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Design of Air Booster for 1200 Ton Mechanical Press

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Abstract- A mechanical press is used for pressing of sheet metals to give it the desired shape. Mechanical press is a machine that changes the shape of the work piece by applying tones of load on it for accurate output. Mechanical punch presses fall into two distinct types, depending on the type of clutch or braking system with which they are equipped. Generally older presses are "full revolution" presses that require a full revolution of the crankshaft for them to come to a stop. This is because the braking mechanism depends on a set of raised keys or "dogs" to fall into matching slots to stop the ram. It is a 1200T mechanical press. It consists of a ram, upper die, lower die and cushion. For pressing upper die is pressed on sheet metal and lower die. At that time the cushion gets activated and it holds the lower die. The cushion is supported by hydraulic and pneumatic pressure. The press is a try-out press. It requires pressure up to 7 bar. The pressure provided by the company compressor is 5bar. To increase the pressure there are two options. One is to use compressor for which we have to compress air from atmospheric pressure. So it will consume more power.

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DESIGNOFAIRBOOSTERFOR1200TONMECHANICALPRESS

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Design of Air Booster for 1200 Ton Mechanical Press

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Abstract- A mechanical press is used for pressing of sheet metals to give it the desired shape. Mechanical press is a machine that changes the shape of the work piece by applying tones of load on it for accurate output. Mechanical punch presses fall into two distinct types, depending on the type of clutch or braking system with which they are equipped. Generally older presses are "full revolution" presses that require a full revolution of the crankshaft for them to come to a stop. This is because the braking mechanism depends on a set of raised keys or "dogs" to fall into matching slots to stop the ram. It is a 1200T mechanical press. It consists of a ram, upper die, lower die and cushion. For pressing upper die is pressed on sheet metal and lower die. At that time the cushion gets activated and it holds the lower die. The cushion is supported by hydraulic and pneumatic pressure. The press is a try-out press. It requires pressure up to 7 bar. The pressure provided by the company compressor is 5bar. To increase the pressure there are two options. One is to use compressor for which we have to compress air from atmospheric pressure. So it will consume more power. Moreover the space required for it very large. The another option available for it is to use a compact and power saving device. Such a device is called booster. A booster is a double acting cylinder. It has two chambers. One chamber has bigger area which consist of piston end. Another chamber has small area and it consists of rod end. Large force is applied to piston end by pressurized air. This force is transmitted to rod end of piston. The area at this end is small and hence the air at this end is compressed to very high pressure. Thus pressure rise is obtained.

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I. Introduction

A booster is a device that amplifies available line pressure in order to perform work requiring much higher pressure. It operates a hydraulic cylinder without the need for a hydraulic power unit. The low pressure is converted by the booster to a much higher hydraulic pressure on the output side.

Figure 1 : Image of Booster

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The principle of the air booster works much the same as our liquid pumps in which a larger air drive piston is directly connected to a smaller pumping piston. The incoming air from the compressor drives the booster and also feeds the supply to the unit. 90% of industrial facilities use compressed air in their process. Unfortunately, most compressed air systems are inherently inefficient, converting less that 20% of their energy input into useable compressed air. Consequently, reducing unnecessary compressed air usage and improving the efficiency of the compressed air systems themselves are excellent energy-saving strategies. Compressed air is often used because it is believed to be convenient, safe, and labor-saving. These advantages may justify the high cost of compressed air, but often more energy-efficient alternatives exist. Air leaks, improper pressure regulation, and airflow restrictions can easily reduce a system's useful capacity by 50% or more. Typically, these problems are "solved" by adding a new compressor, when fixing the problem would be much more cost effective and energy-efficient. The Automatic Airline Booster Pump was designed to boost airline pressure automatically in surge tanks or die cushions, or for any high pressure application, such as testing, where small quantities of high pressure air are needed. To operate this booster you simply pipe airline pressure to the master control valve, to the intake side of the booster, and run a high pressure line from the booster to your surge tank. The booster will then operate automatically to boost pressure in the die cushion or surge tank in the desired ratio. This booster is completely valved, ready to operate, with only three airline connections necessary. The booster is completely air actuated with no electrical connections necessary.

