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Hydraulic Die Casting Using Automation

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ABSTRACT: Die casting process is highly intensive and functioning with many complex units. In die casting industries, automation plays a vital role to get a better result in quality, quantity, time consuming in manufacturing process. The process is generally deals with a Programmable Logic Controller as a digital computer used to automate in electromechanical processes. Automation system generally networked with Human Machine Interface to show die casting parameter values for all the time in graphical manner. In such process there is a need of human to monitor and control the set ranges in Human machine Interface which shouldn't go varied at a period of time, if time goes miss there will be a chance of machine error to occur. For this purpose the proposed system is play the vital role by viewing the step processes with set ranges of entire working system's avail in industry remotely using ZigBee with the monitoring technology Supervisory Control and Data Acquisition. On this basis, service engineers or operators can easily view the conditions of industry automations, diagnose problem and help engineer to monitor and control the current operation in control room itself. This system is implemented to fetch graphical data's of individual automations networked Human Machine Interface to single monitor and simulation result has been achieved using LabVIEW software.

KEYWORDS: Remote terminal unit, ZigBee transceiver, Supervisory control and Data Acquisition system.

I. INTRODUCTION

Die casting is the process of forcing molten metal, under high pressure, into mold cavities (which are machined into dies). Most die castings are made from non-ferrous metals, specifically zinc, copper, aluminum, magnesium, lead, and tin based alloys, although ferrous metal die castings are possible. Thedie casting method is especially suited for applications where a large quantity of small to medium sized parts is needed with good detail, a fine surface quality, and dimensional consistency. Advances in technology have allowed die cast machine manufacturers to produce machines capable of casting pieces with weights up to 45 kilograms. This level of versatility has placed die castings among the highest volume products made in the metalworking industry. There are four major steps in the die casting process. First, the mold is sprayed with lubricant and closed. The lubricant helps to control the temperature of the die and also assists in the removal of the casting. Second, molten metal is shot into the die under high pressure; between 10-175 MPa (1,500-25,000 psi). Once the die is filled, clamping pressure is maintained until the casting has solidified. Third, the die is opened and the shot is ejected by the ejector pins (shots are different from castings because there can be multiple cavities in a die, yielding multiple castings per shot). Finally, the scrap, which includes the gate, runners, sprues and flash, must be separated from the casting(s). This is often done using a special trim die in a power press or hydraulic press. An older method separates by hand or by sawing, in which case grinding may be necessary to smooth the scrap marks. A less labor-intensive method is to tumble shots if gates are thin and easily broken; separation of gates from finished parts must follow. This scrap is recycled by remelting it. Approximately 15% of the metal used is wasted or lost due to a variety of factors. The high-pressure injection leads to a quick fill of the die, which is required so the entire cavity fills before any part of the casting solidifies. In this way, discontinuities are avoided even if the shape requires difficult-to-fill thin sections. This creates the problem of air entrapment, because when the mold is filled quickly there is little time for the air to escape. This problem is minimized by including vents along the parting lines; however, even in a highly refined process there will still be some porosity in the center of the casting. Most die casters perform other secondary operations to produce features not readily castable, such as tapping a hole, polishing, plating, buffing, or painting. There are two basic types of die casting machines: hot-chamber machines and cold-chamber

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machines. The machines are rated by how much clamping force they can apply. Typical ratings are between 400 and 4,000 short tons

II.PROCESS CYCLE FOR DIE CASTING

A. Clamping.

The first step is the preparation and clamping of the two halves of the die. Each die half is first cleaned from the previous injection and then lubricated to facilitate the ejection of the next part. The lubrication time increases with part size, as well as the number of cavities and sidecores. Also, lubrication may not be required after each cycle, but after 2 or 3 cycles, depending upon the material. After lubrication, the two die halves, which are attached inside the die casting machine, are closed and securely clamped together. Sufficient force must be applied to the die to keep it securely closed while the metal is injected. The time required to close and clamp the die is dependent upon the machine - larger machines (those with greater clamping forces) will require more time. This time can be estimated from the dry cycle time of the machine.

