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DESIGN AND FABRICATION OF SEMISOLID FILLING MACHINE

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ABSTRACT

In industries filling machines are used for packaging, mainly for food or beverage but also for other products. These are used to fill either in bottles or covers, depending on the product. Filling of liquids is easy when compared to semi liquids like cosmetic cold creams, petroleum jelly, heavy lubricant oils and greases.

No one type of filling machine can handle all liquids in all industries. For example, a machine that fills cool drinks/water cannot fill heavy oils/petroleum jelly. Although there are many different types of filling technologies, there are relatively few that are cost effective to own and operate. The choice of filling machine depends on the range of viscosities, temperature, chemical compatibility and hazardous environment considerations.

This project deals with lower capacity filling machine used by small to medium sized companies typically found only in the mass marketing industry. For example, in a company where manual operation is done for filling petroleum jelly involves more labour and time with less production rate. This problem can be overcome by implementing a filling machine to increase production rate and reduce production time where mass production is required.

The advantage of this type of filing machine is that involves conventional mechanical technology that is easy to understand for most users. It is also the most cost effective, accurate and fastest way to fill semi liquid products.

I. INTRODUCTION

Filling machines:

Filling machines are used for packaging, mainly for food/beverage but for other products as well. These are used to fill either a bottle or a pouch, depending on the product.

- Design to fill high, medium and low viscosity products.
- Fill light liquid products at higher speed and also capable to fill the product from water to heavy oils.
- It is the most fastest and most reliable repeatable filling method used by sizeable number of industries.
- The filling machine means filling by a volume of the product opposed to weight or level.
- Mainly available in two types- Automatic and Semi-automatic.

Automatic filling machines:

Automatic fillers offer a significant jump in production for a number of facilities. These uses computer programme or sensors to assist the operation of filling. In automatic machines the bottles move into the fill area without assistance from the operator. The justification for installing an automated filling machine ordinarily revolves around two considerations, namely labour saving through automation, and saving of raw material through improvements in filling accuracy. Such improvements are normally sufficient to motivate such a machine where financial payback of less than a year can be achieved.

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Fig: 1.1-Automatic filling machine

Semi-automatic filling machines

Semi-automatic fillers are useful for more than just getting out a greater number of filled bottles or containers. Semi-automatic liquid fillers can be manufactured based on the same filling principles as automatic filling machines. Automatic machines move bottles into the fill area without assistance from the operator, while the semi-automatic machines will require some manual labour.

Fig: 1.2-Semi Automatic filling machine

Types of fillers

There are many different technologies and capacities of filling machines available on the world market.Choosing the best filling machine for your application is a complex decision based on a host of factors including product characteristics, container characteristics, fill size, daily production needs, plant environment and performance.
There are five types of filling machines available,

1. over flow liquid filler
2. Servo pump liquid filler
3. Peristaltic liquid filler
4. Time gravity liquid filler
5. Piston liquid filler

Problem definition

In industries filling machines are used for packaging, mainly for food or beverage but also for other products. These are used to fill either in bottles or covers, depending on the product. Filling of liquids is easy when compared to semi liquids like cosmetic cold creams, petroleum jelly, heavy lubricant oils and greases. No one type of filling machine can handle all liquids in all industries. For example, a machine that fills cool drinks/water cannot fill heavy oils/petroleum jelly. Although there are many different types of filling technologies, there are relatively few that are cost effective to own and operate. The choice of filling machine depends on the range of viscosities, temperature, chemical compatibility and hazardous environment considerations.

Scope of the project

This project deals with lower capacity filling machine used by small to medium sized companies typically found only in the mass marketing industry. For example, in a company where manual operation is done for filling semi solid

fluids involves more labour and time with less production rate. This problem can be overcome by implementing a filling machine to increase production rate and reduce production time where mass production is required.

Approach of this problem

There are expensive filling machine technologies beyond the reach of most small to medium sized operations. There are also some very cheap machines, including Chinese and other foreign imports that cost owners more to maintain and often result in production downtime or quality issues. After designing and building many different types of filler machines over a 20 year period, there are relatively few filling machines which can fill high viscous fluids like semi solids.

To fill high viscous fluids by utilizing modern technology and to make the machine successful run we are combining the two modern principles of pump type and piston type. The advantage of this type of filing machine is that it involves conventional mechanical technology that is easy to understand for most users. It is also the most cost effective, accurate and fastest way to fill semi solids products. This project has more advantages over manual type because of improving production. We use the simple process to see the performance. Here, the solenoid valve plays a vital role and has a control signal to open/close the valve to deliver the compressed air.