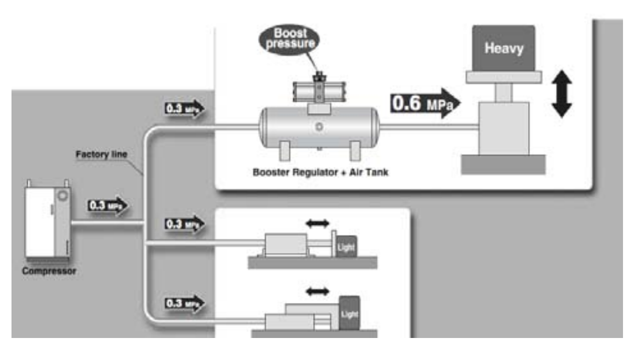

Figure 3 : Layout of executed Air Booster

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II. Principle & Working of Design Air Booster

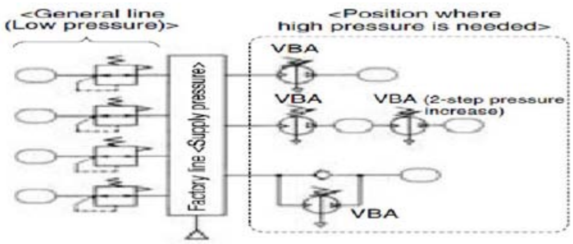

Figure 2 : Circuit diagram of Air Booster of single/multistage compression

A booster, or pressure intensifier, is a device that amplifies available line pressure in order to perform work requiring much higher pressure. It operates a hydraulic cylinder without the need for a hydraulic power unit. A booster is basically a cylinder and is similar in internal design, except that the rod end of the piston does not extend outside. The rod becomes a ram for hydraulic fluid. A booster is equivalent to a transformer, or pulley system, in that it changes the ration of pressure input to pressure output but does not amplify power. Low pressure air, as found in most plants or shops, is connected to the large cylinder. Pressures are typically 80 to 100 psi. This low pressure is converted by the booster to a much higher hydraulic pressure on the output side. This discharge has an amplified pressure potential equal to the product of the supply pressure and the booster ratio. Total power is not changed, as the low pressure input air must operate against a large area piston in order to produce high pressure from a much smaller surface area.This total force is exerted by means of piston rod, or ram, to the output section of the booster. The output section contains there hydraulic fluid. Just the end of the rod applies pressure to this fluid.

Low pressure air enters the input section of the booster. It pushes against a large area piston. For example, if a 100 psi air supply pushes against a 4" diameter piston, it is working against an area of approximately 12.6 square inches, for a total force of 1,260 pounds. This total force is exerted by means of the piston rod, or ram, to the output section of the booster. The output section contains a hydraulic fluid. Just the end of the rod applies pressure to this fluid. Let's say that the rod end has a 1" diameter. Its area is about .8 square inches. Divide the .8 square inches into the total applied force of 1,260 pounds and the result is 1,590 pounds per square inch. We have transformed 100 psi into 1,600 psi, or a ratio of 16 to 1. Standard boosters are available in ratios running from approximately 2 to 1 up to 36 to 1. In the selection of a particular booster, not only does the ration have to be taken into account, but also the output volume has to be matched to the cylinder which the booster will drive.

III. Operating Power of Air Booster

In our example above, we have an output of 1600 psi hydraulic pressure. When this 1600 psi is bed to a cylinder, the total area of the piston in the cylinder in now under a pressure of 1,600 psi! Therefore, instead of an air cylinder which would have to work under 100 psi air pressure, we now have a cylinder working under 1600 psi hydraulic pressure. True, this cylinder will only perform work at this pressure through a volume of fluid in the cylinder that is equal to the same volume displacement in the booster, but for many operations, this volume displacement at such increased pressures is completely satisfactory. In shop air is used as the power source, as this is the most common way boosters are used. It is, however, quite possible to use oil as the operating power source, particularly for extremely high pressure applications. For example, if you need to develop 40,000 psi and had a choice of 80 psi air or 3,000 psi oil, the air booster ratio would be 500:1 and the oil only about 13:1. It's obvious that using an oil to oil booster system would be far less expensive. Standard boosters are air to oil only.

IV. Calculations and Graphs

According to the relation

Pressure = force/area; P=F/A;

But, Force=mass flow rate *velocity;

$$F=\dot{m}*v/A;$$

Mass flow rate = density*area*velocity;

$$\dot{m}=\rho*a*v;$$

Therefore;

$$P=\rho*a*v*v;$$

Therefore according to this relation;

$$V=620.20\,m/s;$$

a) Calculations of Mass Flow Rate

For tank inlet at 5 bar pressure with 2.54 cm diameter of inlet pipe ;

$$\dot{m}=\rho*a*v;$$

Where;

ρ, density of air=1.298;

V, velocity = 620.65;

D, diameter of inlet pipe = 2.54*10E-2;

$$\dot{m}=1.298*\pi/4(2.54*10E-2)E2*620.65;$$

$$\dot{m}=.414\ kg/s;$$

Mass flow rate = .414 kg/s;

