Design and Development of Plastic Recycling Machine

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Abstract- *The project work addresses the development of a small injection molding machine for forming small plastic articles in small scale industries . The reason for the development has arisen because plastic is non-biodegradable in nature which is resulting in increase in carbon footprint, rising major environmental concerns therefore its high time we consider recycling plastic.*

The injection molding process requires the use of an injection molding machine, raw plastic material, and a mould. The shredded plastic is fed into the hopper where then it is further fed into the barrel and with the help of the lever action the plunger pushes the raw plastic into barrel which is then gradually heated with the help of three band heaters of each 220volts the plastic is melted in the injection molding machine and then injected into the mould, where it cools and solidifies into the final part.The critical parameter in the product design is related to the temperature operated with; which also influences the quality of mould.Thus the objective is satisfied by eliminating carbon footprints ,and the results obtained from the test were satisfactory and need further improvements to increase efficiency.

Keywords- carbon footprints, cost effective, Design and development, injection molding, recycling plastic, shredded plastic

I. INTRODUCTION

Plastic is polymeric chemical compound consisting of any of a wide range of synthetic or semi-synthetic organic compounds that are malleable and so can be moulded into required solid objects.

Plasticity is the general property of all materials which can deform irreversibly without breaking but, in the class of mouldable polymers, they can be reversible.

Plastics are typically organic polymers of high molecular mass and often contain other substances. They are usually synthetic, most commonly derived from petrochemicals.Due to their low cost, ease of manufacture, versatility, and resistance to water, plastics are used in a variety of products of different scale, including paper clips and spacecraft. They have prevailed over traditional materials, such as wood, stone, leather, metal, glass, and ceramic, in some products previously left to natural materials.

In developed economies, about a third of plastic is used in packaging and roughly the same in building applications such as piping, plumbing or vinyl siding. Other uses include automobiles, furniture, and toys. In the developing world, the applications of plastic may differ 42% of India's consumption is used in packaging.

Plastics have many uses in the medical field as well, with the introduction of polymer implants and other medical devices derived at least partially from plastic.

The word *plastic* derives from the Greek, meaning "capable of being shaped or molded"

II. PROBLEM IDENTIFICATION AND PROBLEM DEFINITION

Problem Identification: (Recycling waste plastic) Now a days the plastic bottles ,supporting frames etc. are normally used after use these plastics are disposed of they take lot of space and as it is this increases pollution .Hence this can have to be recycled taking in consideration and environmental concerns. Plastics crushed can be melted and can be used to produce different kind of product but it is an extremely laborious work .Hence we need a simple machine which will reduce the human efforts.

Problem Definition: (Plastic Recycling Machine) Plastic recycling machine is a simple machine, compact, light-weight. A manual method is used to compress the molten plastic heated by coil heater of capacity **** Liquid plastic is then delivered to the barrel and then to the die to produce a required product**.**

III. INJECTION MOLDING PROCESS DESCRIPTION

Injection molding machine offers many advantages to alternatives manufacturing methods, including minimal losses from scrap (since scrap pieces can be melted and recycled),

and minimal finishing requirements. Injection molding machine differs from metal die casting, in that molten metal's can simply be poured, and plastic resins must be injected with force. It is the most common used method for mass production of plastic articles of heated cylinder, heating the materials in the heating chamber, and forcing the molten metal into a closed mould, where the final solidification of the molten metal in form of the configuration of the mould cavity takes. The intending injection machine will be made from mild steel and medium carbon steel. It can only be used for the production of small components such as key holder, bottle cap, tally, ruler, and clothes peg. The mild steel is used for the construction of supporting plates, hopper, mainframe, mould, and platens, handle, and tie bars. This is because; they are not subjected to constant heat. It is easily weldable ,and has good workability but show poor response to heat treatment.

An injection molding machine is a piece of equipment which consists of two basic elements, the injection unit and the clamping unit. Injection molding can be used with a variety of plastic resins. The chosen resins for this process are polyethylene; polypropylene, ABS, and fluorocarbons, because of characteristics of intricate shapes can easily be produced.

The main aim of the research work is to design, construct and testing of small injection molding machine while the specific objectives of the research work are to design and construct a small injection molding machine, and testing. The scope of the work is to design and construct a cost effective & environmental friendly small injection molding machine for production of small plastic articles.

