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IMPROVING OF FUNCTIONAL PARAMETERS FOR PRESSURE CASTING MACHINE WITH HIGH DEGREE OF FINISHING

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ABSTRACT

The paper presents a mathematic model of static and dynamic characteristics for casting machine. This machine has a hydraulic action for the casting chamber (her closing and introducing of molten alloy). This action is made by use an axial piston pump with the variable cylinder with pressure regulator. The mathematic model of how the injection pump functions (for molten alloy) can do by a computer simulation. This kind of approach for the study problem leads to the identification of key parameter and malfunction of these hydraulic parts. The malfunction simulation for the important work parameters (hydraulic force necessary to push the molten alloy in the shell, pressure compensated flow controls the strength to close the two rooms where the molten alloy is sent) show permanently the operator the place where a damage is produce and it is necessary his intervention.

KEYWORDS: casting machine, permanent mould, hydraulic action, molten alloy, variable cylinder.

1. Introduction

Alloys castings are usually thought of as being the cheapest castings available. However, when cost of providing a function is considered, aluminum castings often prove to be more economical than or as economical as gray iron castings. When considering the economics of competitive aluminum casting processes, permanent mold casting occupies a unique place.

Usually, the cost of a permanent mold casting is less than a sand casting (often substantially less), and usually higher production rates can be obtained. However, the cost of tooling for sand casting is less than that for permanent mold. When compared to die casting, permanent mold tooling is dramatically lower than dies cast tooling, but piece prices are somewhat higher. It is the combination of these two cost factors, piece price and tooling costs that enables permanent mold castings to be extremely competitive over a wide range of medium quantity orders. Each of the casting processes has a particular combination of properties in addition to the cost factors just mentioned.

When quality (strength and soundness), is the key consideration, permanent mold aluminum casting stands out as clearly superior to either sand or die casting. This is so because strength in castings (alloy and heat treating being held constant), depends on two considerations:

- Fineness of metallurgical grain structure.
- Absence of voids caused by shrinkage or the presence of gas or air.

A fine grain structure is obtained when castings are cooled rapidly from a molten to a solid state. The permanent molds from iron heat rapidly and in the casting aluminum alloy is creates a fine grain structure. In contrast, aluminum cast in sand requires much more time to solidify, which allows a coarser grain structure to form.

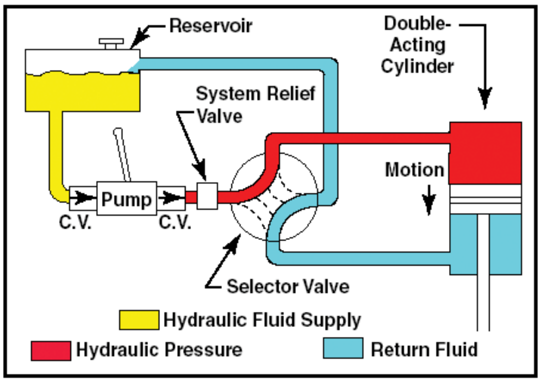

***Fig.1.** Hydraulic action system for casting machine -functionary schedule.*

In the modern hydraulic systems, the axial piston pumps with variable cylinder is used in most applications when it is necessary to control of pressure for alloy cast in permanent molds. Such a pump with pressure control, produce the necessary liquid flow and grow up the machinery efficiently. These types pumps used with proportional valves or self valves make the hydraulic systems to be more efficient and flexible. In the next schedule (fig.1), is shown a functionary hydraulic system.

2. Hydraulic pressure control

In practice, the pressure by comparing actual values with the reference forms a system that is applied to pilot valve. In figure 2 is presented the scheme of this type of pressure, for which the reference pressure (representing the entry into the system) is taken mechanical arc K3.

Simultaneous modeling of all components of a hydraulic system can describe the dynamic operating conditions thereof. Components of the vehicle off the hydraulic pressure are the main hydraulic cylinder (1) for changing the angle swinging disc - the piston axial pump with variable cylinder;-proportional valve that controls the pump.