Mass flow rate of air for tank inlet at 7 bar;

At 7 bar pressure, according to the relation;

$$P=\rho*a*v^{\wedge}2;$$

Velocity, v=734.37 m/s;

Mass flow rate, $\dot{m}$= ρ*a*v;

Where;

ρ, density of air=1.298;

V, velocity = 734.37;

D, diameter of inlet pipe = 2.54*10E-2;

$\dot{m}$=1.298*π/4(2.54*10E-2)E2*734.37;

$\dot{m}$=.48 kg/s;

Mass flow rate through booster at 7 bar pressure;

According to the relation;

$\dot{m}$= ρ*a*v;

Velocity of flow is given by;

V=734.37 m/s;

Diameter of inlet pipe of booster,

D=0.82*10E-2;

According to the relation;

P= ρ*a*v*v;

Mass flow rate through booster is given by;

$\dot{m}$=1.298*π/4(0.82*10E-2)E2*734.37;

$\dot{m}$=0.05031 kg/s;

Therefore, number of booster required is given by the relation;

No. of booster = mass flow rate through tank/mass flow rate through booster;

N= 0.48/0.0503;

N= 10 (approx.);

b) Calculations for No. of Boosters

Stroke length of cushion cylinder = 300 mm;

Bore diameter of cushion cylinder, D =1120 mm;

Ram speed, v = 100 m/s;

Reset time, t = 1 minute;

Therefore,

According to the relation, discharge is given by;

Q = π/4*D*D*S/10E6 ltr;

Q = π/4*1120E2*300/10E6 ltr;

Q = 295 ltr;

Flow rate is given by;

Flow rate = Q*60/t ltr/min;

Where,

Time for one stroke, t= 3 seconds;

Therefore flow rate is given by;

Q = 295*60/3;

Q = 5408 ltr/min;

therefore flow rate at 1 bar pressure is given by;

Q = 5408 ltr/min;

Therefore flow rate at 7 bar pressure is given by;

Q = 5408*(0.707 – 0.101/0.101);

Q = 46854 lt/min;

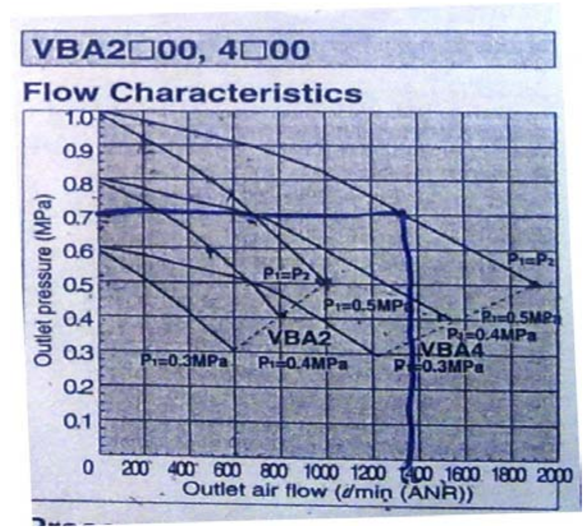

Figure 4 : Plot for output pressure vs flow rate of air

According to the graph;

From 0.5bar to 0.7bar;

Q_b=1350 ltr/min;

Because

$Q > Q_b$;

As the discharge of tank of cushion is more than the discharge through the booster, an extra tank will be installed for the storage of booster output to maintain the pressure.

Tank specifications:

Stroke time, T_c = stroke length/speed;

T_c= 300/100;

T_c = 3 sec;

c) Calculations for Tank Capacity

According to the relation;

Volume of tank required, V = (Q-Q_b/2)*(T_c*K/60)/ (P_3-P_2)*9.9;

Where;

K, single side stroke = 1;

P_3, max. Pressure = 10 bar = 1 MPa;

T_c, stroke time = 3 sec;

Q_b, discharge through booster = 1350 lpm;

Q, discharge through the tank = 46854 lpm;

Taking all the values in relation, volume of tank required is given by ;

V =(46854 – 1350/2)(3*1/60)/ (1 – 0.75)*9.9;

V = 777 ltr

d) Time Required Charging The Tank Is Given By Relation

$$T = V/10^{*}\ (t_2\text{-}t_1)/N;$$

Where,

N, no. of booster required = 1;

$$P_2/P_1 = 0.7/0.5;$$

$$P_2/P_1 = 1.4;$$

From the graph shown;

Time required for 10 litres of tank = 0.5;

$$T = 0.5 * 777/10;$$

$$T = 38 \text{ sec};$$

Therefore time required to fill the tank is 38 seconds.

