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DESIGN AND MANUFACTURING OF SEMI-AUTOMATIC CONTROLLED FLOW RATE FILLING MACHINE

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Abstract – *The filling machines are extremely important in packaging industries and upon observing certain limitations of the preexisting machines such as them being expensive, having limited filling applications and product wastage problems, we sought out to making a machine which solves these problems by using a timer-based principle in which we can control the flow speed of the fluid by using a rotary motor. This principle enabled us to solve these problems and fill fluid with different viscosities. This is a pocket friendly machine and can be extremely helpful in filling materials like sanitizers and soaps which are the demand of the current pandemic situation.*

***Key Words*: fillers, packaging, semiautomatic, liquid filling, viscosity, foamy, flammable, etc**

1. INTRODUCTION

The packaging industry in India was valued at USD 75.95 billion in 2019. It is expected to reach USD 103.32 billion by 2025. This is at a CAGR of 5% over the forecast period 2020 – 2025. According to the Packaging Industry Association of India (PIAI), the sector is growing at 24% to 27% per annum.[1]

Packaging machinery is used throughout all packaging operations, involving primary packages to distribution packs. This includes many packaging processes: fabrication, cleaning, filling, sealing, combining, labeling, overwrapping, palletizing.

Filling machines are used for packaging, food/beverage, and other products. These are used to fill either a bottle or a pouch, or any container, depending on the product. This application can be used for any product dealing with the packaging industry; different filling applications are predominantly liquid for various products.

2. AIM AND OBJECTIVES FOR THE PROJECT

- To manufacture a machine which fills any flowable liquid of any viscosity (foamy and flammable)
- To control the flow speed of the liquid for different viscous fluids by using a pump motor
- Solve the after-filling drip problems occurring in existing filling machines
- Establishing a cost-efficient filling machine for small scale industries.
- To manufacture a machine this has less than 2% accuracy.

3. COMPONENTS SPECIFICATIONS

Table-1 List of Components

Components	***Dimensions/Specifications***
Structure	*Length 11550 mm, Width 875 mm, Height 1950 mm, Working Height 880 mm*
NOZZLE	*Inner diameter 8 MM, Outer diameter 16 MM*
Pump motors 1 and 2	*0.18 kw, Rpm 850 rpm@50hz, i/p supply 3 ph, 230 v ac*
ROTARY GEAR PUMPS 1 AND 2	*SIZE 3/4 * 3/4, RPM 1400RPM@50HZ FLOW 33.33 LPM*
VFD FOR PUMP 1 AND 2	*0.18 KW, I/P SUPPLY 1PH 230VAC O/P SUPPLY 3 PH, 230 V AC*
TIMERS FOR PUMP 1 AND 2	*MODEL FLT7211 I/P SUPPLY1 PH, 230 V, AC*
Tank structure	*Capacity 100 liters l=700 mm ,b=405mm,H=450mm*
STIRRER MOTOR	*0.18 KW RPM1350 RPM@50HZ I/P SUPPLY3 PH, 230 V AC*
STIRRER GEAR BOX	*TYPE BOX 040, RATIO 20*
INFEED HOSE PIPE, OUTFEED HOSE PIPE	*PVC BRAIDED, ID-20MM, OD- 26 MM*

4. DESIGN (3D MODELS)

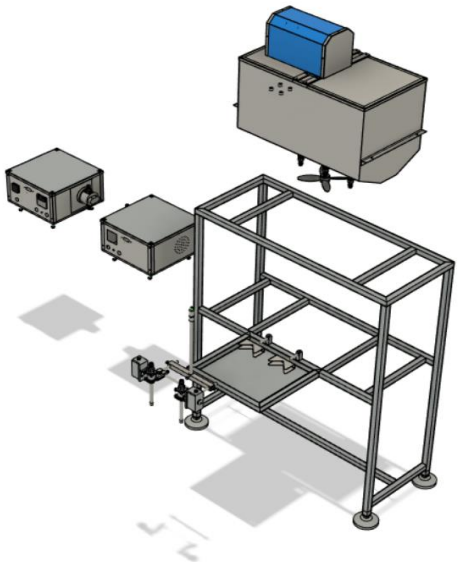

Fig -1: Exploded view

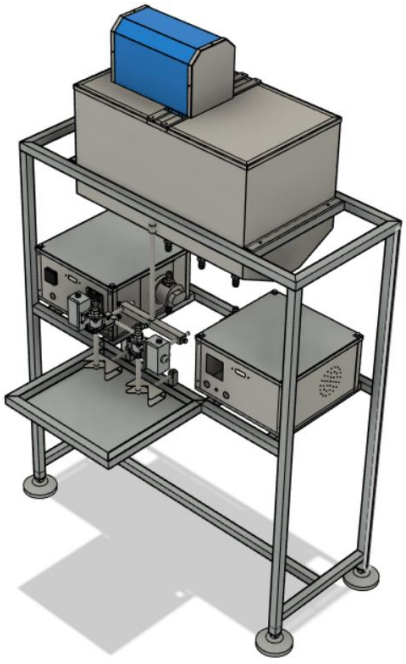

Fig -2 Final design

5. WORKING PRINCIPLE

This machine works on the principle of timing cycles controlled via variable frequency drive which can be used to control rpm of the rotary pump and fill fluids of different viscosity from 100 ml onwards.