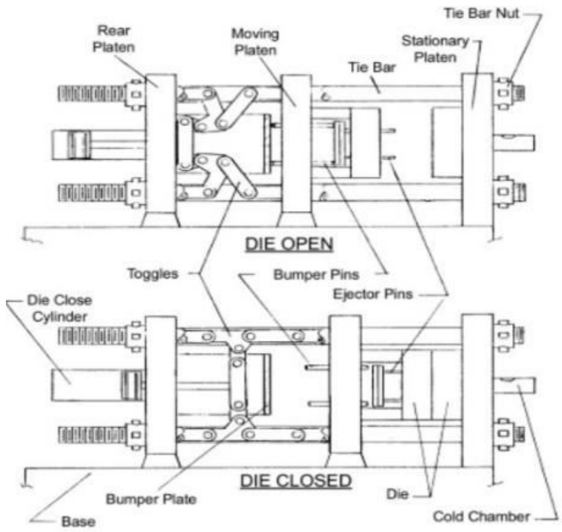

Fig. Typical die casting machine construction. The hydraulic die closing cylinder straightens the toggle links to close the die. This arrangement achieves high die clamping forces and rapid die opening and closing action.

B. Injection-

The molten metal, which is maintained at a set temperature in the furnace, is next transferred into a chamber where it can be injected into the die. The method of transferring the molten metal is dependent upon the type of die casting machine, whether a hot chamber or cold chamber machine is being used. Once transferred, the molten metal is injected at high pressures into the die. Typical injection pressure ranges from 1,000 to 20,000 psi. This pressure holds the molten metal in the dies during solidification. The amount of metal that is injected into the die is referred to as the shot. The injection time is the time required for the molten metal to fill all of the channels and cavities in the die. This time is very short, typically less than 0.1 seconds, in order to prevent early solidification of any one part of the metal. The proper injection time can be determined by the thermodynamic properties of the material, as well as the wall thickness of the casting. A greater wall thickness will require a longer injection time. In the case where a cold chamber die casting machine is being used, the injection time must also include the time to manually ladle the molten metal into the shot chamber.

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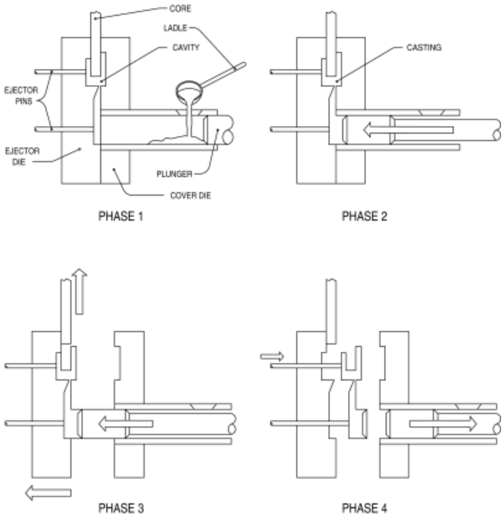

Fig. Operating sequence of the cold chamber die casting process: 1) Die is closed and molten metal is ladled into the cold chamber. 2) Plunger pushes molten metal into die cavity. The metal is held under pressure until it solidifi es. 3) Die opens and plunger advances to insure casting stays in ejector die. Cores, if any retract. 4) Ejector pin push casting out of the ejector die and plunger returns to ready to cast position.

C. Cooling.

The molten metal that is injected into the die will begin to cool and solidify once it enters the die cavity. When the entire cavity is filled and the molten metal solidifies, the final shape of the casting is formed. The die cannot be opened until the cooling time has elapsed and the casting is solidified. The cooling time can be estimated from several thermodynamic properties of the metal, the maximum wall thickness of the casting, and the complexity of the die. A greater wall thickness will require a longer cooling time. The geometric complexity of the die also requires a longer cooling time because the additional resistance to the flow of heat.

D. Ejection.

After the predetermined cooling time has passed, the die halves can be opened and an ejection mechanism can push the casting out of the die cavity. The time to open the die can be estimated from the dry cycle time of the machine and the ejection time is determined by the size of the casting's envelope and should include time for the casting to fall free of the die. The ejection mechanism must apply some force to eject the part because during cooling the part shrinks and adheres to the die. Once the casting is ejected, the die can be clamped shut for the next injection.

