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AUTOMATION OF IN FEED CENTERLESS GRINDING MACHINE

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ABSTRACT

In-feed centerless grinding technique offers a major contribution to the industries. This is the alternative in-feed centerless grinding technique using regulating wheel. Mainly centerless grinding is divided in three types, and those are End feed, in-feed and through feed Centerless grinding. This paper mainly deals with low cost automation on in-feed Centerless grinding machine using regulating wheel suitable for multiple in-feed type jobs. It deals with the development of a Centerless grinding automation technique for the job having multiple diameter, steps or projections on the job. In this new method of automation hydraulic cylinders, sensors besides a control panel, pressure gauge, and a hydraulic power pack added. Relay control is used for the electrical control. The objective of this work is to reduce the cycle time, consistency in the quality of job and to reduce the production cost. In this focus is concentrated on compact centerless grinding unit. The higher machining accuracy is obtained. Results showed imp rovement in the surface roughness and productivity of the job.

KEYWORDS: centerless grinding, Regulating wheel, in feed, Automation, Hydraulic power pack.

INTRODUCTION

Centerless grinding is a machining process that uses abrasive cutting to remove material from a workpiece. Centerless grinding differs from centered grinding operations in that no spindle or fixture is used to locate and secure the workpiece; the workpiece is secured between two rotary grinding wheels, and the speed of their rotation relative to each other determines the rate at which material is removed from the workpiece. Centerless grinding is typically used in preference to other grinding processes for operations where many parts must be processed in a short time.

In the manufacturing industries for high accuracy and productivity machining of cylindrical component such as bearing raceways, silicon ingots, pin gauges and catheters centerless grinding operation have been extensively carried out. On specialized centerless grinders are available commercially, one is with regulating wheel and other with surface grinder and they are different from each other in character how the workpiece supported and how the workpiece rotational speed is controlled during grinding. In feed centerless grinding is commonly employed for the mass production of rotationally symmetrical parts having multiple diameters, steps or projection on the job. It is used when work is being grind has shoulder or head. By this process several diameters of workpiece may be finished with required surface roughness value.

By considering production cost and Quality the two types of centerless grinders are highly suitable for small variety and large volume production. However the centerless grinder is special purpose machine and relatively costly, putting it at a disadvantage of large variety and small volume production, the demand for in feed centerless grinding has increased rapidly in recent years. As a solution to this problem the work proposed the automation of centerless grinding technique in case of in feed type jobs. That can be performed by using regulating wheel. It approaches to the automation which reduces use of energy of worker, production cost, keeps consistency in quality of product and increases the productivity.

There are many drawbacks in manual working procedure of in feed centerless grinding like manpower fatigue, availability, labor cost, quality issues and more cycle time causes less productivity. With the help of this

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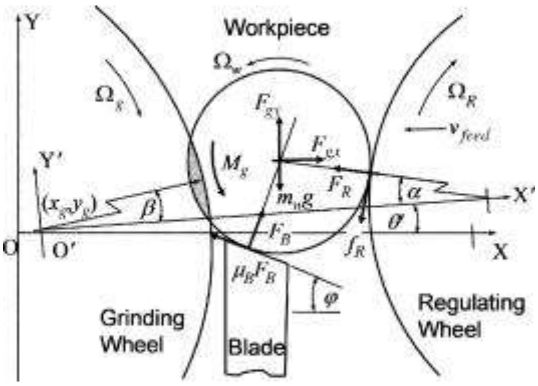
automation labor cost is reduced so it saves the production cost. Due to which economy of scale is increased three time more than the current one as well as consistency in quality is also achieved. The burning of job, poor surface finish, ovality in pipe like these issues regarding quality are reduced.