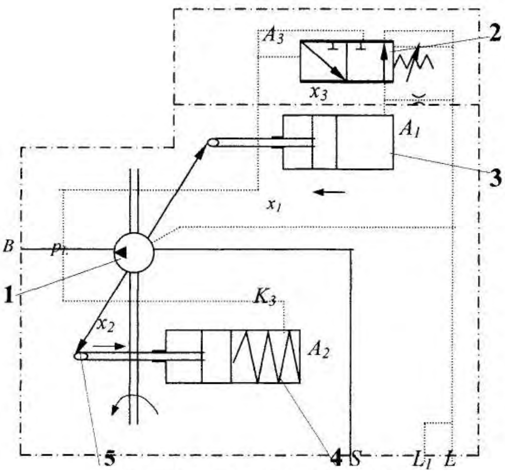

Fig.2. *Hydraulic action pump system: - pump with axial piston; 2 - proportional hydraulic valve; 3-cylinder; 4 - hydraulic cylinder (to which piston is returning with the arch); 5 - prize adjustment.*

Secondary hydraulic cylinder arc, adjust the position which closes the two cavity. In these cavity is injected molten alloy under pressure.

The disc is swinging pistons rods connected with two hydraulic cylinders.

The disc can be rotated with the two pistons, around the central position with a given angle.

The two pistons push with some force that depending on the position of the disc and angle adjustment.

Force push is the determining factor for the volume of liquid suppresses which is pumped. If the angle of adjustment is zero, the strength of the press and suppress is zero.

Disk swinging is connected with rods. The proportional control valve and the arc pressure are corresponding to the control valve.

There are two situations:

a) If the pressure of pi is less than the reference pressure operating valve control valve does not move through liquid. This has the result that there is no pressure pi to act on the surface of the piston cylinder. Angle swinging disc and pump flow, Qp, have maximum values.

b) If the pressure of pi is greater than the pressure reference acting valve control, it begins to open, leading to a flow of liquid, the main cylinder plunger. As pressure grows on the surface of the piston got it moves to the left (x is the displacement of the main piston cylinder). Pump flow is reduced in proportion to this displacement.

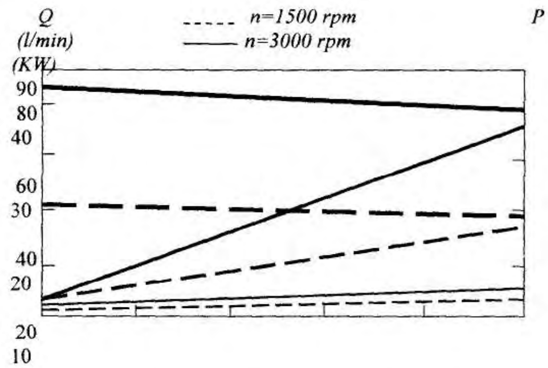

Fig.3. *Pump parameters at 1500rpm and 3000rpm.*

The hole, located between the cylinder and proportional valve 1, attenuates pressure oscillations on the proportional valve. The results are the increase of stability and reduce power losses. Changing the operating conditions of the car must be made as soon as possible and if possible without oscillations. For the analysis, we use mathematical model of axial piston pump with variable cylinder with pressure control. We can do an examination of the operating conditions of the pump, and recorded functional parameters.

Structural, an automatic hydraulic system is a sequence of energy conversions like C_i , C_J and C_2 (Electric motor converts, electrical energy into mechanical energy. At its level, is done first conversion C_i.

Hydrostatic generator converts mechanical energy into pressure potential energy, thus achieving the second converter C_2, This energy is taken of the adjustment and control and is transformed in accordance with the parameters of the plant. In the hydraulic engine (circular or linear) is performed last C_3 conversion energy, hydraulic energy is transformed into mechanical energy and then transmitted to the body in active actuation system. Automatic hydraulic systems have a size of entry x, and output size x_e (figure no.4), the components (blocks 1 ... n) are cuadripoli or sexapoli and connection lines (poles) is the support of information variables

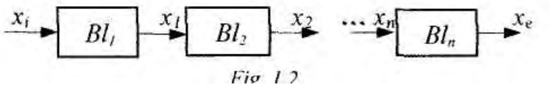

***Fig.4**. Automat system schedule.*

The action involves the existence of global dimension like n_i, Qp, Q_M, n (v) that are called direct variable. Another variable are the characteristic frequency of the system sizes M (F), M2 (F), were F is a variable effort, which includes the reserve power system for the creation of necessary force or moment to defeat resistant body of work. The displacement x and the force on piston *F'* are from the exterior of the system.