E. Trimming.

During cooling, the material in the channels of the die will solidify attached to the casting. This excess material, along with any flash that has occurred, must be trimmed from the casting either manually via cutting or sawing, or using a trimming press. The time required to trim the excess material can be estimated from the size of the casting's envelope. The scrap material that results from this trimming is either discarded or can be reused in the die casting process. Recycled material may need to be reconditioned to the proper chemical composition before it can be combined with non-recycled metal and reused in the die casting process.

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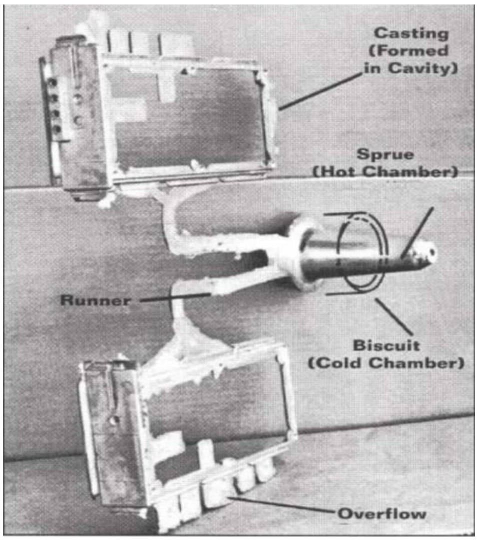

Fig. A typical complete die cast shot as it comes from the die. Sprue (or biscuit), runners and overflows must be trimmed from the actual castings. After trimming, sprue, runners, and overflows are remelted and reprocessed.

III. ELECTRICAL SYSTEM

A. Motor and Control Panel

An electric motor(s) provides power for the machine. Generally, the motor is directly coupled to hydraulic pumps. Electrical power is converted into hydraulic power when the electric motor spins the hydraulic pumps. The pumps force oil into the hydraulic lines under pressure. The motor is located adjacent to the reservoir. Also located at the rear of the machine will be an electric power cabinet that encloses the motor starter and machine control logic. A disconnect switch is mounted on the outside of this panel along with the lockout tag. The motor(s) operate at high voltage, usually 440/480 volts. This area must be kept clean and dry in order to avoid an electric shock hazard. The couplings between the motor and pump must be guarded because these rotate at high speed and could cause injury if contacted.

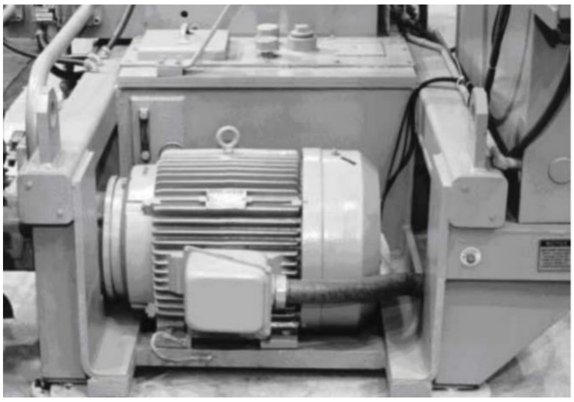

Fig. Motor shown at rear of DCM

B. Solenoids

Solenoids are used to shift valves to control the volume and direction of hydraulic fluid flow. A solenoid is an electromagnet that shifts a metal core. This is the same device that engages the car starter motor when you start your car. This core is attached to a valve spool to control and direct the oil flow. The solenoid/valves are relatively robust but should not be used as steps or otherwise abused.

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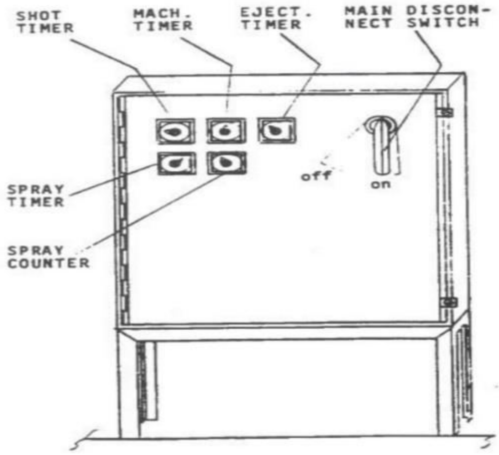

Fig. Line diagram of an older style control panel for hot chamber die casting machine

C. Limit Switches

Limit switches are the sensors, eyes and ears, of the electrical control system. They are located in many different places on the die casting machine. They are used to sense the position of doors, guards, cylinders and other moving components on the die casting machine. Their maintenance is essential to the safe operation of the machine. Limit switches must never be defeated or tied back. Broken connectors and exposed wiring at limit switches should be repaired immediately in order to assure safe operation of the machine. The trip rods or switch actuating mechanisms at the limit switch will cause pinch points. The machine may also have other types of switches and sensors. Some of the limit switch functions may be accomplished with proximity switches. There may also be pressure switches that react to a given level of hydraulic pressure.

