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Design Development and Testing of an Automatic Desktop Injection Molding Machine

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ABSTRACT

The paper is focused on design and manufacturing of a low-cost desktop injection Moulding machine. The design of mechanical elements of injection Moulding machine are discussed. The volume of barrel with and without injection screw is also discussed. The heating system i.e. Heaters and thermocouple coupled with PID controller is also discussed. The flow rate of ABS, PLA and PVC plastic materials has been found at a constant temperature and different temperature for constant flow and with different RPM of screw are also discussed.

Keywords *–DIMM. PLA, ABS, PP, Arduino, flow Rate, Catia v5r21.*

1. INTRODUCTION

In the recent times a new generation of desktop machines are designed and developed, in the present papera desktop injection moulding machine which is a relativelynew concept in plastic injection moulding industry hasbeen designed and developed. We have also tested three different materials viz PLA (polylactic acid), ABS (acrylonitrile butadiene styrene) and PP (poly propylene) at three different temperatures viz 150^0C, 180^0C and 220^0C to optimize the machine performance for different materials at different RPM's of injection screw. Theseincredibly small machines have given the designers a new possibility for making prototypes unleashing their imaginations and yet they are very economical. The desktop injection moulding (DIMM) machine is primarily aimed to produce fewer to large volume of small sized products at very economical rate. The DIMM not only reduce the initial investment of machine but also reduces the cost of moulds significantly and there by producing the parts economically.

2. DESIGN OF DESKTOP INJECTION MOULDINGMACHINE

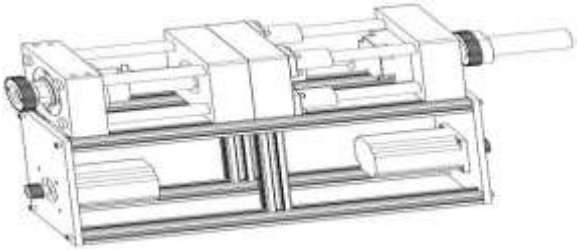


Fig 2.1- Schematic diagram of DIMM

Desktop Injection Moulding consists of a Frame made of Four Aluminum plates and Four stainless steel rails. A helical screw

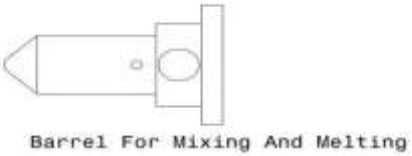


Fig 2.2a - Screw and 2.2b - barrel

for mixing and injecting is made of stainless steel. Barrel for mixing and melting of material is made of Aluminum. The barrel and screw system is designed to produce a maximum 7gms object. Support for Screw is made of Aluminum and ball bearings are fixed inside the support. The Back and forth of moving plate are guided by linear bearings. The linear actuator is a simple screw inside a threaded pipe made of stainless steel. The moulds are placed within the moving and fixed plates of the frame andare made of Aluminum. The Machine is fixed on a frame made of Aluminum extrusion profile 20X20. Two NEMA 23 motors with holding torque of 2.3 Nm are fixed inside the frame. GT2 timing pulleys & belts are connected to helical screw -Motor & linear Actuator – Motor. The powering unit is an

SMPS of 12v 10Apms output. The machine is operated by means of an Arduino Uno R3PWM electronic circuit board. Coil type heater of 350 watts along with a thermocouple and PID controller is used for heating the barrel at constant temperature.

