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70(10A): 336-341; 2022. DOI: 10.18311/jmmf/2022/32780

Print ISSN : 0022-2755
Journal of Mines, Metals and Fuels
Contents available at: www.informaticsjournals.com/index.php/jmmf

Automatic Feeder for Hardness Testing Equipment

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Abstract

This paper presents the development of the concept of automating the process of feeding the rocker arm bearing shafts into the hardness testing equipment. The present system used in industry for feeding is a manual feeding of the rocker arm bearing shafts (RABS) into the hardness testing equipment. A labourer feeds each and every component by hand, picking up 10-15 components at a time and then feeds it into the hardness testing equipment one by one. The eddy current principle is used here to check the hardness of the component. Hardness testing of components is done to ensure the rocker arm bearing shafts meet the hardness standard to ensure that it works for the designed purpose without any failure.

The proposed system is an automated process. Suitable mechanical and electronic components are used to achieve automation and a finalized concept was generated. The proposed system consists of an automatic vibratory feeder bowl, a pneumatic double acting cylinder and proximity sensors. When the components are placed in the vibratory bowl due to the action of the feeder the components get stacked up then moves through a chute and then it will be pushed into the hardness testing equipment with the help of a double acting cylinder. The sensors are used to monitor and control the feeding process.

Keywords: *RABS;hardness testsing; vibratory feeder bowl; pnemaric double acting cylinder; proximity sensors.*

1.0 Introduction

Increasing quality demands, product liability regulations, global competition and tightly specified hardening tolerances have forced manufacturers of induction hardened components to consider special measures in the field of material testing. Induction hardening increasingly includes conducting 100% testing to verify proper material structure and hardness. The installed testing system must be fast, reliable and simple to use. The test technology employed must be effective, simple to implement and economical. The objective is to increase quality (zero defects) through 100% testing and to reduce overall testing costs by automation and reduced destructive testing [1].

Automation or automatic control is the use of various control systems for operating equipment such as machinery, processes in factories, boilers and heat treating ovens, switching in telephone networks, steering and stabilization of ships, aircraft and other applications with minimal or reduced human intervention. Some processes have been completely automated. The biggest benefit of automation is that it saves labour, however it is also used to save energy and materials and to improve quality, accuracy and precision. The term automation, inspired by the earlier word automatic, was not widely used before 1947, when General Motors established the automation department. It was during this time that industry was rapidly adopting feedback controllers, which were introduced in the 1930s. Automation has been achieved by various means including mechanical, hydraulic, pneumatic, electrical, electronics and computers, usually in combination. Complicated systems, such as modern factories, air planes and ships typically use all these combined techniques.

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Figure 1: Vibratory Feeder Bowl
Outer Diameter 300mm
Input Power 220v 50Hz Ac

Figure 2: Double Acting Cylinder
Make FESTO
Diameter 16mm
Stroke Length 50mm
Rod Diameter 6mm

Figure 3: FRL Unit
Make FESTO
Design Filter Regulator
Op Pressure 1-16 Bar

Figure 4: Direction Control Valve
TypeSolenoid
No. of Positions3
No. of Ports 5

Figure 5: Proximity Sensor
Type Inductive
Range 8mm

Figure 6: Pressure Switch
Make Danfoss

2.0 Method and Material

2.1 Methodology

In order to achieve this automating feeding equipment, the following methodology has been adopted. Concept generation is the first and the most important thing in a project development. Deriving the best possible concept involves various steps like understanding the problem, researching suitable established solutions, brainstorming and ideation and assessing the ideas and solutions. Based on the concepts the procurement of the components is done. The main fabrication of the feeder equipment is broken down into miscellaneous components and different processes and fabrication have been performed and then later assembled step by step. The material selection and the material procurement like feeder bowl, pneumatic valve fittings and cylinders have been selected based on the requirement. The fabrication material for the base frame considered is mild steel due to its high weldability, machinability, high toughness and good elastic strength. The functional testing of the fabricated model is done to check for errors and the required action is worked and implemented for better performance.