D.Hydraulic System

The die casting machine functions are operated by a hydraulic system. This means that a fluid, usually fire resistant oil, is used to power the cylinders that make the machine move. This hydraulic system operates at high pressures and high flow rates. For those reasons alone, we need to keep safety in mind. Under unusual operating conditions the hydraulic fluid may be hot enough to cause burns. Leaks and spills should be repaired and cleaned up quickly. These not only waste costly oil but also can cause slippery surfaces that could result in injuries if someone slips and falls

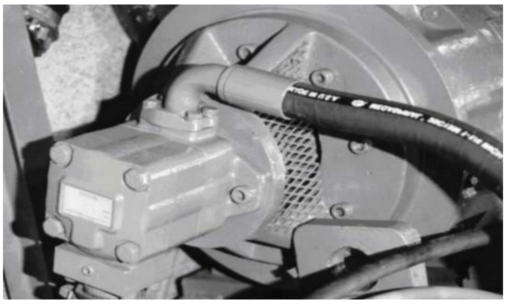

Fig. Close-up of hydraulic pump mounted at the end of the motor shaft.

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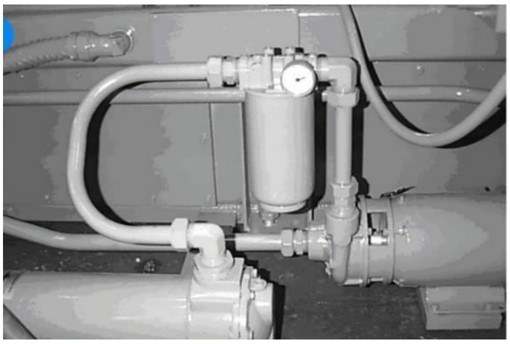

Fig. View of filter at outlet of circulating pump used to pump hydraulic fluid through the heat exchanger.

E.Hydraulic Pumps

A die casting machine usually has a minimum of two hydraulic pumps. One pump is capable of providing oil at high pressures but in low volumes. A second pump would be capable of providing a high volume of oil at low pressures. For example, the pumping capabilities of a 400-ton machine may be 8 gallons per minute of 2000 PSI oil from the highpressure pump and 40 gallons per minute of 40 PSI oil from the low pressure pump. This type of pumping capability is used to solve the various demands of the die casting machine. The die close cylinder requires a large amount of oil to open and close the moving platen. Once the die faces close, only a small volume of highpressure oil is required to stretch the tie bars and lock the die. Just the act of closing requires the output of both pumps. (In cases where the output of both pumps is still too slow, an accumulator will be used to speed die closing.)

F.Filters

Filter(s} are required to keep the hydraulic fluid clean. The filter(s) are located at the outlet of the pumps to assure that clean oil is sent to the various valves and cylinders. The filters require routine maintenance to make sure they work properly. Most filters have a visual differential pressure gage on them that should be checked frequently to make sure that the oil is clean. Small dirt particles in the oil can cause valves to stick and fail because of the small clearances in the valves.

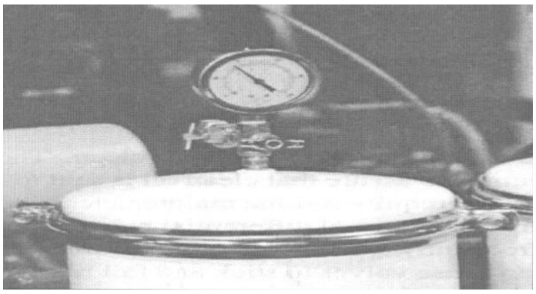

Fig. Differential pressure gauge on top of a filter

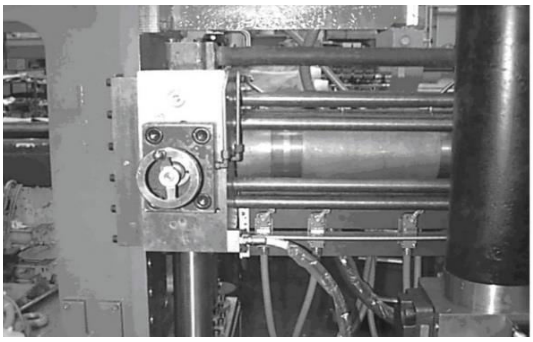

Fig.Hand operated speed control valve for shot cylinder.