V. Advantages

a) Long Holding Time

Another case is where you want to exert a high pressure for a long time, such as maintaining pressures on printing rolls. A booster-cylinder system will maintain a continuous pressure with very little power input. In a pump-cylinder system, the pump must be kept in continual operation. (In order to achieve such holding pressure, there must be a relief valve inserted in the system.

b) Extreme High Pressure

Pressures over 10,000 psi can be obtained with special boosters while virtually impossible with ordinary pumps. When you require an inexpensive way of achieving high pressures, even up to 50,000 psi, the booster is the answer.

c) Cost Ratio

Another reason for using boosters is the cost ratio of a booster system vs. pump system. You have a machine which requires a linear actuator pressure of 5,000 psi. If you were to design in a complete 5,000 psi hydraulic system into this one machine, it could cost you many times a booster system! Again, remember that we are talking about one machine requiring intermittent high pressure.

d) Save Space & Weight

In many applications, booster driven cylinders can replace an extremely large, low pressure air cylinder with a small, efficient, high pressure hydraulic cylinder. Coupled with reduced circuitry, the overall weight of a machine can be reduced, as well as the total space required.

e) Lower Cost

A booster system is less expensive than an overall hydraulic system with its pump-motor requirements. They also require only a fraction of the air of a direct air cylinder installation. Hydraulic requirements are also much smaller to operate a given function. This system is a low cost solution when high pressure and relative high volumes of air is required in a pneumatic application. This system can save money when requirements need up to a 600 PSI supply of air with reserve capacity

VI. Applications

a) High pressure from ship air

One of the principal applications for boosters is in the conversion of low pressure shop air to high pressure hydraulic operation for a specific function where a hydraulic cylinder is required. Many operations require the smooth power inherent in a hydraulic cylinder, yet do not require the expenditure for a complete hydraulic installation. The small, yet powerful movement of a booster driven hydraulic cylinder can be used to hold a piece for riveting, as a spot welding clamp, for punching, piercing, forming, crimping, bending, stamping, shearing, marking, etc. The complete installation of booster, air-oil tank and cylinder can be mounted directly on the equipment itself.

b) Testing

Testing of manufactured parts for physical strength, leaks or burst rating can easily be accomplished with a booster-cylinder combination or a booster alone. A hydraulic cylinder will give a precise, high pressure force for mechanical testing, and a booster can be linked up directly, to a die casting, for instance, to test for leaks.

c) Fluid Transfer

Fluids that are difficult or impossible to transfer with a conventional pump can be fed through a valve-booster combination. Depending on the type of fluid, boosters can be produced with special metals, such as stainless steel.

d) Liquid Injection

High pressure injection of liquids are readily handled with a booster. Such liquids, injected into high pressure gas lines or containers, might include lubricants, antifreeze or odorants.

VII. Conclusion

I have been successful in implementing the booster system to increase the pressure of press by a desired ratio. For this no extra power input is needed. The pressurized air from the main compressor is taken as input to booster. It saves a lot of power consumption. Further no major modification is required in the circuit. Only small space is required for booster, reservoir and valves.

The press is a try-out press. Now the press can be used for pressure higher than company pressure. Thus various pressures can now be applied for pressing the sheet metal. Thus we can decide for which pressure the sheet gets pressed to desired shape to obtain good surface finish and wrinkle free surface. Thus the efficiency of pressing operation and machine is increased.

References Références Referencias

1. D. J. Brake, C. A. Nixon, “Design and operational aspects in the use of booster, circuit and auxiliary fan systems”, Mine Ventilation Australia, Brisbane, Australia.
2. J. F. Agrawal, R. D. Askhedkar and P. M. Padole, “Design Of Medium Duty Mechanical Press For Ginnery”, Department of Production Engineering, Y. C. College of Engineering, Nagpur.
3. J. F. Agrawal et. al.“Assessment of productivity of Mechanical Press Machine used for Compressing Waste Cotton and Methods of Improvement”, Journal of Industrial Engineering. Under Publication.
4. LeGo MaNiAcS, Wilson Burton, Jon Carlson, Brad Cobb, Amber Monceaux, Tyler Ray, Ron York, February 16, 2008, “Manually Operated Punch Press Design”.
5. Bela G. Liptak “Instrument Engineers' Handbook, (Volume2) Third Edition: Process Control”.
6. Hui Li - Lihui Fu -Yuping Zhang, “Optimum Design of a Hybrid-Driven Mechanical Press Based on Inverse Kinematics ”Department of Electromechanical Engineering, Shijiazhuang Institute of Railway Technology, P.R. China.

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