3. Research on the theoretical modeling elements of automatic hydraulic system

3.1. Model pump with constant flow

To develop mathematical models and drawing up schemes of functional blocks is departing from equilibrium equation of flow and movement. It uses the dynamic equilibrium equation of moments of electric motor and generator training. For pumps with constant flow (PDC) equations have following form:

$$Q_P = \frac{q_P}{2\pi}\omega_P - a_P p - \frac{q_P}{2E}\frac{dp}{dt} \qquad (1.1)$$

$$J\frac{d\omega_P}{dt} + b_P\omega_P + \frac{q_P}{2\pi}p + \frac{q_P}{2\pi}c_{fP}p = K_e(\omega_s - \omega_P) \qquad (1.2)$$

Where: Qp is the pump flow [m / s]; qp-capacity pump (to the avoid of fluid no active) [m^3]; cop - pump angular velocity [rad / s]; ap - linearization loss gradient flow [(m^3 / s) / (N/m^2)], p-pressure pump of the instant [N / m] E-modulus of elasticity of the liquid [N/m^2]; J-moment of inertia of the combined engine pump, coupling and rotor electric motor [Nms^2];bp- linearization gradient of losses proportional to speed [(Nm) / (rad / s)]; Ke – tilt of feature mechanical engine power [(Nm) / (rad / s)]; cop - speed angular synchronism of electric motor [rad/s];CJP- dry friction coefficient. Size of entry is instantaneous pressure p (t), and output size is instantaneous flow Qp (t) parameter is considered angular velocity of synchronism basket. Applying relations (1.1) and (1.2), Laplace transform for zero initial conditions and based on equations (1.3) and (1.4), may develop functional pump scheme with constant capacity.

$$Q_P(s) = \frac{q_P}{2\pi}\Omega_P(s) - a_P P(s) - \frac{q_P}{2E}P(s)s \qquad (1.3)$$

$$J\Omega_P(s)s + b_P\Omega_P(s) + \frac{q_P}{2\pi}P(s) + \frac{q_P}{2\pi}c_{fP}P(s) = K_e[\Omega_s(s) - \Omega_P(s)] \qquad (1.4)$$

3.2. Model pump with adjustable flow.

In case of generator capacity adjustable replaced in equations (1.1) and (1.2) of constant pump capacity following sizes: q_p / 2π = k_P ψ p, where ψp is a factor, ψ = 0, l and k_p is the maximum pump divided by 2n. It notes, too, with q_p / 2, the average quantity of liquid from the pump inactive spaces. The result is a nonlinear mathematical model:

$$Q_P = K_P\psi_P\omega_P - a_P p - \frac{q_P}{2E}\frac{dp}{dt} \qquad (1.5)$$

$$J\frac{d\omega_P}{dt} + b_P\omega_P + K_P\psi_P(p - p_2) + c_{fP}K_P\psi_P(p - p_2) = K_E(\omega_s - \omega_P) \qquad (1.6)$$

Apply Laplace relation on the equations (1.5. and 1.6.) and result:

$$Q_P(s) = K_P\psi_P\Omega_P(s) - a_P P(s) - \frac{q_P}{2E}P(s)s \qquad (1.7)$$

$$(Js + b_P + K_E)\Omega_P(s) + K_P\psi_P[P(s) - P_2(s)] + c_{fP}K_P\psi_P[P(s) - P_2(s)] = K_E\Omega_s(s) \qquad (1.8)$$

Based on written mathematical relationship (a nonlinear mathematical model) can produce functional layout pump with adjustable capacity. The two models were presented in theory by writing differential equations describing the mathematical models.