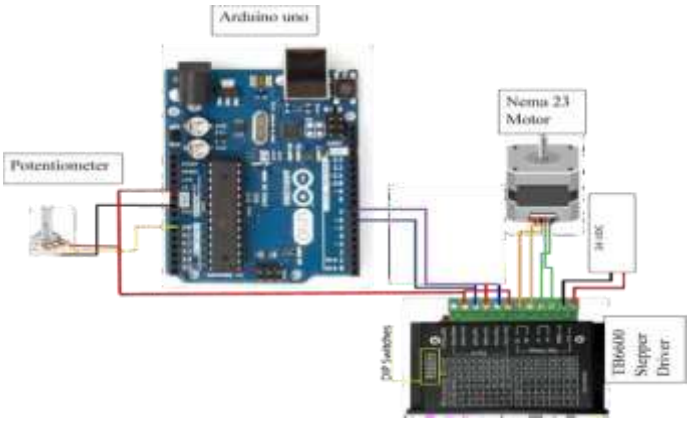


Fig 2.3 - Motor driver controller circuit

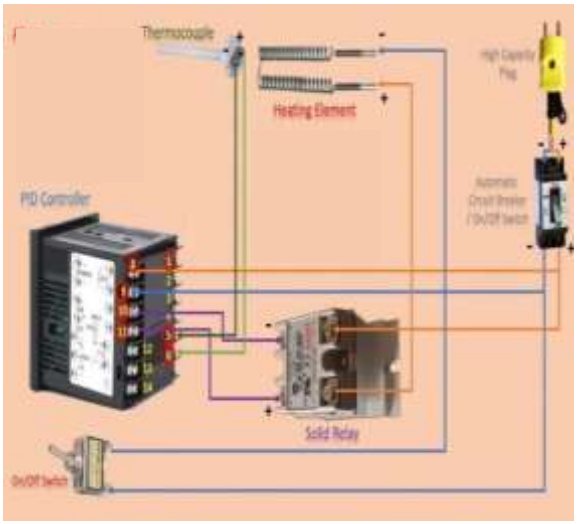


Fig 2.4 - Temperature controller PID circuit

3. TESTING OF DIFFERENT PLASTIC MATERIALS

Fig 3.1 – Different types of material

10 grams samples of each material is taken and fed into the machine and recorded the time it takes to eject fromthe barrel at three different RPMs and at three different temperatures. Hence, we have conducted a total of 27 trails and the data is recorded accordingly.

4. EXPERIMENTAL RESULTS

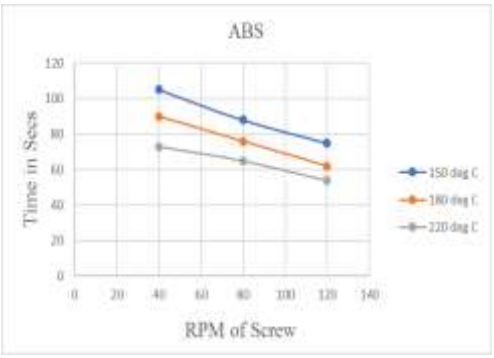
The experiments are carried out and the results are asshown:

4.1. Results for same material at different temperature

Table 4.1 Results for ABS material:

Temp	RPM	Time for 10gm of material ejection in (secs)
150^0c	40	105
150^0c	80	88
150^0c	120	75
180^0c	40	90
180^0c	80	76
180^0c	120	62
220^0c	40	73
220^0c	80	65
220^0c	120	54

Table 4.1 explains the details of ABS material takes how much time for ejection into mold at different temperatureand various speed (RPM)



Graph 4.1 Indicates the time taken for ejection verses RPM of screw at different temperatures of ABS material.

Table 4.2 Results for PLA material

Temp	RPM	Time for 10gm of material ejection in (secs)
1500c	40	92
1500c	80	81
1500c	120	68
1800c	40	60
1800c	80	52
1800c	120	35
2200c	40	51
2200c	80	37
2200c	120	22

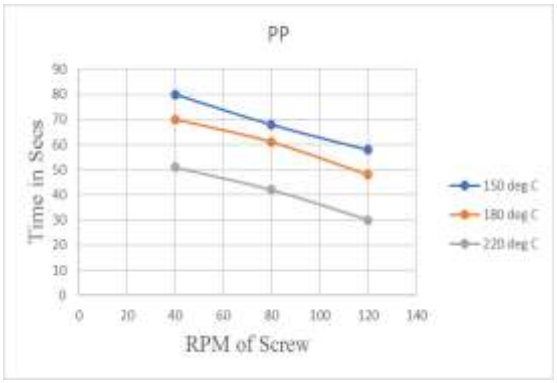
Table4.2 indicates time taken by PLA material for ejection into mold at different temperature and at various speed (RPM)

Graph4.2 indicates the time taken for ejection verses various speed of screw at different temperatures of PLAmaterial.

Table 4.3 Results for PP material

Temp	RPM	Time for 10gm of material ejection in (secs)
1500c	40	80
1500c	80	68
1500c	120	58
1800c	40	70
1800c	80	61
1800c	120	48
2200c	40	51
2200c	80	42
220^{0}c	120	30

Table4.3 explains the details of PP material takeshow much time for ejection into mold at different temperature and various speed (RPM)



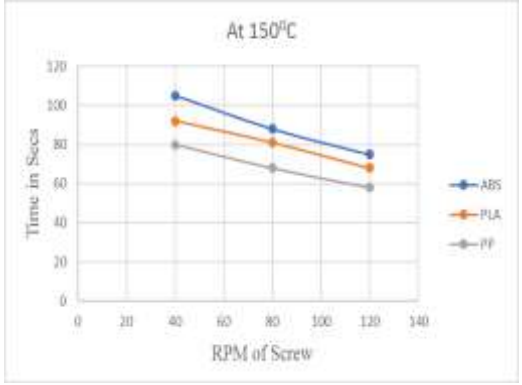
Graph4.3 indicates the time verses various speed of screwat different temperatures of PP material.

