the final station to orientate the parts to the desired orientation and is used to reorientation a part that is 180° reversed. It consists of a 180° pneumatic rotary actuator which rotates a short chute by 180°, two pneumatic rotary actuator acting as stoppers at the entrance and exit of the chute, two reflective fibre optic sensors PS5 and PS6 which are used for detecting the presence of the part and a limit switch LS3 which can detect if the rotating station has turned 180°. The overall sequencing of the rotation is controlled by PLC. The computer would signal the PLC to perform a rotation operation when required. The exit of the rotation station would first be closed by the pneumatic actuator to catch the part. Upon sensing of feeding part in the rotation station, the entrance would be closed by another pneumatic actuator and the rotary actuator would perform a 180° rotation before releasing the part from the rotation station. The feeding part would then slide out and activate another reflective fibre optic 16 sensor (PS7) to signal "end of rotation" and return the rotation station to its initial condition. If the part is in the desired orientation, no signal would be generated by the computer and it would be allowed to slide through the station as it moves down the chute. Rejection station: This is the last station of the whole system, it would reject any part upon sensing it when a "reject" signal is given by the computer. This is to ensure that only parts determined to be in the desired orientation will be picked up. The rejection station consists of a diverting chute that is connected to a pneumatic cylinder. Upon sensing of feeding part by the fibre optic sensor (PS7), the chute would be lowered by the cylinder to reject the part if a "reject" signal is received, or be inhibited when the part is moving in the desired orientation.

THE COMPUTER SUB-SYSTEM:

The main functions of the computer sub-system include:

(1) Controlling the stepper motor, so that the wiper blade station and the narrow track station can be programmed.

(2) Receiving the analog data from the scanning station 1 and scanning station 2, and converting the analog data to digital data.

(3) Using neural network software to recognize the orientation of the parts.

(4) Sending the activation signal based on the orientation it has recognized to activate the orienting devices. Most functions mentioned above were achieved with the help of the data acquisition card and the motor control card installed in the computer.

Selection of Components

Ball Bearings

A bearing in which the parts are separated by a ring of small freely rotating metal balls which reduce friction .The ball bearings are to be fed using the rotary bowl feeder. A ball bearing is a type of rolling-element bearing that uses balls to maintain the separation between the bearing races. The purpose of a ball bearing is to reduce rotational friction and support radial and axial loads. It achieves this by using at least two races to contain the balls and transmit the loads through the balls. In most applications, one race is stationary and the other is attached to the rotating assembly (e.g., a hub or shaft).The material of ball bearing is selected to be AISI 440c stainless steel. Stainless steel bearings are better at anti-corrosion and heat –resistance properties.

Fig 9: Ball Bearing

The chemical composition of AISI 440C stainless steel bearing is given below:-

Chemical composition in %:-

Carbon (C) : O.95- O.12 %

Silicon (Si) : max 1%

Manganese (Mn) : max 1%

Phosphorous (P) : max 0.04%

Sulphur (S) : max 0.03%

Chromium (Cr) : 16-18%

Molybdenum (Mo) : max 0.75%

Hardness : 58-60 Rockwell

Shaft:

A shaft is a rotating machine element, usually circular in cross section, which is used to transmit power from one part to another, or from a machine which produces power to a machine which absorbs power. The various members such as pulleys and gears are mounted on it.

Materials:

The material used for ordinary shafts is mild steel. When high strength is required, alloy steel such

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as nickel, nickel-chromium or chromium-vanadium steel is used. Shafts are generally formed by hot rolling and finished to size by cold drawing or turning and grinding.

Stresses:

The following stresses are induced in the shafts.

1. Shear stresses due to the transmission of torque (due to torsional load).
2. Bending stresses (tensile or compressive) due to the forces acting upon the machine elements like gears and pulleys as well as the self-weight of the shaft.
3. Stresses due to combined tensional and bending loads.
4.

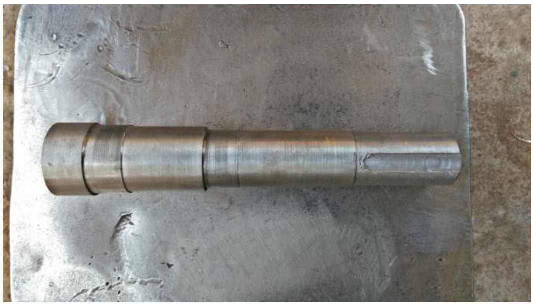

Fig 10: Shaft

Pulley:

A pulley is a wheel on an axle or shaft that is designed to support movement and change of direction of a taut cable or belt along its circumference. Pulleys are used in a variety of ways to lift loads, apply forces, and to transmit power. In nautical contexts, the assembly of wheel, axle, and supporting shell is referred to as a "block."A pulley may also be called a sheave or drum and may have a groove between two flanges around its circumference. The drive element of a pulley system can be a rope, cable, belt, or chain that runs over the pulley inside the groove

Fig 11: Pulley

V-belt:

The most common systems for transmitting power from a drive to a driven shaft are belt, gear, and chain drives. But V-belt drive systems, also called friction drives (because power is transmitted as a result of the belt's adherence to the pulley) are an economical option for industrial, automotive, commercial, agricultural, and home appliance applications. V-belt drives are also easy to install, require no lubrication, and dampen shock load.