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 7.122|

||Volume 10, Issue 4, April 2021||

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G. Valves

Valves are used to control the amount and direction of oil flow. Solenoid operated valves are used to direct the flow to the head or rod side of a cylinder or they may direct oil to shift a large valve, such as the pilot operated (PO) check valve at the base of the accumulator. Some of the valves may manually operated. For example, the valves controlling the speeds of injection or die closing may be fitted with large hand wheels. These valves are used to control or shut off the oil flow. On modern machines the speed control of machine functions is controlled by a series of valves mounted on a manifold. The manifold provides a centrally located source of hydraulic fluid for the speed control valves

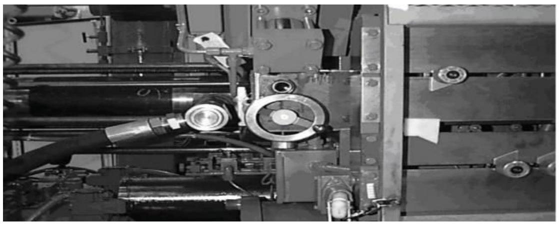

Fig. Hand operated speed control valve for die close cylinder

Fig. Heat exchanger used to cool hydraulic oil in die casting machine

H.Heat Exchanger

Most machines will have a heat exchanger. This is a large tubular tank located adjacent to the reservoir. It operates similar to a boiler. Internally the heat exchanger will have a large number of pipes going through. Cooling water will circulate through these pipes. Hydraulic fluid will be let into one end of the heat exchanger; the fluid will flow over the water-cooled piping and give up heat to the water. The fluid will then flow out the exit. Factors affecting the efficiency of the heat exchanger are the same as those affecting die cooling. If the water lines fill up with lime (calcium), heat flow is reduced. If fluid flow is to slow, heat flow is reduced. Leakage in the heat exchanger can be troublesome in two ways. First too much water can contaminate the hydraulic oil. Second the hydraulic fluid will contaminate the recirculating water. As an operator, you should be aware of the hydraulic fluid temperature. If the fluid gets to hot, check for flow of hydraulic fluid and coolant through the heat exchanger.

I.Cylinders

Hydraulic cylinders or actuators are used to open and dose the machine, to inject the metal into the die. They may also be used to operate the ejection system, move slides in and out of the die, actuate a safety ratchet and open and close a safety door at the die parting line. These cylinders may be liquid or air operated. Cylinders operate very simply; a fluid comes in one end and pushes an internal piston to the end of the cylinder. In order to accomplish work one end of a rod is connected to the piston and the other end of the rod is connected to whatever we want to move. Hydraulic cylinders can be very powerful. The force that a cylinder develops depends on its size and the pressure of the hydraulic fluid.

IV. DIE CASTING MACHINES & MACHINE SPECIFICATION

A. Hot chamber die casting machine.

Hot chamber machines(Fig.1) are used for alloys with low melting temperatures, such as zinc, tin, and lead. The temperatures required to melt other alloys would damage the pump, which is in direct contact with the molten metal. The metal is contained in an open holding pot which is placed into a furnace, where it is melted to the necessary temperature. The molten metal then flows into a shot chamber through an inlet and a plunger, powered by hydraulic pressure, forces the molten metal through a gooseneck channel and into the die. Typical injection pressures for a hot chamber die casting machine are between 1000 and 5000 psi. After the molten metal has been injected into the die

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cavity, the plunger remains down, holding the pressure while the casting solidifies. After solidification, the hydraulic system retracts the plunger and the part can be ejected by the clamping unit. Prior to the injection of the molten metal, this unit closes and clamps the two halves of the die. When the die is attached to the die casting machine, each half is fixed to a large plate, called a platen. The front half of the die, called the cover die, is mounted to a stationary platen and aligns with the gooseneck channel. The rear half of the die, called the ejector die, is mounted to a movable platen, which slides along the tie bars. The hydraulically powered clamping unit actuates clamping bars that push this platen towards the cover die and exert enough pressure to keep it closed while the molten metal is injected. Following the solidification of the metal inside the die cavity, the clamping unit releases the die halves and simultaneously causes the ejection system to push the casting out of the open cavity. The die can then be closed for the next injection.

