Automated Compressed Air Control System

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ABSTRACT

Gravity die casting method is competitive casting method when production quantity is relatively small or when heat treatment is needed to improve the mechanical properties. This casting method gives better tolerances and surface finish than sand casting. The tooling costs are somewhat higher than by sand casting. In this we are going apply an automation system for the opening and closing of compressed air input valve by means of current position of dies. When die will be opened the supply of compressed air will be off and when die will be closed again the supply will be started again. Gravity die casting is a casting method when the production quantity is relatively small and/or when heat treatment is needed to improve the mechanical properties. The tolerances and the surface finish are the same asachieved by gravity die casting. The tooling costs are somewhat higher than by sand casting.

Keywords: automation, die casting, heat treatment, tolerances, sand casting

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1. INTRODUCTION

AboutGravity Die Casting

Casting process in which the melt is poured from a pressurized pouring furnace via a riser tube into a permanent mold (die). This process is mainly used in the production of light metal castings, particularly those made from aluminum casting alloys (see Low pressure casting plant) but also those made of magnesium alloys (magnesium low pressure casting plant) with a casting weight of around 1 to approx. 70kg. However, there are also plants for heavy metal casting (brass casting). This process is widely used in the production of aluminum wheels. The production of castings with complex designs is possible using the low pressure casting process, examples are: crankcases, cylinder heads, pump casing and chassis parts.

Working Of Gravity Die Casting

Sometimes referred to as Permanent Mould, GDC is a repeatable casting process used for non-ferrous alloy parts typically aluminium, Zinc and Copper Base alloys. The process differs from HPDC in that Gravity- rather than high pressure- is used to fill the mould with the liquid alloy. GDC is suited to medium to high volumes products and typically parts are of a heavier sections than HPDC, but thinner sections than sand casting. There are three key stages in the process. The heated mould [Die or Tool] is coated with a die release agent. The release agent spray also has a secondary function in that it aids cooling of the mould face after the previous part has been removed from the die. Molten metal is poured into channels in the tool to allow the material to fill all the extremities of the mould cavity. The metal is either hand poured using steel ladles or dosed using mechanical methods. Typically, there is a mould “down sprue” that allows the alloy to enter the mould cavity from the lower part of the die, reducing the formation of turbulence and subsequent porosity and inclusions in the finished part. Once the part has cooled sufficiently, the die is opened, either manually or utilizing mechanical methods.

1.1 Problem Statement

Design and develop an automated system for opening and closing a compressed air supply valve with respect to the position of dies used in die casting method of foundries and forging industries. Also build a prototype model of the same which will show the working of automatic compressed air supply to the die casting set up with respect to the position of dies.Use pneumatic actuator system to on-off the limit switch and compressed air supply valve. The whole system should be monitored by electronic control unit. The electronic control unit is 8051 microcontroller based circuit which triggers the whole system to operate the actuator and compressed air supply.

1.2 Objectives

- To Design and develop an automated system for opening and closing a compressed air supply valve with respect to the position of dies used in die casting method of foundries and forging industries.
- To fabricate a prototype model of the same which will show the working of automatic compressed air supply to the die casting set up with respect to the position of dies.
- To design the electronic control unit of 8051 microcontroller based circuit which triggers the whole system to operate the actuator and compressed air supply.
- To propose a low cost automation system to industries.
- To shut-off and start the compressed air supply with respect to dies position i.e. open or close which will implement into cost and energy conservation.
- To reduce the wastage of compressed air energy.
- To avoid accidents and problems caused when compressed air supply is on at time of die is open. Which will provide a safe working environment.

1.3 Scope of work

In this project we are going to automate the working of compressed air input valve to the low pressure die casting by means of using a limit switch to operate the control valve and a sensor to give signal to the limit switch,

Degrees of automation are of two types, viz Full automation and Semi automation. In semi automation a combination of manual effort and mechanical power is required whereas in full automation human participation is very negligible.

2. WORKING

The compressed air is received from the compressed air storage i.e. pneumatic compressor. This compressed air is flown through hoses to the check valve i.e. non return valve. Thus it enters to the pneumatic actuator. The working of limit switch is done by microcontroller.The position of dies at instance of when the dies is closed is sensed by sensor which sends it the analogue to digital convertor.The ADC converts the data from analog to digital and sends it to the microcontroller.

The microcontroller reads the data from ADC and displays the data as per the position of dies i.e. the dies are open or closed.Thus the path of input to the controlling system is handled to give the output of display that the dies are open or not and according to the position of dies the limit switch will act and open or close the compressed air supply to the dies.

