Design of Hydraulic Door Open/Close System in Reheating Furance

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ABSTRACT *–In consideration of furnace, the door operation (open /close) is based on gear mechanism. During door operation stresses are developed and are acting on limited areas of the gear wheels, the maximum wear occurs at the gear tooth. Due to this wear, replacement of gearwheels and frequent maintenance is required and is more expansive. Our work is to overcome the problem by replacing of hydraulic system instead of gear wheel mechanism. This hydraulic system is more effective and smooth operation for opening and closing the door.*

Keywords— Door, Gear wheel, Hydraulic

1. INTRODUCTION

Furnace is used to heat the object in the closed system. A door is provided to open and close the furnace for loading and unloading the object. Industrial furnaces have large size door. So it is not possible to operate by manually. Generally gear and sprocket is used to operate the door by chain. It is not efficient and frequent failure will happens. To overcome these demerits, we are using the hydraulic system for operating furnace door.

2. COMPONENTS USED

A. Reservoirs

Reservoir is equipment usually designed for performing a number of functions. The reservoir also provides a place for separate out of the fluid and permit contaminants to settle out. A well-designed reservoir will helps to dissipate any heat that is generated in the system.

Reservoir Construction

An industrial reservoir is conforming to industry standard. The tank is constructed of welded steel plate with extension of the end plates supporting the unit on the floor. The entire inside surface of the tank is painted for reduce rust. The reservoir is designed for fluid maintenance. The bottom of the tank has a drain plug at the lowest point. So the tank can be drained completely. The filter hose provided with a fine mesh screen to keep our contamination which the fluid is replenished.

B.Filter

The primary function of filter is to retention by some porous medium of insoluble contaminations in the fluid.

C. Strainer

Strainer function is to trap contaminants from fluid flowing through it.

D. Hydraulic Cylinders

Cylinders are linear actuators that convert the fluid energy to linear output motion or force.

Cylinder Construction

The parts of a cylinder are barrel, piston rod, caps and suitable seals. Barrels usually made up of seamless steel tubing, the inside of the barrel is finished by honing operation. The piston usually cast irons or steels. Piston rings are used where some leakages can be controlled. A very low rate T -rings or 0- rings with two heavy duty backup rings is often used. Ports are attached directly to each end of barrel.

E. Directional Control Valves

Directional valves as the name impulse are used to control the direction of flow. Directional valves vary considerably in construction and operation.

Four - Way and Three Position Valves

The two ways and four way valves direct inlet flow to one of the two outlet ports. In case of four way valve, there is an alternate port and it is connected to the reservoir and the remaining oil moves into the reservoir.

Almost all these valves are sliding spool type and there are rotary valves which are mostly used in pilot control. There are three positions – for extraction, retraction and neutral position.

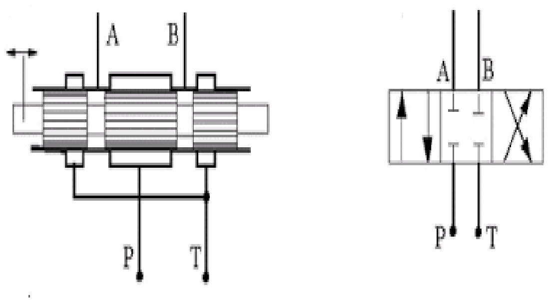


FIGURE-2.1 4/3 VALVES

Pressure Controls

Pressure controls are of different types such as relief valve, sequence valve, braking valve based on their primary function.