II. METHODOLOGY

Design of the model, process flow diagram

Generally the filling machines are used for filling liquids like water, drinks, etc., which works on the principle of gravity since their viscosity is very low. But in the project, the material we are using is of semi solid type with high viscosity which requires force for pumping the fluid. Out of the above mentioned three principles of filling machines, we are combining two of them pump type and piston type for this project. The design for this method of pumping and filling is shown below.

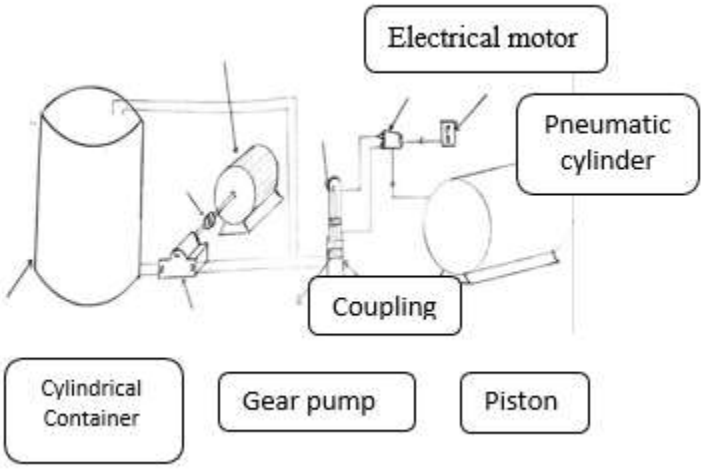

Fig: 3.1-Design of the model

The semi solid material is first taken in the cylindrical container and is sucked by the oil gear pump which runs with the help of the electric motor. The sucked material is delivered to the T junction just before the pneumatic cylinder for recycling the excess material after pumping the material into the mountings with piston below the pneumatic cylinder. The material in the mountings is pushed down by force exerted from piston movements. The movement of piston in the mountings is created by the pneumatic cylinder, this pneumatic action in the pneumatic action is controlled by the cyclic timer and the solenoid valve which works by the compressed air from the compressor. The entire process is showed in the process flow diagram which is shown below.

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Components used in the project

***Container*:** A container is a basic tool, consisting of any device creating a partially or fully enclosed space that can be used to contain, store, and transport objects or materials. The containers are of many shapes and material but the container which we are using to hold the base material which is required to be filled is of cylindrical in shape and the material of the container is mild steel.

Fig: 3.3-Cylindrical Container

Specifications
Shape: Cylindrical
Material: MS
Diameter: 8 inches
Height: 9 inches
The volume of the material which can be stored inside the container is,

$$V = \frac{\pi}{4} d^2 * \text{h}$$

$$V = \frac{\pi}{4}(14)^2 * 30 = 892.053 \text{ cubic inch (or) } 14618.14 \text{ cubic cm}$$

Gear pump:
A gear pump uses the meshing of gears to pump fluid by displacement. They are one of the most common types of pumps for hydraulic fluid power applications. Gear pumps are also widely used in chemical installations to pump high viscosity fluids. Working: As the gears rotate they separate on the intake side of the pump, creating a void and suction which is filled by fluid. The fluid is carried by the gears to the discharge side of the pump, where the meshing of the gears displaces the fluid. The mechanical clearances are small in the order of 10 μm. The tight clearances, along with the speed of rotation, effectively prevent the fluid from leaking backwards. The rigid design of the gears and houses allow for very high pressures and the ability to pump highly viscous fluids.

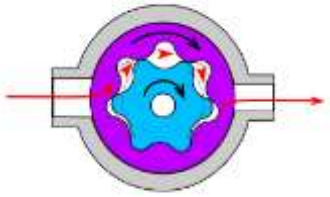

Fig: 3.4-Working of gear pump

Specifications
Motor required: 0.5HP
Capacity: 20LPM

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Inlet & Outlet size: 0.5x0.5 inch
Type: Rotary oil gear pump

Fig: 3.5-Gear pump

III. EXPERIMENTAL SETUP

Arrangement of components:

- According to the design we opted, for pumping the semi solid fluid we first started with the purchase of the Tank of size of diameter 8inches and height of 9inches and also a Gear pump for pumping action.
- For the alignment of motor shaft and gear pump we used a star rubber coupling, for tight fitting of the coupling to the shaft, we made a key way on a lathe machine.

Fig: 4.1-Keyway on shaft of gear pump

- After making a keyway, aligning of motor to the pump made a problem. To overcome it we purchased two angle plates and made holes on drilling machine with drill size of 5mm and using nuts and bolts with inch threads we tightened the alignment.