2.2 Procured Components and its Specifications

2.3 Description of the Components

Vibratory Feeder Bowl

Vibratory bowl feeders are common devices used to feed individual component parts for assembly on industrial production lines. They are used when a randomly sorted bulk package of small components must be fed into another machine one-by-one, oriented in a particular direction. Vibratory feeders rely on the mechanical behavior of a part, such that when gently shaken down a conveyor chute that is shaped to fit the part, they will gradually be shaken so that they are all aligned. They thus leave the feeder's conveyor one-by-one, all in the same orientation. This conveyor then leads directly to the following assembly or machine. Orientation relies on the shape and mechanical behaviour of an object, particular the position of its center of mass in relation to its center of volume. It thus works well for parts such as machine screws, with rotational symmetry and a clear asymmetry to one heavy end. It does not work for entirely symmetrical shapes, or where orientation depends on a feature such as colour. The ramps within a bowl feeder are specifically designed for each part, although the core mechanism is re-used across different parts.

Double acting Pneumatic Cylinder

Double-acting cylinders (DAC) use forces of air to move in both extend and retract strokes. They have two ports to allow air in, one for outstroke and one for in stroke. Stroke length for this design is not limited; however, the piston rod is more vulnerable to buckling and bending. Additional calculations should be performed as well.

Directional Control Valve

Directional control valves are one of the most fundamental parts in hydraulic machinery as well and pneumatic machinery. They allow fluid flow into different paths from one or more sources. They usually consist of a spool inside a cylinder which is mechanically or electrically controlled. The movement of the spool restricts or permits the flow, thus it controls the fluid flow.

FRL Unit

Use of air preparation devices, such as filters, regulators, and lubricators (FRLs) is an excellent means of keeping air supply in top condition, as well as enabling tools and equipment to operate at their peak performance. A particulate air filter is a device composed of fibrous materials which removes solid particulates such as dust, pollen and bacteria from the air. A chemical air filter consists of an absorbent or catalyst for the removal of air borne molecular contaminants such as volatile organic compounds or ozone. Air filters are used in applications where air quality is important, notably in building ventilation systems and in engines. A pressure regulator is a valve that automatically cuts off the flow of a liquid or gas at a certain pressure. Regulators are used to allow high-pressure fluid supply lines or tanks to be reduced to safe and/or usable pressures for various applications. Gas pressure regulators are used to regulate gas pressure and are not used measuring flow rates. Flow meters, Roto meters or Mass Flow Controllers are used to accurately regulate gas flow rates.

Pressure Switch

A pressure switch is a form of switch that closes an electrical contact when a certain set pressure has been reached on its input. The switch may be designed to make contact either on pressure rise or on pressure fall.

Proximity Sensor

An inductive sensor is an electronic proximity sensor, which detects metallic objects without touching them. The sensor consists of an induction loop. Electric current generates a magnetic field, which collapses generating a current that falls asymptotically toward zero from its initial level when the input electricity ceases. The inductance of the loop changes according to the material inside it and since metals are much more effective inductors than other materials the presence of metal increases the current flowing through the loop. This change can be detected by sensing circuitry, which can signal to some other device whenever metal is detected. Common applications of inductive sensors include metal detectors, traffic lights, carwashes, and a host of automated industrial processes. Because the sensor does not require physical contact it is particularly useful for applications where access presents challenges or where dirt is prevalent.

3.0 Results and Discussions

3.1 Manual Feeding

The present system now is that the rocker arm bearing shafts are fed to the hardness testing equipment by a labourer by hand. The labourer picks up about 12-15 components in hand at a time and then he feeds single component one after the other into the hardness testing equipment. As rocker arm bearing shafts are manufactured in large volumes it becomes a very tedious process to feed all the components by hand and also it cannot be continuously fed by a labourer.