5.1. WORKING

- Liquid in tank is filled up and all the power supply sources are turned on.
- V.F.D is used to set the frequency of the pump motor which controls the rpm of the rotary motor. This is set according to the viscosity of the material and is done by trial-and-error method.
- The volume of the liquid dispensed according to the input parameters is checked via a manual timer by the user during the first operation of the specific liquid.
- The filling phase timings are then noted down for future purposes.
- Filling phase timing (time taken to fill the specific product) and resting phase timing(time taken to replace the filled bottle with an empty one) inputs are given to the machine to get a desired filling application cycle.
- Footswitch is used to give the start command and filling starts.
- Filled bottles are replaced by the user, and the sensors detect the bottle and automatically start filling again according to the user defined timing parameters.
- The desired volume is dispensed, and anti-dripping shut off valve prevents dripping
- Stirrer is provided to maintain homogeneous structure of product
- Liquid level controller is used to maintain volume accuracy in the mother tank
- Transfer valve opens as the quantity of the product in mother tank decreases, and the tank is filled from the interconnected storage tank.
- Footswitch is pressed again to give the stop command
- After the operation automatic cleaning is performed via a water stream passed through the internal parts.

6. EXPERIMENT

Post assembly of the components, the machine was prepared to carry out the filling applications' required trials. We tested the machines filling outputs with two different fluids with varying viscosities:

1) Imidacloprid with 30.5% SC (High viscous fluid (880 cp) and Flammable)
2) Cypermethrin 25% EC (Low viscous fluid (88 cp) and Flammable)

6.1 PROCEDURE

1. The bottles' weights were measured in gm when they were empty.
2. The mother tank was filled with Imidacloprid with 30.5% SC (High viscous fluid (880 cp) and Flammable).
3. First, we set the frequency in both VFDs and commenced the filling application.
4. The time taken to fill the bottles of 100 ml, 250ml, 500ml, 1000ml capacities were measured by a manual timer for the first bottle for each capacity.
5. The time taken for the filling applications of varying capacities was noted down and kept constant for future references to fill the respective capacity again when required.
6. After noting down the filling time, we took ten trails for each capacity.
7. For the filling of 100 ml fluid, the time required to fill, which was previously measured, is inputted in the timer, and the frequency is set along with the resting phase timing (the time is taken to replace a filled bottle with an empty one).
8. After inputting all parameters, the filling cycle for ten trials in the semiautomatic operation is commenced by a footswitch.
9. After the 10th filling application, the footswitch is pressed again to stop the semiautomatic operation for filling 100ml fluid.
10. The exact process is performed for 250ml,500ml, and 1000ml.
11. The filling is done via both pumps and nozzle, and each nozzle fills one bottle each.
12. For an entire cycle of 10 trials, a total of 20 bottles of 100ml, 250ml, 500ml, and 1000 ml capacities were filled.
13. The exact process is carried out Cypermethrin 25% EC (Low viscous fluid (88 cp) and Flammable).

6.2 OBSERVATIONS AND CALCULATIONS

1) TRIAL WITH IMIDACLOPRID WITH 30.5% SC (HIGH VISCOUS FLUID (880 CP) AND FLAMMABLE)

SR NO	96GM(100 Ml)		240 GM(250 ml)	
	PUMP1	PUMP-2	PUMP-1	PUMP-2
1	96.5	95.4	241.2	242.8
2	96.1	96.3	240.5	240.9
3	96.6	96.4	242.9	244.4
4	97.7	96.4	241.2	243.9
5	96.9	96	241.7	241.2
6	96.2	94.7	239.4	239.5
7	95.3	97.4	241.9	241.2
8	96.9	95.8	243.5	242.9
9	96.4	95.6	241.4	243.1
10	96.3	95.1	241.7	243.8
MIN	95.3	94.7	239.4	239.5
MAX	97.7	97.4	243.5	244.4
DIFF.	2.4	2.7	4.1	4.9
SETVALUE	96	96	241	240
ACCU	±1.25%	±1.40%	±0.85%	±1.02%
SEC(Time)	2	2	4	4
FREQ(HZ)	6.6	6.4	7.9	8.4
SPEED	18 BPM-19 BPM		12-13 BPM	