Fig : 4.2-Alignment of shaft & gear pump

- We made a container from 8inch long pipe and closed at one end by welding a plate to it. To make an outlet to the container we made a hole using gas welding at the bottom of tank of size of diameter 0.5 inch, after that we welded with a nipple to that hole of tank to make a permanent joint.
- Later we purchased an MS Block of cuboid of dimensions 62mmX115mm as mounting below pneumatic cylinder. We machined a hole of dia 35mm for easy moment of piston inside the mounting block, and also

drilled a hole of 0.5inch for the intake of material and also made ½ inch internal tapping to it for tightening of nipple.

Fig: 4.3-Mounting Block

- At the delivery slot of gear pump we made a joint to mounting by connecting pipes. Initially we can't make a joint to mountings by pipes, so we used nipples which are like pipes consisting of external threads. We used two 2 inch, one 9 inch, one 11inch nipples of ½ inch diameter along with one T-joint and two elbow joints.
- We used a T-joint and connected it to gear pump and mountings and from other end of the T-joint we joined two nipples using elbow joint for filling the semi solid into the cylindrical tank when the cyclic timer is switched off.

For making a board to install some components, we took a square ply board of 9x9 inch dimensions and drilled holes using hand drill for fixing cyclic timer, Solenoid Valve, MCB, Bell Switch using screw and

Fig: 4.4-Setup of MCB, Solenoid valve, Bell Switch and cyclic timer

- Now we took a hose nipple of 1\4 inch and connected it to the solenoid valve and we connected compressor pipe outlet i.e., hose pipe to this hose nipple.
- We took two hose pipes of 6 mm internal diameter and connected them to solenoid valve outlet and to pneumatic cylinder inlet.

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Fig: 4.5-Hose pipes connection

- We joined the Pneumatic cylinder to the top of mounting by using LN Blots with mm threads, so that the two parts are joined tight without leaks.
- Now we made 1\2 inch hole at the bottom of the mounting and connected a nipple to it, so that the semi-solid will come out from the nipple and fill in the packets.
- Further we gave connections to the entire set up on ply board using electrical wires.
- Now this ply board or entire set up is connected to a 3- phase motor and a compressor.

Working model:

The fluid to be filled is of semisolid type i.e., petroleum jelly with high viscosity and is taken in a container. The 0.5hp gear pump connected to a motor with the help of star rubber coupling is used to suck the fluid from container and deliver it to the mountings when motor rotates. This mounting is specially designed to allow the fluid from one end to the other end by the movement of piston in it. This piston is operated by the pneumatic cylinders to exert force on the fluid for delivery**.** The whole working model of our semi-solids filling machine is shown below.

Fig: 4.6-Working model

A pneumatic cylinder is a component which carries out a movement using compressed air as the medium. This movement of the piston is controlled by a solenoid valve and a cyclic timer. The electrical signal of particular time which is been set is sent to solenoid valve. The cyclic timer is the main component in this system; it allows us to operate the pneumatic cylinders and thereby filling the material at particular time. The cyclic timer consists of two knobs ON and OFF with the adjustments of time from 6 seconds to 60 min as well as with their percentages from 0 to 100.

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IV. RESULTS AND ANALYSIS

After successful working of the semi-solid filling machine model, we have taken some test trails of filling of semi-solid material i.e., petroleum jelly into the packets by changing the ON/OFF timing of the solenoid valve using cyclic timer. Below there are five test trails taken during running of the machine.

Trail-1

For entire run of the model we fixed the cyclic timer ON & OFF switch at 6 seconds and adjusted the knob at 1% of 6 seconds for ON and 50% of 6 seconds for OFF cycles for trail-1. So that the idle time or valve closing time must be more. The packet we got for the first trail of the model is shown below.

The time taken for filling the packet = 1% of 6 sec

= 0.06 seconds

The idle time the valve is closed = 50% of 6 sec

= 3 sec

Number of packets that can be filled in 1min = $\frac{60\ sec}{\text{Filling time + Idle time}}$ = $\frac{60}{0.06+3}$

= 19.6 packets

No. of packets that can be filled in 1 hour = 19.6 x 60 = 1176 packets/hr

V. CONCLUSION

Instead of using manual operation of filling in industries this method gives us more advantage as the cost of fabricating the machine is also less and there will be less labour requirement. This machine is suitable for mass production increasing the production rate. The ease of operation is also simple and we can control the machine and production rate by just adjusting the timing in the cyclic timer.

VI. FUTURE SCOPE

In future there can be made some improvements to the machine. Instead of adjusting the cyclic timer by using knob, a computerised system may be installed. Also for obtaining production rate with less labour fully automatic machine can be made.

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