4. Modeling of axial piston pump with variable cylinder to control pressure

For modeling and control the pressure to examine static and dynamic behavior of the pump, you known the technical data of the piston axial pump with variable cylinder. It considered the speed of rotation of pump axis. Pump flow rate will be depending on the angle and pressure. Qp flow dependence of displacement (position) xi of the cylinder piston is linear. This can be expressed by the following relationship:

$$Qp = C_Q x_l - C_{Pi} ppL \quad (1.9)$$

Were: (for P_L~0)
Grow up of flow pump is C_Q:

$$C_Q = \frac{Q_{Pmax}}{x_{1max}} \quad (1.10)$$

Angle for constant speed and constant rate of loss depends on internal pressure. It notes with Cptp:

Usually the internal loss coefficient is considered constant. This may be true under certain restrictive conditions of work true of certain restrictive conditions, but can not represent all the operating conditions of the pump because they are changing considerably.

For an appropriate description of actual performance must be considered a non-linear dependence between losses flow and pressure of the pump. pi While pressure does not exceed the reference pressure, not volume of fluid passing through the proportional valve.

Qc is suppress the flow pipe pressure on the consumer. If the pressure pi is less than the reference pressure, Q_C flow pump, through the exit, is given by the following relationship: where v_c is the speed of flow of liquid. If p_i pressure exceeds the reference value proportional valve opens and there is flow through the valve to the main cylinder flow rate. This depends on the movement of the piston valve X_J.

On the surface of the piston cylinder is exercised pressure p. The hole located between the cylinder and proportional valve is crossed by the flow Q_C tank. This flow is dependent on the pressure, area and rate of flow to the hole in the formula:

$$Q_c = v_c \cdot A_{sp} \quad (1.11)$$

Loading on piston cylinder is dependent on the one hand and its position on the other hand pressure. The load (force), depending on piston position, is caused by centrifugal forces that are exerted on the cylinder piston. The pressure in relation to axes of movement of pistons pump is asymmetrical. If neglecting the forces of friction, pressure variation force FA for constant speed of rotation is given by the relationship:

$$F_A = f_A x, - k_A p_L \quad (1.12)$$

Where: A is the coefficient on F_A-dependent position, and pressure coefficient k_A depending of F_A. Aj pressure on the surface of the cylinder piston is influenced by the proportional control valve. Pressure pumping in conjunction with relatively weak spring (the proportional control valve) acting on small piston area. This method allows implementation of various piston speeds in both directions and has a small loss in terms of stability.

For a good control, proportional valve should not have high pressure losses, to ensure a good flow (a high flow) and a flow closes to zero at a zero angle disc swinging.

The whole system of regulating must have a high accuracy (minimum error output) and pump adjustments must be made as soon as soon as it is detected that an error exit. It also requires a response time as a kid.

If proportional control valve has a flow rate high, it brings us to the quick adjustment in the presence of pump output error. Increased flow in the "zero zone" must be significantly reduced through the design in order to increase damping.

Increased flow valve corresponds to "zero point" on tilt pump characteristic curve. Increasing the pressure valve is very important for precision in a stable loop control closed.

There is a method of changing pressure on piston P_J, depending on the valve. Increased pressure in the cylinder valve is attached to determining the accuracy and control is reduced by losses from cylinder.

Pressure can be reduced by practicing an additional hole between the proportional control valve and the piston cylinder of A_i mainly in connection with oil reservoir.

There is an additional damping due to friction between moving parts, which regulates the flow pump.

These parts are: coil proportional valve control pistons to the areas A_i and A_2 and hard swinging about between the two pistons.

5. Conclusions

When molten metal is injected into the cavity under pressure, air often becomes entrapped in the metal. Also, after the metal is injected into the die, additional metal cannot flow into the cavity as cooling and shrinkage take place.

As a result, die cast parts have good strength and soundness near the surface, but the more central portions of the castings often contain voids caused either by entrapped air or gas, or by metal shrinkage. This lowers the mechanical properties of the castings and may also cause blistering during heat treatment.

Reservoirs of molten metal (called risers) are used in both sand and permanent mold casting to supply additional metal as cooling and metal contraction take place. This enables both sand and permanent mold castings to be made without shrinkage voids of the type often present in die castings.

