Automatic waste Plastic Recycle Machine Integrated with Extrusion Hopper Mechanism

Abebe Mengistu Alemayehu, A Harsha Vardhan Reddy, Nehemiah Mengistu, Lemii Negera Woyessa, P.Vijay

Abstract: Dumping of waste plastic, which are non-biodegradable causes serious environmental problems. Not only do they take up huge amount of space in dumping landfills but also being a non-renewable resource, it faces depletion. Hence, it is very essential wherever possible to reduce these waste plastics means of recycling. In addition, the increasing trends of plastics in varied applications drives for more solutions for reuse of waste plastics. The existing recycling machines, which are currently in operation, are expensive and are operational only for large-scale industries. In addition, shredder and extrusion work separately but on this study shredder and extrusion are integrated to perform the given task simultaneously including mold. All section of the machine operates based on timing. Present work hence focuses on designing a plastic recycle machine for small-scale applications by incorporating an extrusion hopper mechanism. Various machines parts and assembly of hopper, shredder, extruder, heating-coil, molder, and frame are designed and analyzed using CATIA, ANSIS and FESTO. Detail analysis of the machine becomes an efficiency of 80%, having a capacity of delivering up to 20.4 kg of finished plastic blocks per hour. The working capacity of the machine were almost three full cycle per minutes which gave the production rate of 180 products per hour.

Keywords : ANSIS, CATIA, Extrusion Process, Recycle Machine, Waste Plastic.

I. INTRODUCTION

The world consumes more and more plastics. Plastics are materials with many different applications. The use of plastics often saves energy, but it causes thus climate emissions. More recycling of plastics reduces the climate gas emissions. The annual report for the Ethiopian fiscal year 2014-2015 prepared by Solid Waste Management Agency revealed that awareness creating among the society was one of the functions performed in collaboration with different Media outlets such as Ethiopian Television, local FM radio stations and newspapers. Accordingly, 186% of respondents claimed to get the information from Media which usually transmit interviews, complaints from residents 51% respond as they learned about the situation from fliers distributed by the Woreda Administration. Billboards and posters erected along roadsides also contributed in alerting 10% of the respondents. [2]

1.1. Background: There are two major categories of plastics include thermoplastics and thermosets. These are easily recyclable into other products. These thermoplastics include polyethylene, low and high density (LDPE, HDPE) polypropylene (PP), polyvinyl chloride (PVC), polystyrene (PS), polyethylene terephthalate (PET) etc. Thermoset plastics contain alkyd, epoxy, ester, and melamine formaldehyde, polyurethane and so on, which are cross linked on curing and will not soften with heat to allow these to be formed into different shapes. [3]

![Figure 1 waste plastic around revers (takes, 9 February)](image1)

![Figure 2. Hauling the waste by truck](image2)

II. LITERATURE REVIEW

Home wastage or municipal waste of materials converting into fuel in various countries. A research [4] done on coconut waste. From Previous done researches and projects, we take the relevant information to design and manufacture appropriate plastic recycling machine for our country.

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III. DESIGN ANALYSIS; MATERIAL AND METHOD

Method
Mechanism synthesis
Develop a mechanism that can perform the required tasks easily.

Data collecting
Collecting primary and secondary data that are relevant for the project. Primary data are collected by Measurement of waste plastic size directly, interviewing: waste management sector, climate change and environmental conservation sector, agriculture departments in DBU and calling phone for waste management and environmental conservation ministry of Ethiopia and secondary data are collected from different literatures from the internet and books.

Design
Conceptual design of different alternative mechanisms, Detail design of components, Elements outline design selection of best elements and the best mechanisms was being made. In addition to this we perform analytical and software analysis to part design

Prototype manufacturing
Manufacturing the mechanical parts and assembling to form waste plastic recycling machine.

Field testing
The machine must be test for performance.

Concept generation and component selection
Plastic recycling machine comprise a lot of systems such as shredder system, plastic conveying system, feeding system, extruding system, molding system and final product conveying system. These each system have different mechanism. The best mechanism for each system is selected as bellow according to their complexity, ease of fabrication and simplicity by considering different selection parameters including maintainability, availability, cost, weight, efficiency and so on.