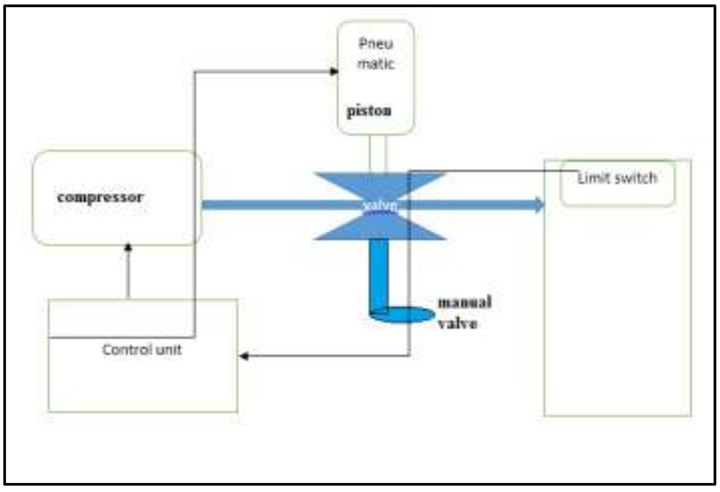

Fig. 1 Block Diagram

Later on receiving data from the microcontroller the microcontroller sends the data to the relay and gives the input to the relay to actually give the signals to the limit switch. The relay gives the signal to close the supply of compressed air if the dies position is open as sensed by the sensor. And vice versa if the position of dies is closed.

Thus when limit switch receives the data to cut off the compressed air supply from relay, it actuates a pneumatic actuator which pushes the limit switch to off position i.e. the supply of compressed air to the dies is closed. The working of limit switching to on or off the compressed air supply may be automatic by use of pneumatic actuator or may be done by manual help who will on or off the lever switch by seeing the display on the microcontroller that the position of dies is open or closed.

2.1 Components And Details

Fig. 2 Pneumatic Actuator Assembly

A linear actuator is used in industry to create motion along a straight line. The actuator can be either mechanical,electro-mechanical, hydraulic, pneumatic or piezoelectric. Linear actuators are commonly used on CNC machining centers to provide linear motion on all three axes. Other applications include robotics, aerospace, factory automation and medical instrumentation. The linear electric actuator is a very common type of linear actuator which uses an electric motor to convert rotary motion into linear motion. They are commonly used in consumer electronics and in devices which are electrically powered.

Fig.3 Compressor

Limit Switches:

A limit switch is an electromechanical device that consists of an actuator mechanically linked to a set of contacts. When an object comes into contact with the actuator, the device operates the contacts to make or break an electrical connection.Limit switches are used in a variety of applications and environments because of their ruggedness, ease of installation, and reliability of operation. They can determine the presence or absence, passing, positioning, and end of travel of an object. They were first used to define the limit of travel of an object; hence the name “Limit Switch.”The limit switch is ideal for applications in which heavy-duty pilot ratings, a high degree of versatility and rugged NEMA Type 4 and 13 oil-tight (6P on select rotary shaft models) enclosures are desired, including:

- Conveyor systems
- Transfer machines
- Automatic turret lathes
- Milling and boring machines
- Radial drills

Limit switches are incredibly important on a CNC machine. Due to the danger inherent with CNC machines it is necessary to put some fail safes in place. Limit switches help a lot with the safety aspect but also are very important for giving CNC machines a known zero position, which it can return to at any point.Limit switches will help prevent a CNC machine’s axis from travelling beyond its limit and potentially causing damage and will also allow; should a power cut occur during operation, to return to the machines known zero which could safe an otherwise wasted job.

Solenoids:

Electrically actuated directional control valves form the interface between the two parts of an electro-pneumatic control. The most important tasks of electrically actuated DCVs include.

i)Switching supply air on or off

ii)Extension and retraction of cylinder drives

Electrically actuated directional control valves are switched with the aid of solenoids. They can be divided into two groups:

i)Spring return valves only remain in the actuated position as long as current flows through the solenoid

ii)Double solenoid valves retain the last switched position even when no current flows through the solenoid.

In the initial position, all solenoids of an electrically actuated DCVs are de-energized and the solenoids are inactive. A double valve has no clear initial position, as it does not have a return spring. The possible voltage levels for solenoids are 12 V DC, 12V AC, 12V 50/60 Hz, 24V 50/60 Hz, 110/120V 50/60 Hz, 220/230V 50/60 Hz.

Electronic sensors:

Inductive, Optical and capacitive proximity switches are electronic sensors. They normally have three electrical contacts. One contact for supply voltage other for ground and third for output signal.In these sensors, no movable contact is switched. Instead, the output is either electrically connected to supply voltage or to ground. There are two types of electronic sensors with regard to the polarity of output voltage.