In 2009 Hashimoto and oliveira presented a CIRP keynote on Industrial challenges in centerless grinding [4]. That survey focused to understand what are the challenges in industrial use of grinding process. They have analyzed main problems in more efficient engines and changes in their components that will affect the grinding performance. By their industrial experience in grinding they selected some challenges and tried to solve these. They have explained different sources of information on industrial challenges in grinding. W Xu and Y Wu in 2010 studied and much of work is devoted to the in feed centerless grinding techniques but that was by using surface grinder and ultrasonic shoe [2]. But in feed centerless grinding by using surface grinder limits the size of job and also it require more cost. In this the workpiece is held by shoe and blade. The rotational speed of the workpiece is controlled by shoe which is connected to piezoelectric ceramic device on a metal elastic body. Workpiece rounding process is investigated by simulation. They achieved higher machining accuracy at lower speed rate and lager material removal at faster workpiece rotational speed. Krajnik and Drazumeric studied only the modelling and simulation in the centerless grinding operation [3]. In 2009 in the APEM journal they have developed and implemented different simulation model that assist in efficient system set-up. In 2014 Barrenetxea et al. [6] worked on the new algorithm for analysis and optimization of in feed centerless grinding. Which depend on high level integration of grinding model in to a web-based simulation. They have optimized the high quality process, high productivity process with reduced cycle time. They devoted their much of work to stability analysis and optimization algorithm for the set-up of in feed centerless grinding.

OPERATION OF AUTOMATION IN INFEED CENTERLESS GRINDING

Figure 1:



Geometrical arrangement in infeed centerless grinding using regulating wheel

Fig. 1 shows the operation principle of in feed centerless grinding using regulating wheel. A unit composed of a regulating wheel, grinding wheel, workpiece rest blade, the lead screw connected to regulating wheel which fed at an angle α through an arm containing sensors, hydraulic cylinder and hydraulic power pack. The workpiece is constrained between the grinding wheel and work rest blade. When regulating wheel is fed forward in radial direction on to the workpiece with a feed rate υ in feed type grinding operation is performed where the grinding wheel and regulating wheel is rotated in the opposite direction and the workpiece rotates in clockwise direction. Once the required stock removal which is 0.2mm (200μ) has been attained the feed of regulating wheel is stopped automatically. During grinding the workpiece rotational speed Ωw is controlled by the automatic movement of the regulating wheel. In addition, the blade is wedge shaped with the tilt angle of ϕ (usually called blade angle) and the value of ϕ is in general 30^{o} in terms of the optimum workpiece rounding condition demonstrated by Harrison and Pearce (2009).

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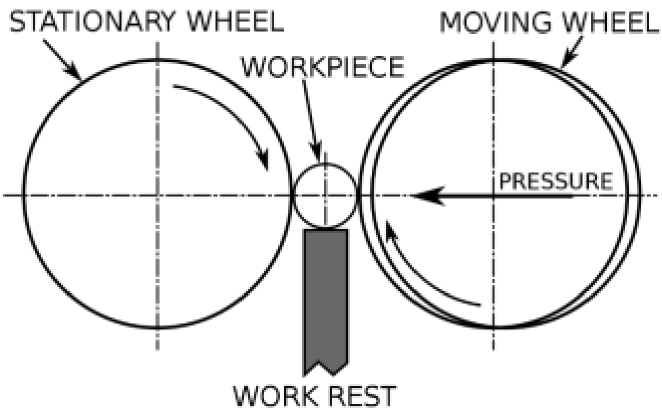
Figure 2:



The above figure shows working of the in feed centerless grinding. Grinding wheel and regulating wheel rotates in opposite direction and workpiece rotates corresponding to wheels rotation.

a) Design consideration of load condition:

Pressure require to rotate the lead screw is 60 bar. So the cylinder of 40mm diameter, 25mm rod diameter and 50mm stroke length is selected.