Table 1. Shaft selecting table

| Criteria   | Single shaft % | Double shaft % | Triple shaft % |
|------------|----------------|----------------|---------------|
| Availability | 15%           | 13             | 13            | 13            |
| Weight     | 14             | 9              | 10            |
According to the above data, who’s prepared by matrix single shaft plastic shredder is selected for this system. It will have main components fixed bleed, rotary bleed, rotary bleed base, rotary bleed guide, rotary bleed head with frame.

i. Design of hopper

Volume of the hopper = \( \frac{1}{3} [A_1 + A_2 + \sqrt{(A_1+ A_2)] \times h_2} + (A_1 \times h_1) \)

Where,

- \( A_1 \) = Area of top pyramidal section
- \( A_2 \) = Area of bottom base
- \( h_1 \) = Height of hopper for rectangular section only
- \( h_2 \) = Height of hopper for pyramidal section only

\( A_1 = 60 \times 60 \text{MM} = 3600 \text{MM}^2 \)
\( A_2 = 20 \times 20 \text{MM} = 400 \text{MM}^2 \)
\( h_1 = 60 \text{MM} \)
\( h_2 = 80 \text{MM} \)

\( V = \frac{60}{3}[3600 + 400 + \sqrt{(3600 + 400)}] + (3600 \times 80) \)

Figure 10. Pulley

Depending on the table, HSS is selected for waste plastic cutting blade.

Figure 11. Front and End View of the Cutting Blade

Torque \( T \), produced by the shaft **Invalid source specified.**

\[ T = F \times r \]  

Where:

- \( F \) = Force required by the shaft to turn the polythene
- \( r \) = Distance of the blade end from the center of the shaft

Angular Velocity, \( \omega = \frac{2\pi n}{60} \)  

Linear Velocity, \( v = r \times \omega \)  

But, From Newton’s Second Law of Motion:

\[ F = m \times a \]  

Where:

- \( m \) = mass of the shaft in Kilogram
- \( t \) = time in second

Substituting (4) into (5) gives:

\[ F = 2\pi m n \]  

For one second, the force required will be:

\[ F = 2\pi m n \]  

Substituting (6) into (2) gives:

\[ T = 2\pi m n r \]  

Power required to overcome the torque and to rotate the

![Figure 12. Open belt drive](image)

Table 2 Characteristics of roller chains according to IS: 2403 — 1991 [11]

| ISO chain member | Weight of chain (kg/m) | Breaking load (Kn) minimum |
|------------------|------------------------|---------------------------|
|                  | Simple                 | Duplex                    | Triplex                   |
| 05B              | 0.18                   | 4.4                       | 7.8                       | 11.1                       |
| 06B              | 0.39                   | 8.9                       | 16.9                      | 24.9                       |

Table 3. Power rating (in kW) of simple roller chain.

| Speed of smaller sprocket or pinion (rpm) | Power (kW) |
|------------------------------------------|------------|
| 06B                                      | 06B        |
| 08B                                      | 08B        |
| 10B                                      | 10B        |
| 12B                                      | 12B        |
| 16B                                      | 16B        |
| 100                                      | 0.25       |
| 200                                      | 0.47       |
| 300                                      | 0.61       |
| 500                                      | 1.09       |
| 700                                      | 1.48       |
| 1000                                     | 2.03       |
| 1400                                     | 2.73       |
| 1800                                     | 3.44       |
| 2000                                     | 3.80       |

Note: The r.p.m. of the sprocket reduces as the chain pitch increases for a given number of teeth.
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Fig-13 screw drawn by CATIA software

Product design
In this project the product is sprocket gear, each dimension is taken from real its usage area.

Area $A$ =area of whole-area of hole-area of key way-area of pitch

\[ A = (2\pi x 64^2 + 2\pi x 64 x 40) - (2\pi x 20^2 + 2\pi x 20 x 40) - 6 x 40 - \frac{1}{2} x 22 (2\pi x 8^2 + 2\pi x 8 x 40) \]

$= 31628.3mm^2$

$= 3.1628 x 10^4 - 2m^2$

Volume of part = volume of the whole – volume hole-volume of key way-volume of pitch

\[ V = \pi x 942 x 40 - \pi x 202 x 40 - 40 x 12 x 5 - \frac{2 x 3.14 x 8^2 x 40}{2} \]

$= 373105.8mm^3$

$= 3.73105 x 10^4 - 4m^3$

The total part volume is 2x3.731058x10^-4m^3 = 7.462x10^-4m^3

since the machine produce two parts at a time.