Entrapment of air is not a problem in pouring of either sand or permanent mold castings. However, sand molds can generate gasses that can be entrapped in the metal.

There are several major reasons why aluminum castings have replaced iron castings (and are likely to continue to do so).

Weight savings is often the first reason designers look to aluminum. Density of aluminum is about 39% that of gray iron. or conversely, a shape weighing 5Kg. in aluminum will weigh about 13Kg. in gray iron. In practice, however, substitution of one material for another will not necessarily follow the 1.00 to 2.58 density ratio. Sometimes the aluminum casting must have ribs added, sections made thicker, or inserts used in order for the desired functions to be accomplished. Such changes will reduce the weight savings below that anticipated by following the weight ratio.

On the other hand, many casting designs are dictated by the needs of the foundry, often causing heavier designs in iron than are needed to meet the needs of the application. In these cases, the better cast ability of aluminum enables thinner sections (well ribbed for rigidity), to be used. Weight savings can be increased to as much as 1 to 5 or 1 to 6 compared to iron. While the value of less weight in the finished part is usually well understood, as in the trucking industry where additional payloads are made possible with weight savings on truck parts, sometimes savings are neglected. For example, freight costs to the point of manufacture may be documented, but freight costs of the completed product to the end user may receive limited consideration. Or the savings made when replacement parts are difficult by air may be well understood, but the manufacturing savings made possible by lightweight aluminum are ignored. As an example, an aluminum casting weighing 15kg. can be moved by hand through a machining line, while a 34Kg. iron casting would call for the use of hoists. Similarly, the light weight of aluminum often makes it possible to do equipment repairs in the field, which would not be possible if gray iron castings were involved. Machining costs of aluminum castings are often the major factor in making aluminum competitive with gray iron.

Usually, aluminum sand and permanent mold castings cost more than equivalent iron castings before machining. However, machining costs of aluminum are often substantially less (ranging to 40% less), than the costs of machining equivalent gray iron shapes. As a result, casting plus machining costs of aluminum are often comparable to, or less than, gray iron costs.

The better cast ability of aluminum castings makes possible closer tolerance control and better surface finish, and as a result, less machining stock (often, 50% less), is required. In addition, aluminum alloys have better maneuverability ratings and can be machined at higher rates with equal tool life than can gray iron castings. Depending on the type of cutting operation, metal removal rates of aluminum castings are two to seven times faster than those of Class 20 gray iron. Considerably less energy is required for machining aluminum than gray iron. Horsepower requirements for removing an equal volume of aluminum are from 1/1 to 1/10 that of gray iron. The advantages of aluminum are often best demonstrated by examining specific applications. There are four major steps in the die casting process. First, the mold is sprayed with lubricant and closed. The lubricant both helps control the temperature of the die and it also assists in the removal of the casting. Molten metal is then shot into the die under high pressure; between 10—175 MPa (1,500—25,000 psi). Once the die is filled the pressure is maintained until the casting has solidified. The die is then opened and the shot (shots are different from castings because there can be multiple cavities in a die, yielding multiple castings per shot) is ejected by the ejector pins. Finally, the scrap, which includes the gate and runners, must be separated from the casting. This is often done using a special trim die in a power press or hydraulic press. An older method is separating by hand or by sawing, 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 re melting. 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.

For example, the good thermal conductivity of aluminum castings makes them particularly suited for use as transmission cases or for cooling system parts in truck engines. The good ductility of aluminum leads to its use for hand tools and similar applications. Also, the attractive appearance and corrosion resistance of aluminum castings have led to their use as control levers and equipment covers. Strength, corrosion resistance, and thermal conductivity are the reasons for the use of aluminum castings for radiator tanks and side-frame supports.

A major reason for the use of aluminum castings in tractors and construction equipment is their contribution to the lowering of the center of gravity of such equipment. Other parts that are made of aluminum include pistons, flywheel housings, timing gear housings, oil pans, intake manifolds, torque converter impellers, and turbo-charger compressor housings and wheels. A good knowledge of dynamics and statics characteristics of these hydraulic casting machines is important to obtain quality casting pieces.

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