The project work will involve design concept, operations, design analysis that will entail design of injection plunger, design of the handle, and the leverage on the handle of the machine. Also, assembly drawings of the machine, recommended materials and equipment for the construction of design machine will be provided to assist investors that want to venture into construction of this machine. Development of small injection molding machine for forming small plastic articles in small-scale industries was born out of the fact that most injection molding machines were of big size and most small-scale industries in developing countries could not avoid buying them due to their costs. In solving this problem, there is a need to design small injection molding machine that avoidable by small scale industries for production of small plastic articles, this is the rationale behind this work.

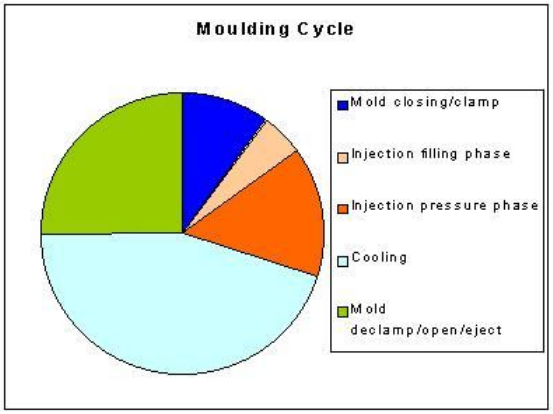

Figure 1: Molding cycle

IV. LITRETURE REVIEW

John Wesley Hyatt(1968)

Findings-developed plastic material called celluloid and entered it in a contest created by a billiard ball manufacturer. The purpose of the contest was to find a substitute for ivory,which was becoming expensive and difficult to obtain.

Hyatt found that an attractive and practical plastic material could be made by mixing nitrocellulose (a flammable nitrate of common wood or cotton cellulose), camphor (a waxy resin obtained from Asian camphor trees), and alcohol and then pressing the mixture in a heated mold.

Hyatt and his brother Isaiah first attempted to market the plastic, which they patented in 1870 as Celluloid, as a substitute for hard rubber in denture plates. In 1872 they moved their Celluloid Manufacturing Company from Albany to Newark, N.J., where they put numerous patents to work in building up what became the premier celluloid company in the world. The Hyatts concentrated on forming celluloid into sheets, rods, and other unfinished shapes, usually leaving their fabrication into practical objects to licensed companies such as the Celluloid Brush Company, the Celluloid Waterproof Cuff and Collar Company, and the Celluloid Piano Key Company.

Geoffrey Boothyd(2002)

Finding- cost estimation at earliest stages of design.

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NEW DIRECTIONS IN DESIGN FOR MANUFACTURING

Developing successful new products requires the ability to predict, early in the product development process, the life cycle impact of design decisions. Ignoring downstream issues (or producing poor estimates) leads to poor product designs that may cause unforeseen problems and excessive costs downstream. Sometimes, when problems are uncovered during design verification or testing, the problems can be corrected by redesign, but the cost of redesign at this late stage can be prohibitive. Sometimes companies must simply accept higher manufacturing costs and reduced product effectiveness resulting from early design errors. If accurate predictions of life cycle needs can be made early in the design cycle, it allows product development teams to create superior designs. This not only reduces the number of redesign iterations, the time-to-market, and the development and manufacturing costs but also improves the customer's experience.

Ching-Chih Tsai,
Member, IEEE, and Chi-Huang **Lu,(**1998)

Findings- The extruder typically consists of a large barrel divided into several constant
temperature zones with a hopper ***at*** one end and a die ***at*** the other
Polymer is fed into the barrel in raw and solid particle form from the hopper and is
pushed forward by powerful screw.

While passing through the temperature zones with gradually increasing temperature, the raw polymer is gradually heated. The heat produced by the heaters in the barrel, together with the heat released from the Friction between the raw polymer and the surfaces of the barrel and screw, causes the melting of feed polymer, which is then pushed by the screw into the molding mechanism from the die. Generally speaking, the quality of the extrudate depends upon the uniformity of temperature distribution, magnitude of the temperature in the barrel, back pressure, and the homogeneity of the physical mixing

A REVIEW OF DESIGN AND DEVELOPMENT OF PLASTIC INJECTION MOLDING MACHINE TO ENHANCE THE EFFECIENCY, ByAnand S. Dangi.(Pg 16 to 18)

Injection molding has been the most popular method for making plastic product due to high efficiency and manufacturability. The injection molding machine includes main for stage for production of plastic parts: filling and packing Stage, cooling stage and ejection stage. Among these stage cooling stage is a very important one because it mainly the productivity, quality and total efficiency of the machine. The cooling stage taken 70% time of cycle time.