Mass of part is calculated using density its volume

\[ M = \text{density}\times\text{volume} = 1420 kg/m^3 \times 7.462 \times 10^{-4} m^3 = 1.06kg \]

The shot weight of the machine is 1.06kg

Table 2. Power low parameters for some common plastics

| Polymer          | m(pa.s)^n | N   | T(°C) | Thermal conductivity (W/m.k) |
|------------------|-----------|-----|-------|-----------------------------|
| High density PE  | 2.00 x 10^3 | 0.41 | 180   | 0.23                        |
| Low density PE   | 6.00 x 10^3 | 0.39 | 160   | 0.19                        |
| PP               | 7.50 x 10^3 | 0.38 | 200   | 0.31                        |
| Acetal           | 8.25 x 10^3 | 0.197| 300   | 0.23                        |

\[ \Delta P_1 = \frac{K_n}{10^4(1 - n)} \left[ \frac{350xQ(1 + 2n)}{N_g x 50 x 4x n x 12 x 3.14 x 12 x 3.14} \right] \times \frac{r^2}{b} \]

Where $K_n$ is shape factor

$K_n = 3.05 x 10^{-4} m^3/Ns$

$n = $ power low exponent =0.197 from the above table4

$\theta = $ melt flow angle =360°

$r_2 = $ Radius of the disc=120mm

$N_g = $ number of gates=2

$b = $ Half thickness of the disc=1.05mm

$Q = $ constant injection rate= 1.293 x 10 ^{-3} m^3/s$

Then the pressure drop is $= 206.5$ bar

The dimension less $\tau$ fill time is defined as

\[ \Delta P_1 = \frac{3.05 x 10^4}{10^4(1 - 0.197)} \left[ \frac{350 x 1293 (1 + 0.197) x 1.057}{2 x 36 x 0.1 mm 0.197 x 1.2 x 0.105} \right] \times \frac{1.2}{0.105} \]

\[ \tau = \frac{V. a}{Q. b^2} \]

Where $V = $ part volume

$= 7.462 x 10^{-4} m^3$

$= 746.2 cm^3$

\[ a = \text{Thermal diffusivity of the polymer} = 0.09 mm^2/s \]

The Brinkman number is given by

Where

$\lambda = \text{Thermal conductivity of the melt}=0.23 (W/m.k)$ from table-6

Inlet melt temperature $T_M=216+273=489k$

Mold temperature $T_W=93 + 273 = 366k$

N=2 nuber of gate

Then
Then the actual pressure drop through mold is calculated as follow

\[
\ln \left( \frac{\Delta P}{\Delta P_1} \right) = 0.337 + 4.7\tau - 0.093B_r - 2.6\tau
\]

By making exponent in both side.

\[
\Delta P = \Delta P_1 x 0.833 = 206.6 \text{bar} x 0.833 = 172.08 \text{bar}
\]

Therefore, the actual pressure drop is less then injection pressure, then design is safe.

**Figure 16.** shows feed system

1. **Nozzle design:**
The main nozzle body extends from the barrel end cap to the sprue the figure bellow shows the nozzle.
The nozzle starting diameter is equal to barrel diameter of plunger=80mm
The nozzle orifice diameter of =12mm

**Figure 17.** sprue nozzle

As we see from the above picture the shape of the nozzle is frustum cone, therefore the volume of nozzle is

\[
V_N = \frac{\pi}{3} h (r_1^2 + r_2^2 + r_1 r_2)
\]

Where \( V_N \) = nozzle volume \( h \) = nozzle length taking the inclination of orifice 25°. \( h \) is calculated as

\[
h = \frac{80 - 12}{2 \tan(25^\circ)} = 73 \text{mm}
\]

\( R \) = radius of plunger \( r \) = radius of orifice

\[
V_N = \frac{\pi}{3} (35^2 + 6^2 + 35 \times 6) = 11782.59 \text{mm}^3 = 1.178 \times 10^{-4} \text{m}^3
\]

section with a radius of 35 mm and a length of 60 mm. The pressure drop is then

\[
\Delta P_{\text{nozzle}} = \frac{2\pi n Q L}{\pi R^3} \left[ \frac{3 + \frac{1}{n}}{\pi R^3} \right]^n
\]

Where \( \Delta P_{\text{nozzle}} \) = pressure drop through nozzle
\( n \) = power low endix

**Figure 18.** gate

\( R \) = avrage radius of nozzle
\( Q \) = flow rate
\( L \) = length of nozzle

\[
\Delta P_{\text{nozzle}} = \frac{2\pi n Q L}{\pi R^3} \left[ \frac{3 + \frac{1}{n}}{\pi R^3} \right]^n
\]

\[
\approx 0.3 \text{bar}
\]

**i. Sprue design:**
it one melt polymer feed system. Its inlet diameter is equal to nozzle orifice diameter i.e. 12mm
The ratio of inlet diameter to outlet diameter of sprue is 1.5
Therefore \( \frac{12}{d_0} = 1.5 \) \( d_0 = \frac{12}{1.5} = 8 \text{mm} \)