Belt makeup:

Belt drives are one of the earliest power transmission systems and were widely used during the Industrial Revolution. Then, flat belts conveyed power over large distances and were made from leather. Later, demands for more powerful machinery, and the growth of large markets such as the automobile industry spurred new belt designs.

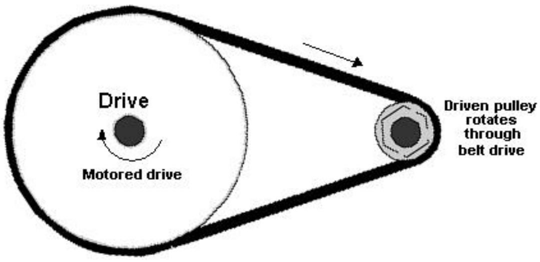

Fig 12: V-Belt

Coupling:

A coupling is a device used to connect two shafts together at their ends for the purpose of transmitting power. Couplings do not normally allow disconnection of shafts during operation, however there are torque limiting couplings which can slip or disconnect when some torque limit is exceeded.The primary purpose of couplings is to join two pieces of rotating equipment while permitting some degree of misalignment or end movement or both. By careful selection, installation and maintenance of couplings, substantial savings can be made in reduced maintenance costs and downtime.

Fig 13: Coupling

Shaft couplings are used in machinery for several purposes. The most common of which are the following

- To provide for the connection of shafts of units that is manufactured separately such as a motor and generator and to provide for disconnection for repairs or alterations.
- To provide for misalignment of the shafts or to introduce mechanical flexibility.
- To reduce the transmission of shock loads from one shaft to another.
- To introduce protection against overloads.
- To alter the vibration characteristics of rotating units.
- To connect driving and the driven part
- To transfer power one end to another end.(ex: motor transfer power to pump through coupling)

DESIGN AND FABRICATION OF COF:

In a typical feeder apparatus, two key components of the apparatus, the feed disc and orienting bowl, are typically constructed of metallic material, either spun or cast metal. There have been certain constructions which have employed a feed disc formed from a non-metallic material, such as ultra-high molecular weight polypropylene resin. Heretofore, though, the orienting bowl of such feeder devices has typically been of metallic construction, including coated metallic material (i.e., a metal bowl coated with polyurethane, or a like resinous material).

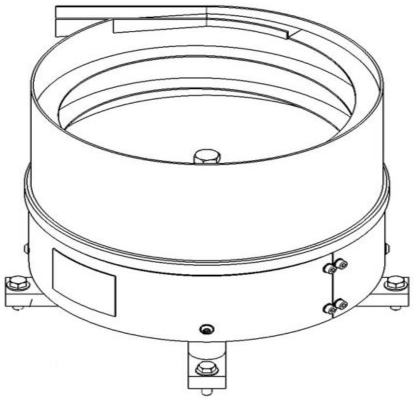

Fig 14: Centrifugal Orienting Feeder

In order to facilitate economical use of such rotary orienting feeders, the present project contemplates an improved feeder construction, wherein the orienting bowl assembly of the feeder includes an outer bowl formed substantially entirely of non-metallic material, such as polymeric resin, which may be provided in a composite form such as by the inclusion of fibrous reinforcement or granular material. Use of such non-metallic material for the outer bowl allows a simpler, less costly, lower weight design to provide the required functionality.

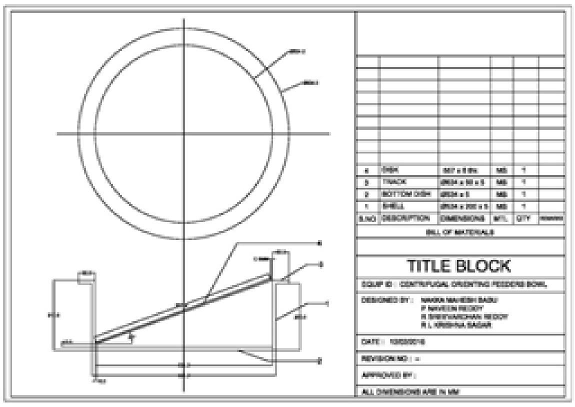

Fig 14: Design of COF

The above design of centrifugal orienting feeder made in AutoCAD software with the selected components and calculations made with the above mentions specifications.