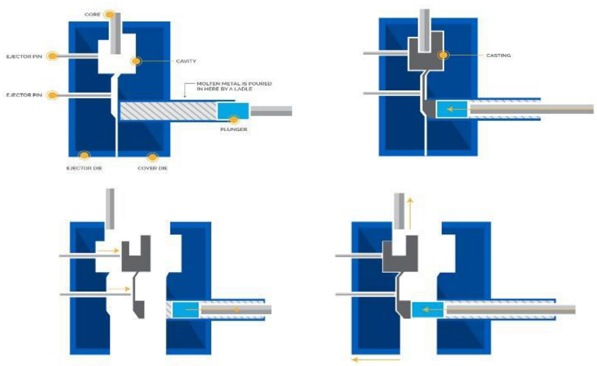

Fig.A. Hot chamber die casting machine

B. Cold chamber die casting machine.

Cold chamber machines(Fig.2) are used for alloys with high melting temperatures that cannot be cast in hot chamber machines because they would damage the pumping system. Such alloys include aluminum, brass, and magnesium. The molten metal is still contained in an open holding pot which is placed into a furnace, where it is melted to the necessary temperature. However, this holding pot is kept separate from the die casting machine and the molten metal is ladled from the pot for each casting, rather than being pumped. The metal is poured from the ladle into the shot chamber through a pouring hole. The injection system in a cold chamber machine functions similarly to that of a hot chamber machine, however it is usually oriented horizontally and does not include a gooseneck channel. A plunger, powered by hydraulic pressure, forces the molten metal through the shot chamber and into the injection sleeve in the die. The typical injection pressures for a cold chamber die casting machine are between 2000 and 20000 psi. After the molten metal has been injected into the die cavity, the plunger remains forward, holding the pressure while the casting solidifies. After solidification, the hydraulic system retracts the plunger and the part can be ejected by the clamping unit. The clamping unit and mounting of the dies is identical to the hot chamber machine.

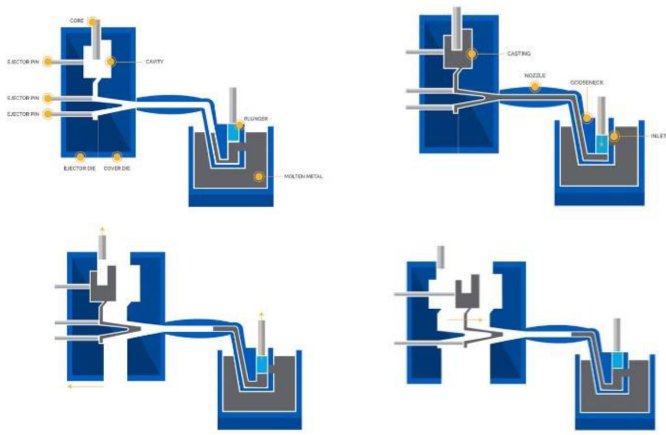

Fig.2. Cold chamber die casting machine

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C. Machine Specification

Both hot chamber and cold chamber die casting machines are typically characterized by the tonnage of the clamp force they provide. The required clamp force is determined by the projected area of the parts in the die and the pressure with which the molten metal is injected. Therefore, a larger part will require a larger clamping force. Also, certain materials that require high injection pressures may require higher tonnage machines. The size of the part must also comply with other machine specifications, such as maximum shot volume, clamp stroke, minimum mold thickness, and platen size. Die cast parts can vary greatly in size and therefore require these measures to cover a very large range. As a result, die casting machines are designed to each accommodate a small range of this larger spectrum of values. Sample specifications for several different hot chamber and cold chamber die casting machines are given below (Table.1).

TABLE.1. MACHINE SPECIFICATIONS.