P = 60 bar

Here,

Area of cylinder bore = $A_1 = \pi r_1^2 = \pi \times 20^2 = 1256mm^2$ (1)

Area of cylinder rod = $A_2 = \pi r_2^2 = \pi \times 12.5^2 = 490.875mm^2$ (2)

Effective rod end area = $A_1 - A_2$

$= 1256 – 490.875$

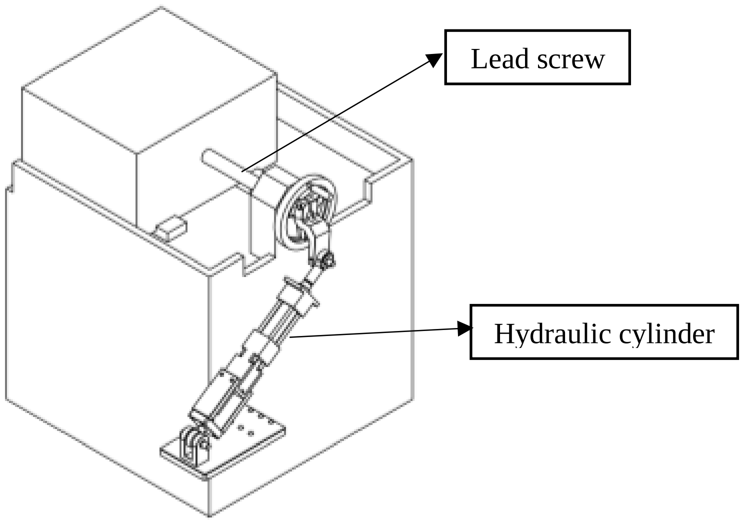
$= 765.375mm^2$

$F = P \times A$ (3)