4.2. Results for Different MaterialsTable 4.4 At 150^{0}C

Material	RPM	Time for 10gm of material ejection in (secs)
ABS	40	105
	80	88
	120	75
PLA	40	92
	80	81
	120	68
pp	40	80
	80	68
	120	58

Table4.4 explains ABS, PLA, PP material takes howmuch time for ejection into mold at same temperature (150^0 C) and various speed (RPM)

At 150^{0}C

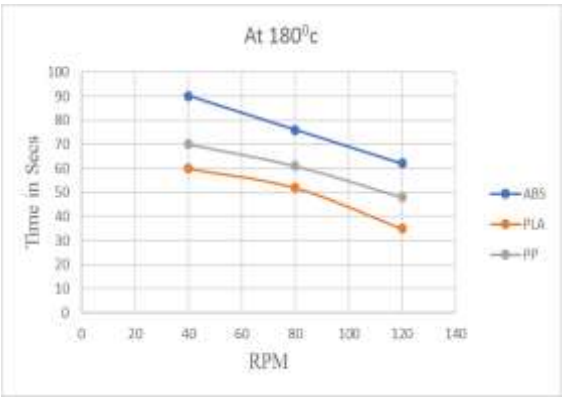


Graph 4.4 Indicates the time verses various speed of screw at same 150^0 C temperature of ABS PLA and PPmaterials..

Table 4.5 At 180^{0}C

Material	RPM	Time for 10gm ofmaterial ejection in (secs)
ABS	40	90
	80	76
	120	62
PLA	40	60
	80	52
	120	35
pp	40	70
	80	61
	120	48

Table 4.5 explains ABS, PLA, PP material takes how much time for ejection into mold at same temperature(180^0 C) and various speed (RPM)



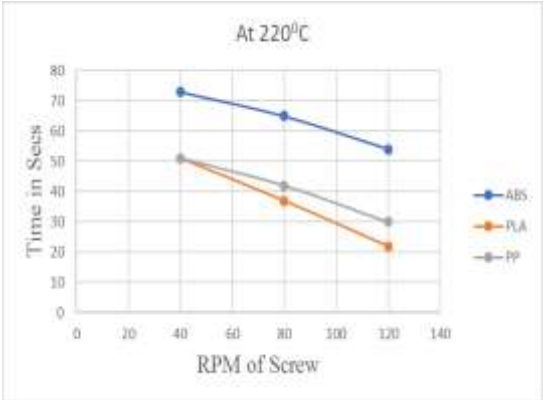
Graph 4.5 indicates the time verses various speed of screw at same 180^0 C temperature of ABS PLA and PPmaterials.

Table 4.6 At 220^0 C

Material	RPM	Time for 10gm of material ejection in(secs)
ABS	40	73
	80	65
	120	54
PLA	40	51
	80	37
	120	22
pp	40	51
	80	42
	120	30

Table4.6 explains ABS, PLA, PP material takes how muchtime for ejection into mold at same temperature (220^0 C) and various speed (RPM)

At 2200C



Graph 4.6 indicates the time verses various speed of screw at same 220^0 C temperature of ABS PLA and PPmaterials.

5. CONCLUSION

- The three materials i.e., ABS, PLA &PP behaved differently at different temperatures at 150^0C though all the three materials have become soft, we noticed PP to behave in a very homogeneous way i.e., the melting of the entire material is very uniform.
- In contrary we also observed that at 150^0C theABS material has behaved weirdly i.e., the material has become highly porous and also the density have become very low, injecting the material at that temperature thus leads to highly discontinuous and the damage to the product is very high, hence this temperature is not recommended for ABS.
- PLA material is found to be having better characteristics than ABS and PP. the melting of material is very fast, injection time is also less compared to the other two materials.
- At 180^0C these three materials characteristics quite equal compared to before temperature i.e., at 150^0C.
- At 220^0C PLA material becomes less viscous and fast injection occurred. The melting of material ABS and PP also very fast and injection rate is also fast.
- At higher temperatures it is found that the PLA has least viscosity among the three materials and has a faster flow rate.
- The ABS material also found melted homogeneously and the material ejection is also increased considerably compared to that at 150^0 C, PP material behaved more uniformly at all the three temperatures and the change in viscosity is not very significant between 180^0 and 220^0 C.
- For PlA material a medium RPM that is 80 is found optimum.
- PP material being high viscous needed higher RPM for ejection 120 RPM is found optimum.
- The ejection of ABS material at 220^0 temperature also demanded a higher RPM i.e. 120 for faster ejection of material.

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