3.2 Proposed Concept

Modal Plan involves one cylinder, a vibratory bowl feeder and two proximity sensors. When the components are placed in the vibratory feeder bowl due to the geometry, vibration and magnetic effect the components stack up one by one in a line and they are fed into the chute through a flexible hose. Here the number of components in the hose is sensed by a proximity sensor. The proximity sensor sends signal to the vibratory bowl in order to control the how much components are to be fed into the chute. After this the components are pushed into the hardness tester one by one with the help of a cylinder. The sequencing of components is controlled by the sensor. The cylinder here used is a double acting cylinder which employs two limit switches to know the forward and backward strokes. After the piston is retracted a component is dropped from the chute. This component is then pushed

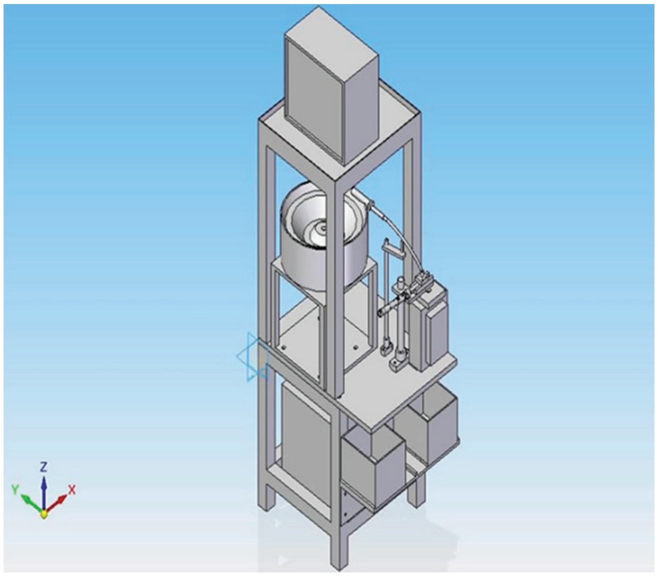

Figure 7: 3D Model Concept

into the hardness testing equipment. After it pushes the component the piston is retracted and again the cycle continues. If it passes the hardness test it falls into the accept bin and if it's rejected it falls into the reject bin.

3.3 Pneumatic Circuit

The pneumatic circuit consists of a main air supply, FR unit, pressure switch, 5/2 Direction control valve, flow control valve, check valve and a feeding cylinder. When the compressed air from the main air supply is supplied to the system the FR unit filters and regulates the compressed air. This air is supplied to direction control valve in order to operate the cylinder and also to control the forward and return stokes of the cylinder. When the compressed air moves from port to the front of the cylinder the piston retracts backward. This is called forward stroke. When the compressed air is supplied from the other port the piston moves back to its initial position. This is called the return stroke. Check valves and flow control valves are provided to each stroke in order to