Positive switching sensors:

In this output voltage is zero if no part is detected in the proximity. The approach of a work piece or machine part leads to switch over of the output, applying the supply voltage.

Negative switching sensors:

In this the supply voltage are applied to the output if no part is detected in the proximity. The approach of a work piece or machine part leads to switch over of the output, switching the output voltage to 0 volts.

3. CALCULATIONS

1) Calculation of lead screw:

We know that mean diameter of the screw:

$$d=d_0-\frac{p}{2}$$

$$d=10-\frac{3}{2}$$

$$\boxed{d=8.5mm}$$

2) α = Helix angle

$$\tan\alpha=\frac{p}{\pi * d}$$

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$\tan\alpha = \frac{3}{\pi * 8.5}$

$\boxed{\tan\alpha = 0.11}$

3) Virtual coefficient of friction

$\mu_1 = \tan\varphi_1$ $\mu_1 = \frac{\mu}{\cos\beta}$

$\mu_1 = \frac{0.15}{\cos 14.5}$

$\boxed{\mu_1 = 0.15}$

4) We know that the force required overcoming friction of the screw:

$P = w * \tan(\alpha + \varphi_1)$

$P = w * \frac{(\tan\alpha + \tan\varphi 1)}{(1 - \tan\alpha * \tan\varphi 1)}$

Where w=axial pressure load

w=5*9.81

$\boxed{w = 49.05 \text{ N}}$

Therefore; above value add in equation no.(4)

$P = (49.05) * \frac{(0.11 + 0.15)}{(1 - 0.11 * 0.15)}$

$\boxed{P = 13\text{N}}$

5) Torque required overcoming friction at the screw(T_1):

$T_1 = p * \frac{d}{2}$ $T_1 = 13 * \frac{8.5}{2}$

$\boxed{T_1 = 55.25\text{N-mm}}$

6) Power required to drive the screw:

Power $= T * \omega$

Power $= T * \frac{2 * \pi * N}{60}$ power$= T * \frac{2 * \pi * 30}{60}$ (N=30rpm…..given in specification)

Where $T = T_1 + T_2$

Uniform wear,

Torque required to overcome friction at bottom(T_2)

$T_2=\mu_2 * w * R$ Hole on plate radius=6

Radius of threads =5

$R=\frac{6+5}{2}$

R=5.5 mm

The above 'R' value add in equation no(7)

$T_2=(0.12)*(9.81*5)*(5.5)$

T_2=32.37 N-mm

Now value of T_1 &T_2 add in equation $T=T_1+T_2$.

Therefore;

T=55.25+32.37

T=87.62 N-mm

T=0.087 N-m

Therefore value of 'T' add in (6) equation and fine the power value.

$\text{Power}=0.087*\frac{2*\pi*30}{60}$

power=0.27318 kw

7) Efficiency of the lead screw:

We know the torque required to drive the screw with no friction.

$T_0=\frac{W*\tan\alpha*d}{2}$ $T_0=\frac{49.05*0.11*8.5}{2}$

T_0=29.23 N-mm

Therefore efficiency

$\eta=\frac{T0}{T}$

$=\frac{22.93}{87.62}$

η=26.16%

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5. ADVANTAGES

- Automation adds to the speed of casting.
- It is best suited for mass production.
- Due to use of automated mechatronic system the accuracy of operation increases.
- Chances of hazards and damages due to manual operations are avoided.

6. DISADVANTAGES

- Additional cost required for doing modification in automated system.

7. APPLICATIONS

- For automobile foundries application
- Industrial application in foundries where fast and accurate production is required.
- Applications regarding loss of compressed air energy like spraying, painting etc.
- In forging and foundry systems where automation of systems is required to achieve higher accuracy and precision of production with minimum loss of energy and money.

6. CONCLUSION

We Designed and developed an automated system for opening and closing a compressed air supply valve with respect to the position of dies used in die casting method of foundries and forging industries. We also built a prototype model of the same which will show the working of automatic compressed air supply to the die casting set up with respect to the position of dies.

Use pneumatic actuator system to on-off the limit switch and compressed air supply valve provide extra accuracy and higher precision. The whole system is monitored by electronic control unit. The electronic control unit is 8051 microcontroller based circuit which triggers the whole system to operate the actuator and compressed air supply. We propose a low cost automation system to industries that will shut-off and start the compressed air supply with respect to dies position i.e. open or close which will implement into cost and energy conservation. This systemwill reduce the wastage of compressed air energy. It also avoids accidents and problems caused when compressed air supply is on at time of die are open. Which will provide a safe working environment.

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