Type	Clamp force (ton)	Max. shot volume (oz.)	Clamp stroke (in.)	Min. mold thickness (in.)	Platen size (in.)
Hot Chamber	100	74	11.8	5.9	25 x 24
Hot chamber	200	116	15.8	9.8	29 x 29
Hot chamber	400	254	21.7	11.8	38 x 38
Cold chamber	100	35	11.8	5.9	23 x 23
Cold chamber	400	166	21.7	11.8	38 x 38
Cold chamber	800	395	30.0	15.8	55 x 55
Cold chamber	1600	1058	39.4	19.7	74 x 79
Cold chamber	2000	1517	51.2	25.6	83x 83

V. CONTROLS

Modern die casting machines (DCM) may differ widely in placement of the machine controls. In general, the basic machine functions are common with most differences occurring in machine accessories and ancillary equipment. This chapter will deal with the basic machine functions and safety related items and some specific cases of accessories and ancillary equipment. Accessories are defi ned as equipment that is optional and in addition to the basic machine functions. Examples of accessories are automated tie bar pulling systems or automated die locking systems. Examples of ancillary equipment are extractors, autoladles, robots, reciprocators and conveyors. The machine controls can be segregated into several logical groups. First, there is a sequencer or logic system, the brains of the machine. The logic system may step the machine through a pre-programmed sequence, or may respond to inputs from the operation via a control panel or may respond to inputs from other devices, such as limit switches, pressure switches, or various transducers. This logic controller may be in the form of a programmable logic controller (PLC), a drum switch or a relay tree. This will depend on the machine's age and rebuild status. It is not uncommon to replace the machine controls with a modern PLC when rebuilding or remanufacturing a machine. Another component of the machine controls system is input devices. These are components that send signals to the machine to report the status of various actuators. Examples are the limit switch activated by the crosshead, or the pressure switch that signals when the accumulator is fully recharged. Pushbuttons and selector switches are also devices that are used to interface with the machine controller. These are all considered to be "input" devices. The last components of the machine control system are the "output" devices. The output devices control the motions of actuators or cylinders. An example of an output device is a solenoid. Solenoids shift valves directing hydraulic fluid flow. Discussion of the machine controls will begin with an example of a simple zinc DCM, followed by an example of a modern aluminum DCM work cell.

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VI. SAFETY

The die casting plant has many unique situations that must be recognized and controlled to insure the physical safety of workers. Safety considerations have been stressed throughout the preceding sections. However, safety is so important to the individual involved that this special section is included to reinforce the operator's awareness of the problems and necessary procedures. In this section, safety devices and procedures are discussed for each of the major hazards. MOLTEN METAL HANDLING Splashes, burns from hot equipment, explosions, and toxic fumes are major hazards when handling molten metal. The following safety procedures should be followed: 1. Wear safety shoes of the molders type in which metal shields are included to prevent injury from falling heavy objects. They also stop molten metal from burning through the shoe should metal be spilled. 2. Wear gloves, hand leathers, asbestos pads, leggings and spats. 3. Wear arm coverings. 4. Wear safety goggles that provide side eye protection. Complete face shields are preferable. 5. Wear respirators during fluxing operations. 6. To prevent explosions, always preheat, until dry, all items to be immersed in molten metal (e.g., shot plungers, stirring paddles, skimming sieves, ingots, etc.). 7. Check all handling equipment before using; and never exceed rated loading. 8. Have all ventilation equipment turned on. Report any defective equipment.

Fire- Because of the combination of molten metal, gas torches, hydraulic fluids, and lubricating greases and oils, there is a potential fi re hazard in a die casting department. Good housekeeping and equipment maintenance are the best fi re safety measures. All accumulation of oil, grease, or oily films must be removed periodically. All hydraulic leaks must be reported immediately. Eliminating accumulations of flammable materials coupled with good metal handling and die heating procedures, greatly reduces the potential fi re hazard. Most serious industrial accidents are the result of someone having not observed an established safety rule. Operating the die casting machine can be a highly rewarding occupation; and if the operator learns and uses the safety procedures, there is little chance of injury.