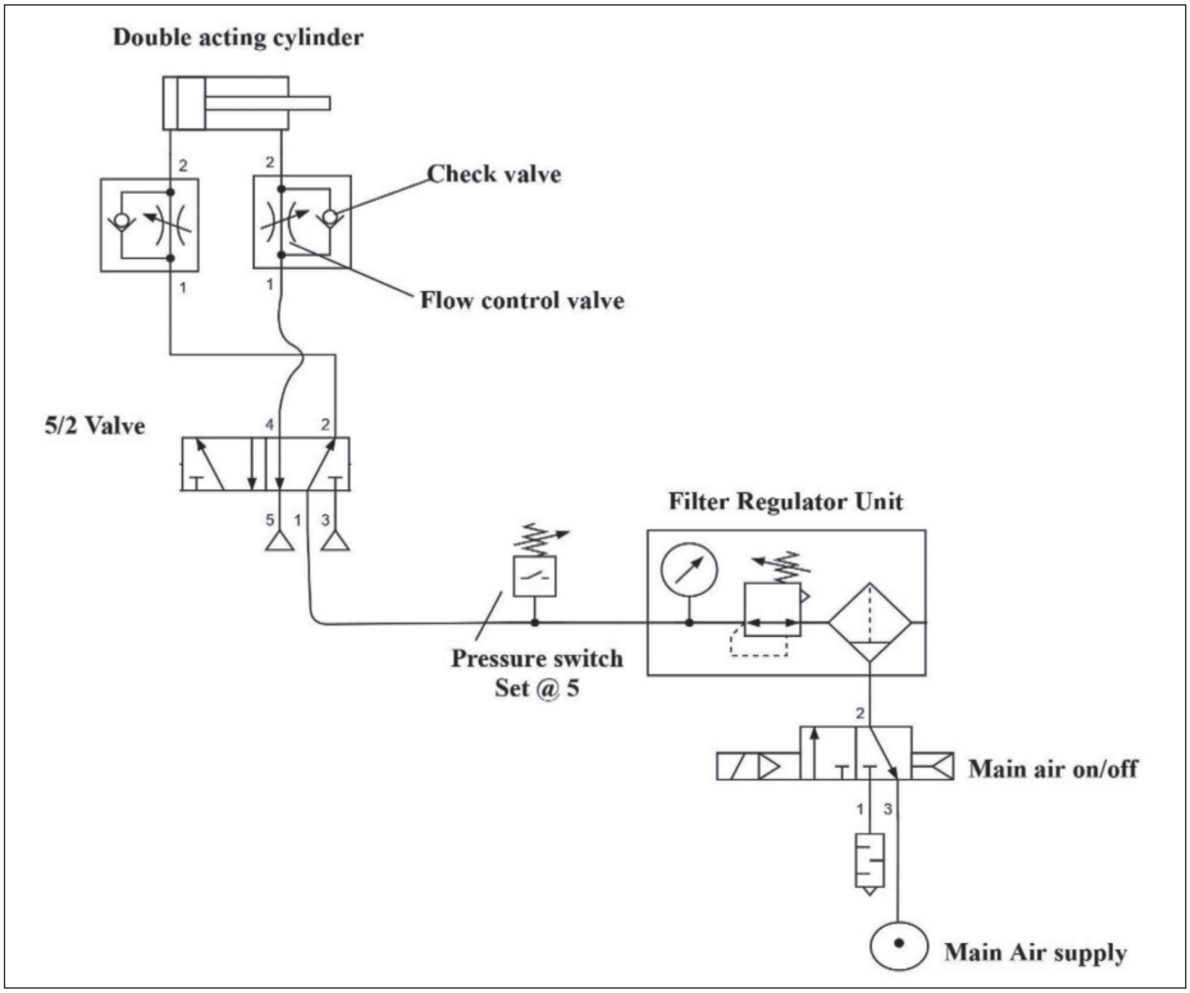

Figure 8: Pneumatic Circuit

control the flow rates and also to ensure the compressed air doesn't return back to the valve. Additional pressure switch is provided to set the desired pressure in the system and also a digital display to read the pressure.

3.5 Calculations

Area of the component
Outer diameter of the component = D = 8 mm
Inner Diameter of the component = d = 5mm

$$\text{AREA} = A = \frac{\pi}{4}(D^2 - d^2)$$

$$= \frac{\pi}{4}(8^2 - 5^2)$$

$$\boxed{A = 30.63\ \text{mm}^2}$$

WKT
Pressure = P = 5 bar = 0.5 N/mm^2

$$P = \frac{F}{A}$$

$\therefore$ F = P × A
Force required = 0.5 × 30.63

$$\boxed{F = 15.31\ \text{N}} \qquad \dots (1)$$

Force required moving the RAB shaft.
Force available at the cylinder
Diameter of the cylinder = 16 mm = 16 × 10^{-3}m