$F = 60 \times 10^5 \times 765.375 \times 10^{-6}$

$F = 4592.25N$

b) Design of Automation: Following figure shows the design of automation



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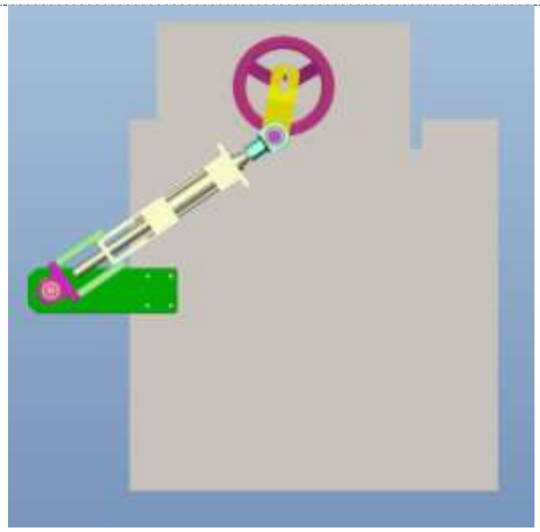
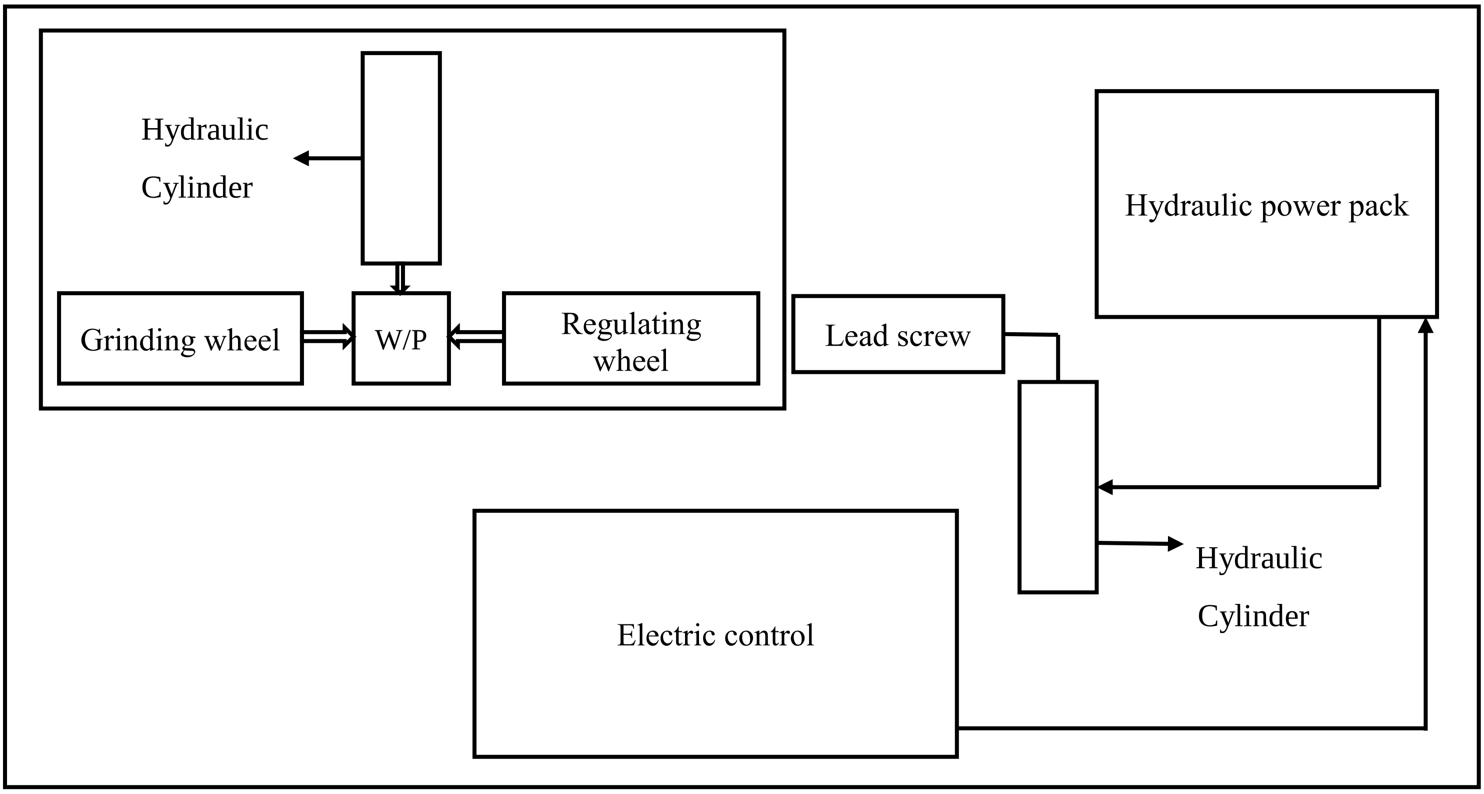


Design of Automation

c) Automation of in feed cylindrical grinding:

Figure 3:



Block diagram of basic component required for Automation

In figure 3. Basic component required for infeed cylindrical grinding are shown:

a) Relay control.
b) Hydraulic cylinder. (DHI-MS4-40)
c) Three proxy sensor.
d) Induction motor (used in hydraulic power pack). (3HP)

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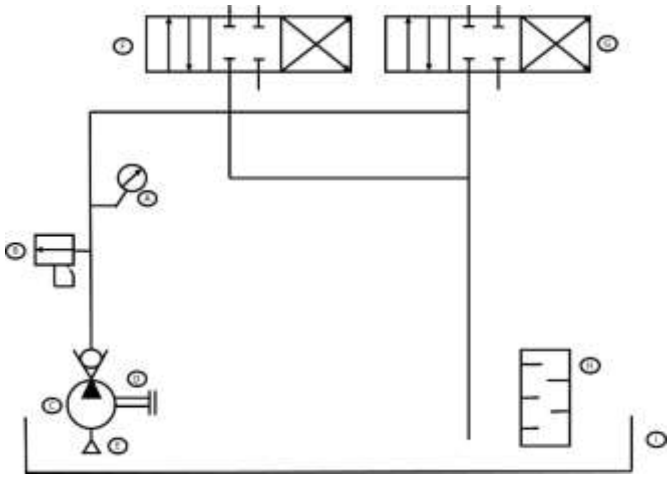
e) Vane pump (used in hydraulic power pack). (PVR-50-36)
f) Direction control valves (used in hydraulic power pack). (DSG-03-3C2-D24)
g) Pressure control valves (used in hydraulic power pack). (DPRH-10-315)