Table-2 **Experimental readings**

SR NO	480 GM(500 ml)		960 GM(1000ml)	
	PUMP1	PUMP2	PUMP1	PUMP2
1	480	480.7	964.4	959.7
2	481.5	480	960.4	955.6
3	478.7	482.6	964.1	958.6
4	478.6	479.7	960.7	957.2
5	478.1	479.9	961.7	958.7
6	480.5	480.4	962.3	956.6
7	480.7	482.8	962	959.8
8	478.2	481.3	964.1	958.7
9	479	482	961.1	956.5
10	479.1	482.8	962.8	957
MIN	478.2	479.7	960.4	955.6
MAX	481.5	482.8	964.4	959.8
DIFF.	3.3	3.1	4	4.2
SETVALUE	480	480	960	960
ACCU	±0.34%	±0.32%	±0.20%	±0.22%
SEC(Time)	7	7	12	12
FREQ(HZ)	8.8	9.6	10.2	10.9
SPEED	9-10 BPM		7-8 BPM	

Table-3 Experimental readings for 500ml and 1000ml

2) TRIAL WITH CYPERMETHRIN 25% EC (LOW VISCOUS FLUID (88 CP) AND FLAMMABLE)

SR NO	111GM(100 Ml)		278GM(250 ml)	
	PUMP-1	PUMP-2	PUMP-1	PUMP-2
1	112.2	111	278.2	277.1
2	111.8	111.4	280.7	276.9
3	113.2	110.8	279.8	279.1
4	111.9	111	279.4	279.8
5	112.6	113.4	280	279.1
6	111.8	112.4	276.2	277.7
7	111.6	109.70	280.2	278.6
8	112.5	111.1	279.9	278.2
9	111.7	109.5	279.7	276.6
10	109.8	112.1	279.8	278.8
MIN	109.8	109.5	276.2	276.6
MAX	113.2	113.4	280.7	279.8
DIFF.	3.4	3.9	4.5	3.2
SET VALUE	111 GM		278 GM	
ACCU	±1.53 %	±1.75 %	±0.80 %	±0.85%
SEC(Time)	2		3	
FREQ(HZ)	8.4	8.4	11.7	11.9
SPEED	18 -19 BPM		14-15 BPM	

Table-4 Experimental readings for 100 ml and 250ml

SR NO	555 GM(500 ml)		1110 GM(1000ml)	
	PUMP1	PUMP2	PUMP-1	PUMP-2
1	557.2	553.3	1108.4	1110.7
2	555.5	552.7	1108.3	1109.8
3	557.1	552.2	1107.6	1111.6
4	556	554.5	1105.8	1110.5
5	555.6	553.6	1108.5	1110
6	556.3	554.6	1103.4	1104
7	555.2	554.4		
8	555.4	553.6		
9	554.9	554.4		
10	553.6	554.1		
MIN	553.6	552.2	1103.4	1104
MAX	557.2	554.6	1108.5	1111.6
DIFF.	3.6	2.4	5.1	7.6
SET VALUE	555 GM		1110 GM	
ACCU	±0.33 %	±0.22 %	±0.22 %	±0.34 %
SEC(Time)	5		13	
FREQ(HZ)	13.5	13.8	11	11.3
SPEED	11-12 BPM		8-9 BPM	

Table-5 Experimental readings for 500ml and 1000ml

6.3 RESULTS AND DISCUSSION

In conclusion, using this timer-based filling principle enabled us to make a cost-efficient machine for small-scale industries with less than 2% accuracy for different viscous fluids (foamy and flammable included) from both pumps and nozzles. We were successful in filling different volumes from the same machine and we successfully solved the after-filling drip problem as well as controlled the flow speed of the liquids with different viscosity by using the V.F.D. In essence, we were able to achieve our aims and objectives behind this project.

7. CONCLUSIONS

To conclude, this project's ambitions were to manufacture a machine which fills any flowable liquid of any viscosity,to control the flow speed of the liquid to fill high viscous fluids faster, solve the after-filling drip problems occuring in existing filling machines, solve the industrial problem of slow output speeds for high viscous fluids and establish a cost-efficient filling machine and after all the stages of manufacturing the machine all of these objectives were successfully achieved by using a timer based operation and by controlling the flow speed of different viscous fluids by using a V.F.D, pump motor and rotary gear pump assembly, this assembly eliminates the need of P.L.C and H.M.I . Additionally, this assembly works in accordance to the capacity of the mother tank so that there is no compatibility issues. The tank also features a stirrer which kept the product's state homogenous and in turn there was no product damage. Furthermore, the after dripping problem was solved by providing shutoff valves at the infeed and outfeed areas of the nozzles; their function is to block the liquid from flowing out after the filling application. In essence, all these factors combined together enabled us to successfully establish a filling machine which fulfills all the objectives set in place before the start of this project.

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