VII. CONCLUSION

A fully predefined program of monitoring for each industrial automation has been monitored and controlled using an LabVIEW. Here the functions of the system can monitor without man power. As per the result it can view the outcome for each automation in control panel display whereas it is said to be HMI. The process parameters can be gradually displaying as different steps section such as Back spray, up blow, mid blow etc, These are mainly categorized under the set ranges which is manually fixed during the change of Die for the manufacturing products. Now after this process it can notified with less man power helps to preventing from human error, this shows the regular work has been minimised with single operator by seating in control room itself.

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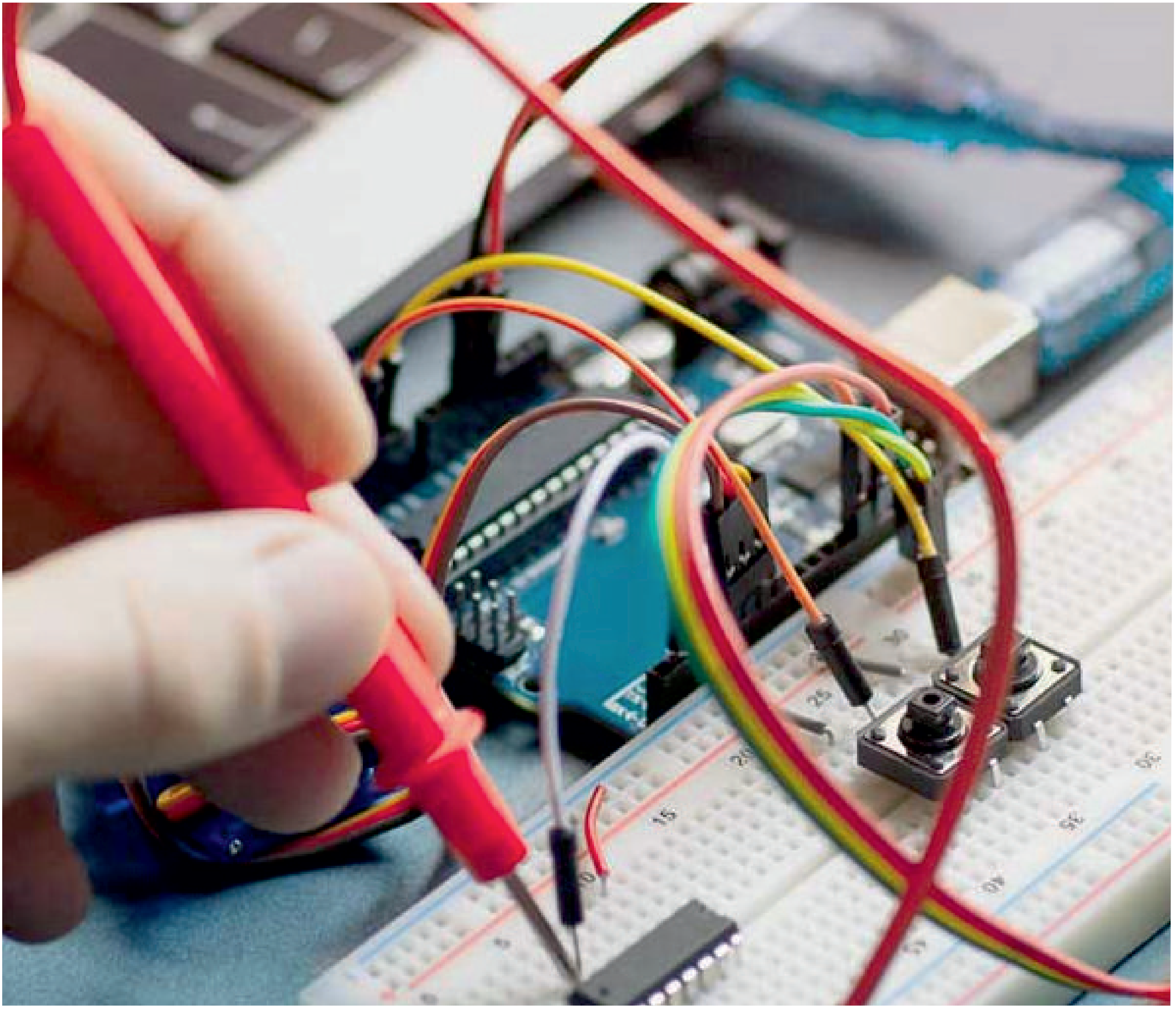

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