The cycle time is calculated as the sum of each of the stage times. However, plasticizing time was not considered in cycle time computations, since it occurs simultaneously in the cooling and packing stages of the previous part .Regarding filling time, which depended mostly on process conditions, it was assumed as a reasonable imposed value, similar to the proposed framework and verified by mold flow .The cooling stage, which in fact begins with mold filling and finishes when enough heat has been removed from the part in order to eject it without distortion, is the most important stage, since it absorbs about 80% of the cycle time.

Recent methods for optimizing of plastic injection molding process – A Literature review Rashi A Yadav ,Research scholar ,Principal S.V. Joshi ,Engineering department

Determining optimal process parameter setting critically influences productivity ,quality and cost of production in plastic injection molding.

Wong C. T et. al N. Ismail and A.M.S. Hamouda

This paper presents the design of plastic injection mold for producing a plastic product. Before proceeding to injection machine and mold design, this part was analyzed and simulated by using mold flow. The analysis and simulation can define the most suitable injection location, material temperature and pressure for injection. The predicted weld lines and air trap were also and over packing and reduce time and cost.

SCOPE OF WORK: We can produce different types of domestic and industry products by recycling the waste plastic. using dies we can produce components on scale and avoid the time consumption. By using multi stage heating coils we can increase the production rate. The results above show that by recycling plastic, we can further reduce the dumping in plastic.

V. OBJECTIVES OF PROJECT

1) Low in cost & Innovative use of scrap machinery.
2) To utilize the plastic from domestic and industrial waste to reproduce useful components like washers
3) To reduce the solid plastic waste & carbon footprints.

VI. METHODOLOGY

Design Concept and Analysis

This design concept encompasses the following:

a) Maximum volume of the melt needed to fill the mould. This entails plunger travel (*l*), diameter of the barrel (*d*), melt density (□*m*) and melt mass (*m*);

b) Design of barrel which entails diameter of the barrel and maximum piston travel; and

c) Design for plunger. While the design analysis entails the following units:

i) The injection unit comprises of the hopper, barrel, heater bands, nozzle, and injection plunger.

ii) The clamping unit consists of the mould, platens, and the handle known as the locking device.

iii) The electrical panel comprises of temperature control, contactors, thermocouple, heat resistance wire, and knob (control button).

Design of injection plunger

In the injection plunger design shown in Fig. 2, the volume of the melt (*V*) the plunger can successfully pushed from the barrel can be determined by knowing the diameter of the plunger.

Design of frame

The frame is the main structure of the machine which was designed after multiple attempts at obtaining a stable structure to with stand load as well as reduce the space taken and cost reduction.

The frame consists of triangular base made of steel square tubes, with a single backbone type structure. The triangular base is aimed to provide maximum strength to the machine.

Design of electronic circuit

To melt the plastic the required temperature varies from 180 to 200 degree Celsius, to obtain this temperature we are using ceramic band heaters of 220 volts over the barrel these band heaters are connected to SSR and the manual controller knob. Which is used to control the temperature. The thermocouple is used to get feedback of the temperature of the barrel.