In this automation work the regulating wheel is mounted on the slide which connected to the lead screw. Lead screw is connected to hydraulic cylinder rod through a split nut cam. Behind the split nut cam, an arm is fitted on which three proxy sensors are connected. For an operation of hydraulic cylinder, the hydraulic power pack is used. In this one more hydraulic cylinder is used for unloading of job.

c) Hydraulic power pack unit:

In this work 3 phase squirrel cage induction motor is used which has the power 3HP, as the requirement is less flow rate for less cycle time i.e. 12sec. this induction motor gives 140rpm. Vane pump is used to pressurize fluid. Here selected the vane pump having 29.5lit/min flow rate, as the life of vane pump is better than the gear pump and it works very smoothly. Here chosen double solenoid pilot operated direction control valve. This valve holds pump pressure and cylinder position at neutral core should be paid if used as two position type because shock occurs when each port is blocked in transit. This is continues pressurized valve. Here used the inline pressure control valve is used for control pressure. The manifold used in the circuit having four ports where port A, B connected to cylinder, port P is connected to the pump and port T is connected to the tank. In this bell housing is used to connect motor to the pump. For the filtration of a fluid suction filter and return line filter is used. Pressure gauge is used to detect the pressure of fluid in the system. The pressure maintained is about 60-65 bar. The fluid used in the system is Castrol 68 grade fluid. The Castrol Hydraulic Oil range are based upon mineral oil enhanced with a stabilized zinc additive system. Castrol Hydraulic is primarily for use in hydraulic equipment, but is suitable for other duties in which lubricants with good oxidation stability and lubrication performance are required. The quality of its base oils and additives permits the application of the Castrol Hydraulic range in lightly loaded gears and for use as circulating oil in applications where a rust and oxidation inhibited oil is required. The range is fully compatible with elastomer materials commonly used for static and dynamic seals such as nitrile, silicone and fluorinated polymers. Mainly the advantages of use of this fluid which gives well anti wear performance, resistance to oxidation and good water separation.

Figure 4:



A) Pressure gauge
B) Relief valve
C) Induction motor
D) Vane pump
E) Suction filter
F) DCV I
G) DCV II
H) Level gauge
I) Oil tank

Hydraulic circuit

Figure 4. Shows hydraulic circuit containing the parts of hydraulic power pack.

RESULTS AND DISCUSSION

In the present work, entire working of in feed centerless grinding machine is automatically controlled. Here the hydraulic system is used to control entire working of the machine. During manual operation of in feed centerless grinding machine, operator have to face many difficulties like unloading, to move the regulating wheel forward towards the job which rests on blade for appropriate cutting of the material and again move the wheel away from

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the job after grinding operation. This process reduces much of efficiency of operator and also consumes the more time. There is problem in the unloading of job that it becomes hazardous to the operator. This process increases the cycle time of the machine and labor cost require in three shift is also high which increases production cost. So in order to overcome all these difficulties we have used hydraulic system, proximity sensors and Relay control. It controls entire working of the machine. For proper working of machine the limit switches, contactors, contractor, relays, timer used among various conditions. As per relay control when induction motor of hydraulic system starts vane pump get started. DCV (Direction control valve) supplies pressurized fluid to hydraulic cylinder through port A. The pressure is maintained about 65-70 bar. Then the piston rod moves rapidly in forward direction. The end of cylinder rod is connected to split nut. When the split nut reaches up to the first sensor during forward motion of rod then speed of the cylinder slows down, this slow motion of piston rod continues till the forward stroke reaches to the third sensor which is situated at the end of forward stroke. During this the lead screw which is connected to the cylinder rod through split nut cam rotates for 180^o.