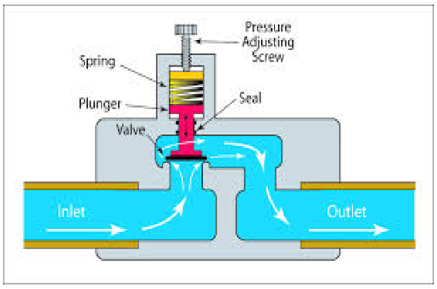


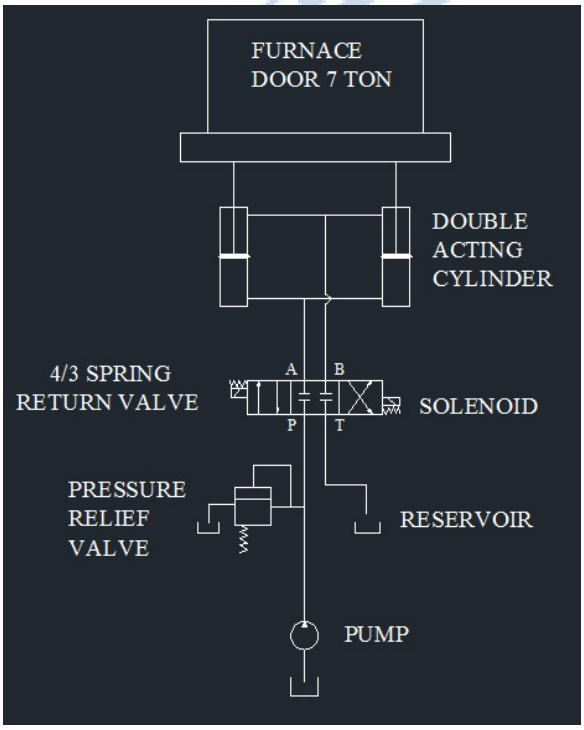
FIGURE-2.2PRESSURE CONTROLS

3. WORKING PRINCIPLE

The fluid from the reservoir is sucked out by the pump and supplied to the cylinder. The direction control valve directs the fluid from the pump into the cylinder. The pressure control valve is used in between direction control valve and the pump to maintain a constant pressure of the fluid.

In the forward stroke, the fluid is supplied to the cylinder through one of the inlet ports of the direction control valve and the piston moves up. This causes the furnace door to lift up. In the reverse stroke, the fluid is supplied through the other inlet valve and the piston to moves downward causing the door to close.

4. DESIGN DIAGRAM



5. DESIGN CALCULATION

A. Design of Cylinder

Total load of the door = 35000 N

Total stroke length = 1m

Required cylinder dimension

Piston diameter = 100mm

Piston rod diameter = 56mm

Required piston velocity

Velocity = (stroke require length of piston)/ time

` = 1/5

= 0.2m/s

B. Required Pressure

During Extension Stroke

Total pressure (p c) = Force / Area of the cylinder

$= 35000 / (\pi/4 \times d^2)$

$= (35000) / (7.853 \times 10^{-3})$

= 44.5 bar

During Return Stroke

Total pressure (p t) = Force / Area of the piston -Areaof the piston rod)

$= 3500 / (\pi /4 \text{ x } (0.1\times2) - (\pi /4 \times (0.056\times2)$

= 64.92 bar

C. Required Flow Rate

Flow rate (q) = Velocity × Area of the cylinder

$= 0.2 \times 7.853\times10^{-3}$

$= 1.5707\times 10^{-3}\ m^3/s$

Required Velocity For During Forward Stroke

Velocity = Flow rate / Area of piston

$= (1.5707 \times 10^{-3}) / (7.853 \times 10^{-3})$

= 0.2m/s

Required Velocity For During Return Stroke

Velocity (V_{re}) = Flow rate /Area of the Piston - area of the piston rod)

$= (1.5707 \times 10^{-3}) / (5.39039 \times 10^{-3})$

$= 0.29 m/s$

Required Total Stroke = Dynamic force + Frictional force

$= w/g \times a + \mu w$

$= 142.71 + 3500$

$= 3642.71$ N

D. Required Dynamic Force

Dynamic force = 0.9 × Total pressure × Area of the cylinder

$= 0.9 \times 64 \times 7.853 \times 10^{-3}$

$= 45888$ N

Maximum pressure = Total force / Area

$= 45888 \times 7.535 \times 10^{-3}$

=58 bar

E. Check for Buckling Load

Total load = 35000N

Modulus of elasticity $= 2.06 \times 10^{11}$ N/m

Equivalent buckling length = Cylinder stroke × √2

$= 1 \times \sqrt{2}$

= 0.707m

Consider the factor of safety = 2

Buckling load= factor of safety × force

=2 × 35000

= 70000 N

Buckling load (k) $= \pi 2EI / L^2$

Where I $= \pi d^4/64$

$d^4 = (64 \times 0.707^2 \times 70000) / (\pi^3 \times 2.06 \times 10^{11})$

= 0.024m

= 24mm

Even through the standard piston rod diameter is 28mm. We have selected 56mm for safety purpose.

CYLINDER 1

Piston diameter = 100mm

Piston rod diameter = 56mm

Pressure = 44 bar

CYLINDER 2

Piston diameter = 100mm

Piston rod diameter = 56mm

Pressure = 44 bar

F. Design of Pressure Relief Valve

Pressure control valve are used in hydraulic circuits to maintain the desired pressure levels. The rule thumb for the main relief valve in a circuit is to be at 10 -20% above the maximum required working pressure.