Preparation of CAD model

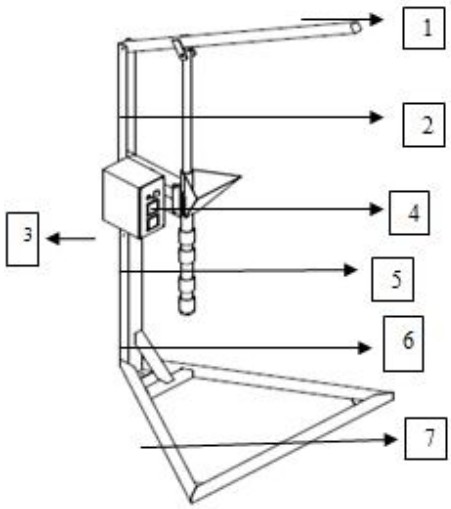


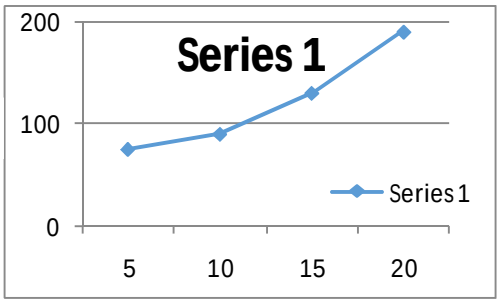
Fig 2: Project Model

NO	COMPONENTS
1	Lever
2	Plunger
3	Control box
4	Hopper
5	Barrel
6	Band heater
7	Frame

VII. TEST AND ANALYSIS

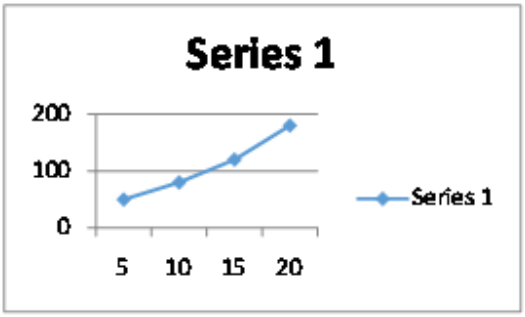
i)Temperature of band heaters

Temperature of band heaters are measured every 5min to obtain optimum temperatures to achieve glass transition temperature in plastics (180^0C -200^0C),the following graph illustrates the temperature of the band heaters versus time.



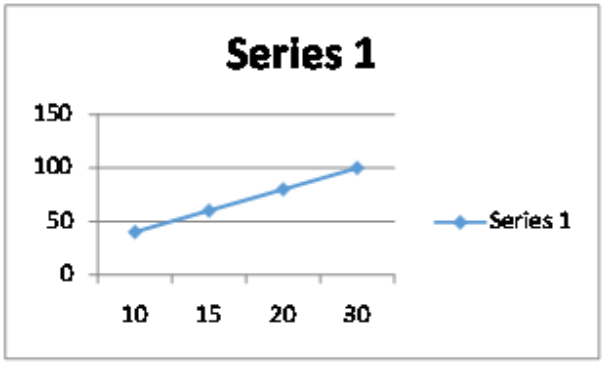
ii)Temperature of inner surface of barrel

Since there needs to be smooth temperature transition from upper part of barrel going downwards , the temperature of the barrel should be maintained at temperature required for melting plastic .the following graph illustrates the temperatue of inner barrel vs time.



iii)Plastic flow in mould

Depending on the temperature of barrel the viscosity of the plastic is low and high ,which affects the percentage of mould filled which causes short shots.the following graph shows the effects of pre heat time on plastic moulds.



VIII. RESULTS

The experiments were conducted and the results obtained are listed below:

1. Minimum pre heat time required before injecting plastic:
2. Minimum pressure required to inject molten plastic into the mould :
3. Minimum cooling time before ejecting out the plastic mould:

TRIAL NO.	PRE HEAT TIME(Min)	QUANTITY OF POLYMER FED(Grams)	TEMPERATURE (degree Celsius)	RESULT (% of mould filled)
1	10	100	70- 80	15
2	10	100	80- 100	20
3	15	100	100- 150	40
4	20	100	150- 170	60
5	30	100	170 -200	100

IX. CONCLUSION AND SCOPE FOR FUTURE WORK

The plastic recycling Machine is designed considering all the parameters, which is fabricated and tested in the physical environment. The product is behaving as expected. The quality, of the plastic component has improved compared to later testing and analysis. As it is a new product many features could not be incorporated, aesthetic features can be added. Once the product is improvised, it can be commercialized under domestic business. The following was achieved by this project

- A domestic product which is compact and can be used at home
- The device is easy to operate
- will produce finished plastic component using waste plastic (HDPE)
- A plastic injection machine in University campus will help students to learn better and make customised products for their projects.

Fig 3: Model of Plastic Recycling Machine

X. FUTURE WORK

Future scope for this project includes automating the plunger action using geared motor, pneumatic pressure. Fabricating a much ergonomic and aesthetical model which can be implemented in Small scale industries which can eliminate dumping of plastic scarp at initial stages.

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