The pitch of the lead screw is 8mm, for 180^o rotation lead screw have to rotate by 4mm. Lead screw rotates rapidly from the 180^o to 65^o then slows down from 65^o to 0^o. Because the time require to achieve the accurate surface roughness value 0.2mm is about 12sec. The regulating wheel is mounted on the slide which is in turn connected to the lead screw. As a result of rotation of the lead screw it pushes the slide in the forward direction towards workpiece. Which rests on the blade against grinding wheel, regulating wheel makes the contact of the workpiece and the grinding wheel then grinding operation is performed. After the accurate surface roughness value get achieved after 12sec relay control activates the DCV which supplies fluid to port B of hydraulic cylinder. Then piston rod moves rapidly in reverse direction in turn lead screw gets its original position. Which make movement of slide backward direction due to which it moves regulating wheel away from the workpiece. After that relay control activates another direction control valve which is connected by hoses to the hydraulic cylinder for unloading. This DCV supplies the fluid to port A of the cylinder which is located at the backside of the work rest blade. Then its piston rod makes forward motion which unloads the job then DCV supplies the fluid to the port B of the cylinder so that piston rod makes revers stroke and the cycle get repeated. By this automation the cycle time of grinding is reduced from 22sec to 12 sec. the production per shift is increased. Prominently spending on skilled labor cost is reduced. The rejection and rework procedure of job is stopped as quality of job is improved.

a) Total cost involved in automating in feed centerless grinder:
Table:

Table 1. Part list and cost required for the automation

Sr. No.	Parts Description	Qty.	Cost (Rs)
1	Hydraulic cylinder	2	15000
2	Hydraulic power pack	1	30000
3	Proxy sensors	3	3000
4	Electric control	1	40000
5	Lead screw	1	15000
6	Grinding wheel	1	9000
7	Regulating wheel	1	7000
	Total cost		1,19,000

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b) Calculation of payback period:

In manual operation energy consumed by the machine in one hour = 9.30 kWh

In Automatic operation energy consumed by the machine in one hour = 7kWh

Reduction in energy consumed in one hour = 9.30-7.00 = 2.30 kWh

Commercial rate of a unit = 11 Rs

If machine is operated for 8 hours in a day

i) Annual saving = annual loss reduction in units * unit price.

ii) So annual saving = 11*2.30*8*365 = Rs 73,876

iii) Total capital investment = Rs 1, 19,000

iv) Payback period= Total capital investment/annual savings

=1, 19,000 / 73,876

= 1.610

Thus this capital is recovers within 1 years and 6 months. But the payback period is less than 2 years because here we are increasing the production rate also so production increases 4 times after automating a machine. So payback period is much less than this.

Figure 5:

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Automation photos

CONCLUSION

The present work concludes that in feed centerless grinding machine automation is possible in minimal cost and improves economy of scale. It gives maximum performances, reliability, robustness, modularity, user friendliness, portability and reusability using PLC, hydraulic system and sensors. The traditional approach which is totally depends on operator which has posed various problems in the field of in feed centerless grinding, like lack of versatility, lesser reliability, lesser efficiency etc., because traditional manual approach needed skilled operator in the close vicinity of the machine. The automatic control of entire machine overcomes all these difficulties. The automation helps even an unskilled worker to operate the machine efficiency. By switching ON a knob of the control panel the whole machine will operate automatically and same process can operates for number of times. The same machine can be used for grinding pieces of multi diameter, steps or projection on the job, when work being grind has shoulder or head. It increased productivity and cycle time of machine is reduced. This automation also gives appropriate surface roughness value. The operation which require much of efficiency of operator is replaced by single automation.

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