Welding:

Welding is a fabrication or sculptural process that joins materials, usually metals or thermoplastics, by causing fusion, which is distinct from lower temperature metal-joining techniques such as brazing and soldering, which do not melt the base metal.

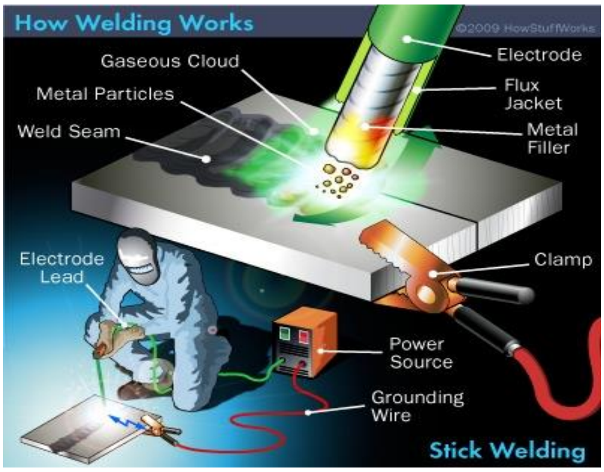

Fig 15: Arc Welding

Oxy – Fuel Welding and Cutting:

Oxy-fuel welding and oxy-fuel cutting are processes that use fuel gases and oxygen to weldand cut metals, respectively, Oxy-fuel is one of the oldest welding processes, besides forge welding. Still used in industry, in recent decades it has been less widely utilized in industrial applications as other specifically devised technologies have been adopted.

Fig 16: Oxy – Fuel Welding and Cutting

Rolling:

In metalworking, rolling is a metal forming process in which metal stock is passed through one or more pairs of rolls to reduce the thickness and to make the thickness uniform. The concept is similar to the rolling of dough.

Fig 17: Rolling

Lathe:

A lathe is a machine tool that rotates the work piece on its axis to perform various operations such as cutting, sanding, knurling, drilling, or deformation, facing, turning, with tools that are applied to the work piece to create an object with symmetry about an axis of rotation.

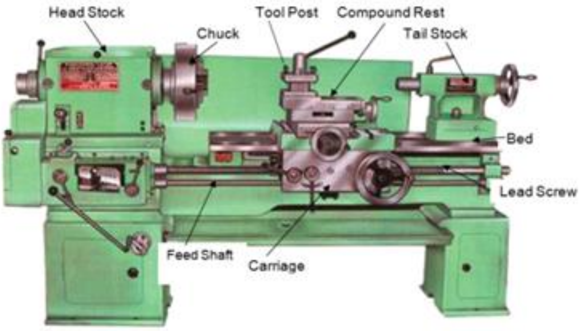

Fig 18: Lathe Machine

Turning Operation:

This operation is one of the most basic machining processes. That is, the part is rotated while a single point cutting tool is moved parallel to the axis of rotation. Turning can be done on the external surface of the part as well as internally (boring).

Fig 19: Turning

Drilling:

Drilling is a cutting process that uses a drill bit to cut or enlarge a hole of circular cross-section in solid materials. The drill bit is a rotary cutting tool, often multipoint. The bit is pressed against the work piece and rotated at rates from hundreds to thousands of revolutions per minute.

Fig 20: Drilling

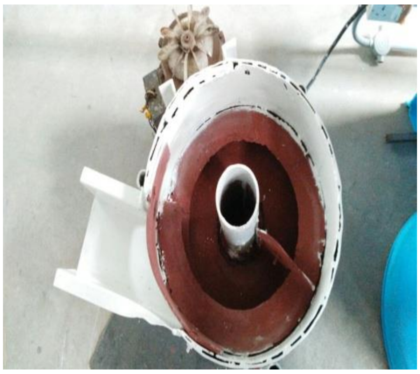

Fig 21: Centrifugal Orienting Feeder (Top View)

Fig 22: Centrifugal Orienting Feeder (Front View)

CONCLUSION:

Centrifugal orienting feeder has been overviewed. Its components and various parts are studied. The feed rate of the bowl feeder has been observed. The motion of the bowl and part are observed. Equations of motions have been written for the motion of bowl and analysis has been done on that basis. The behaviour of feeder has been adequately represented. The proto model made can be used as feeder different kinds of parts and other parts also can be oriented and feed with adjustments of wiper blades.

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