Working pressure = 64bar

Max Working pressure = 64+64× (20/100)

Pressure = 78bar

G. Design of Directional Valve

Directional control valve are used to control the direction of flow in hydraulic circuits. These are two types of DCV

1. Sliding spool type
2. Rotary spool type

Based on our requirement we are selecting the sliding spool type DCV (4/3 solenoid spring cantered DCV).

H. Design of Pump

The main parameters affecting the selection of particular type of pump are discussed here.

- Maximum operating pressure.
- Maximum delivery
- Pump drive speed
- Type of fluid
- Fluid contamination

Consider These Factors We Are Select the External Gear Pump

Maximum pressure = 40-300 bar

Maximum delivery = 0.25-760 lit/min

Speed = 500-3000 rpm

Efficiency = 70-90% (refer fro table SAE J 517)

I. Calculation of Pressure Losses

- Directional control valve
- Filter
- Pipe line

Direction Control Valve

During Extension Stroke

Pressure drop over DCV

P to A =2 bar

B to T = 2 bar

Pressure drop over filter = 1 bar

Total losses =2+2+1= 5bar

Pressure required at pump during the extend stroke = 44+5 = 49 bar

During Retraction Stroke

Pressure drop over DCV

P to B =4 bar

A to T = 2 bar

Pressure drop over filter = 1 bar

Total losses = 4+2+1 = 7 bar

Pressure required at pump during the retract stroke = 64+7 = 71 bar

Pressure Drop in Pipe Line

Pressure drop = γ Hl

Where

γ =oil specific gravity

Hl = Head loss

J. Calculation of Head Loss

Head loss = $f \times lv^2 / d \times 2g$

Friction factor (f) = 64/Re

Pipe length = 5m

Reynolds number (Re) = V d/ υ

=0.2 × 0.1/ 0.32 × 10 4

Re =625

Friction factor (f) = 64/Re

= 64/625

= 0.1024

Head loss = $f \times lv^2 / d \times 2g$

Head loss (hl) = 0.1024 × 5 ×0.2 2 /0.1×2×9.81

=0.01043m

Pressure drop = γ hl

= (1000 × 9.81 × 0.95) ×0.01043

= 1.02bar.

J. Design of Reservoir

The fluid reservoir is the storage tank which the hydraulic fluid is contained. They are usually made of steel sheets. The empirical rules for sizing reservoir,

A. If there is no volume changes in system, the minimum reservoir capacity should be twice the pump delivery per min

B. For high pressure system, the reservoir capacity should be 2-15 per installed horse power.

Reservoir Model

Normal air circulation round the fluid reservoir doubles the cooling. The fluid reservoir is square section of side a length of 2a.

Calculation

The total surface area of vertical plate (A) =2(a*a) +2(2a*a)

$=6a^2$

Height of the vertical plate (L) =a

Temperature in reservoir =70°C

Ambient temperature =20°C

Operating pressure =64 bar

Pump delivery =1.57071it/min

Heat transfer co -efficient for vertical plate $h_v=1.42(\Delta T / L)^{0.25}$

Where

H- Heat transferred In W

H -Heat transfer coefficient in W/ M^2 ° C

A -Surface area in M^2

AT -Temperature difference in °C

Heat transfer co -efficient for vertical plate H_v =1.42(50 / A)$^{0.25}$

$=3.77A^{-0.25}$

Heat dissipation from vertical plate $= H_v A \Delta T*3.6$

$=3.77A^{-0.25} *6A^2 *50*3.6$

$=4071.6A^{1.7 5}$

Air circulation doubles the cooling so

Net Heat Dissipation $=2*4071.6A^{1.75}$

$= 8143.2A^{1.75}$

But the pump efficiency is only 90% working = 0.9*3.5

= 3.5Kw

This energy is dissipated as heat

Therefore $8143.2A^{1.75}$ =3150k

Side A =0.20M

Length 2a = 0.40M

DISADVANTAGES IN GEAR MECHANISM

- Due to fatigue load, breakdown occurs in gear box.
- It requires more time to repair.
- Frequent lubrication is required.
- Maximum wear and tear takes place in gear box.

ADVANTAGES IN HYDRAULIC SYSTEM

- It provides smooth and speed operational function.
- The stroke length attains at the exact time.
- Construction of the hydraulic system is simple.
- No wear and tear occur compare to the gear & chain mechanism.
- Easy to operate.
- It is very compact to open & close the door in reheating furnace.
- Noiseless operation.
- Maintenance cost is less.

CONCLUSION

We have studied the operation of the furnace door and the frequency of its failure throughout the year. By discussing with the furnace operators, we propose the hydraulic system for the door operation to avoid the failures.

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