$$\text{Area of the cylinder} = A_c = \frac{\pi}{4}(D^2)\ \text{m}^2$$

$$= \frac{\pi}{4}(16 \times 10^{-3})^2$$

$$\boxed{A_c = 2.01 \times 10^{-4}\ \text{m}^2}$$

Force = P × A
= 5 × 10^5 × 2.01 × 10^{-4}

$$\boxed{\text{Force} = 100.54\ \text{N}} \qquad \dots (2)$$

Force available at the cylinder
Since (2) is greater than (1) cylinder is able to push the RAB shaft into the hardness equipment testing machine.
Piston diameter = D_p = 16 × 10^{-3} m
Piston Rod diameter = D_r = 6 × 10^{-3} m

$$\text{Area of the piston} = \frac{\pi}{4}(D_p^2)\ \text{m}^2$$

$$A_p = \frac{\pi}{4}(16 \times 10^{-3})^2\ \text{m}^2$$

$$\boxed{A_p = 2.01 \times 10^{-4}\ \text{m}^2}$$

$$\text{Area of the rod} = \frac{\pi}{4}(D_r^2)\ \text{m}^2$$

$$A_r = \frac{\pi}{4}(6 \times 10^{-3})^2$$

$$\boxed{A_r = 2.82\ 10^{-5}\ \text{m}^2}$$

Amount of air consumed by cylinder

$$Q_p = (A_p + A_r) \times S \times n \times \left(\frac{\text{Patm}+\text{P}}{\text{Patm}}\right)\ \text{m}^3/\text{s}$$

Stroke length S = 50 mm = 0.05 m
No. of cycles per min n = 60/min

$$= (2.01\times10^{-4}+2.82\times10^{-5}) \times 0.05 \times\frac{60}{60}\times\left(\frac{1+5}{1}\times 10^5\right)$$

$$\boxed{Q_p = 6.876 \times 10^{-5}\ \text{m}^3/\text{s}}$$

(1) Extending stroke

$$\text{Cylinder speed} = (V_p)_{ext} = \frac{Q_p}{A_p}\ \text{Cylinder speed}$$

$$= (V_p)_{ret} = \frac{Q_p}{A_p - A_r}$$

$$= \frac{6.876\times10^{-5}}{2.01\times10^{-4}} \quad = \frac{6.876\times10^{-5}}{1.72\times10^{-4}}$$

$$\boxed{(V_p)_{ext} = 0.342\ \text{m/s}}$$

Load carrying capacity load carrying capacity

F_{load} = P × ApF_{load}=Px(A_p–A_r)
= (5 × 10^5) × (2.01 × 10^{-4})= (5 × 10^5)×(1.72 × 10^{-4}

$$\boxed{F_{load} = 100.5\ \text{N}}$$

Time
1 sec = 342.08 mm
X = 50mm

Therefore,

$$X = \frac{50}{342.08} X = \frac{50}{397}$$

$$\boxed{X = 0.14\ \text{sec}}$$

(2) Return stroke

$$\boxed{(V_p)_{ret} = 0.397\ \text{m/s}}$$

$$\boxed{F_{load} = 86.5\ \text{N}}$$

Time
1 sec = 397 mm
X = 50 mm
Therefore,

$$\boxed{X = 0.12\ \text{sec}}$$

4.0 Conclusions

The Rocker arm bearing shafts fed into the hardness testing equipment in the present system at an average for one hour is 45 components in 1 minute. Therefore, for 1 hour about 2700 components are fed. But in the proposed and approved system the number of components fed was experimentally found tobe 60 components per minute. Therefore, for 1 hour 3600 components are fed.

$$\text{Efficiency improved} = \frac{3600-2700}{2700} = 33.33\%$$

We have seen the present manual feeding mechanism and analyzed the problems faced. By considering the factors such as workers involved; space constraint; inconsistency of output; cost, we were able to work on our innovative idea to find out the best concept which satisfies the above said factors. Here we have used simple components in order to reduce cost. Thus, we conclude that our new idea enhances a better feeding rate, reduces amount of labor involved, and improves efficiency of the system.

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