Length of sprue \( L=30\text{mm} \)
Volume of sprue

\[
V_{\text{sprue}} = \frac{\pi}{3} x L (R^2 + r^2 + Rr)
\]

\[
= \frac{\pi}{3} x 0.03 ((0.006)^2 + (0.004)^2 + 0.006 x 0.004) = 1.256 \times 10^{-4} \text{m}^3
\]

Estimating pressure drop through sprue is important. It can be estimated directly without calculation of the shear rate as

\[
\Delta P_{\text{sprue}} = \frac{2\pi n L}{\pi R^3} \left[ \frac{3 + \frac{1}{n}}{\pi R^3} \right]^n
\]

Where \( \Delta P_{\text{sprue}} \) = pressure drop through sprue
\( n \) = power low endix
\( R \) = inlet radius of sprue
\( Q \) = flow rate
\( L \) = length of sprue

**i. Runner design**

**Standard Runner Sizes**
utilization and more balanced melt flow, then nonstandard

\[
V_{\text{runner}} = \pi r^2 x L = \pi x (0.006)^2 x 0.008 = 2.262 \times 10^{-7} \text{m}^3
\]

since the runner is two, the volume becomes

\[
V_{\text{runner}} = 2 \times 2.262 \times 10^{-7} \text{m}^3 = 4.524 \times 10^{-7} \text{m}^3
\]

\[
\Delta P_{\text{runner}} = \frac{2\pi n L}{\pi R^3} \left[ \frac{3 + \frac{1}{n}}{\pi R^3} \right]^n
\]

\[
\approx 29991.8 \text{Pa} \approx 0.3 \text{bar}
\]

**i. Gate design**
Number of gates are two that connect the two cavities with runner
Taking the dimensions
Diameter=5mm

**Figure 18.** gate
Volume of the gate is calculated likewise as above= $\pi r^2 x L_g = (0.002)^2 \times 0.008 = 1.005 \times 10^{-5} \ m^3$

Pressure drop thought the gate is calculated as

$$\Delta P_{gate} = \frac{2znL}{R} \left[ \left( \frac{3 + \frac{1}{n} \frac{Q}{\pi R^2} \right) x 1.2933 x 10^{-5} \right]^{1.97}$$

$\Delta P_{gate} = 2 x 7.45 x 0.0008 \times 0.002 \left[ \left( \frac{3 + \frac{1}{n} \frac{Q}{\pi R^2} \right) x 1.2933 x 10^{-5} \right]^{1.97}$

$\Delta P_{gate} = 76225.99 \ Pa = 0.76226 \ bar$

The total pressure drop injection system and feed system is $\Delta P_{total} = \nabla P + \Delta Pnzzle + \Delta Psprue + \Delta Prunner + \Delta Pgate$

$\Delta P_{total} = (172.08 + 0.06018 + 0.497 + 0.3 + 0.76226) \ r$

$\Delta P_{total} = 173.73 \ bar$

The total melt volume through the machine for one production is

$$V_{melt} = V + VN + Vsprue + Vrunner + Vgate$$

$$V_{melt} = 7.46 x 10^{-5} \ m^3 + 1.178 x 10^{-5} \ m^3 + 1.2566 x 10^{-5} \ m^3 + 1.005 x 10^{-5} \ m^3 + 8.66 x 10^{-5} \ m^3$$

The allowable stress of mild steel is given below which is $225 \ MPa$

Therefore, the design of plunger is safe.

### i. Design of barrel for screw

Barrel is hollow cylinder that melts the ingot polymer and the station of screw pushes the polymer through barrel.

The barrel material is mild steel.

Barrel dimension is taken from the standard table-7 above.

Outer diameter of barrel $D_o=230mm$ length of barrel $L_o=2405mm$ hopper inlet diameter $=150mm$

To find the inner diameter of the barrel we must be consider the clearance between screw to barrel it listed below the table

| Screw diameter | Max. clearance(mm) | Min. clearance(mm) |
|----------------|--------------------|--------------------|
| 80             | 0.3                | 0.2                |
| 90             | 0.35               | 0.25               |
| 100            | 0.375              | 0.275              |
| 105            | 0.4                | 0.3                |

Therefore, inner diameter of barrel, $D_i=2x0.375+D_o=0.75+120=120.75mm$.

Thickness of barrel $t_b = (d_o - d_i)/2 = 54.5mm \approx 55mm$

Let’s check the circumferential and longitudinal stress at barre

Where $R_i=internal \ diameter \ of \ barrel$

$R_o=external \ diameter \ of \ barrel$

$P=Injection \ pressure=117.2 \ MPa$

Assume the safety factor of the barrel is 2. The allowable stress of mild steel is

$$\sigma_{all} = \frac{\sigma_s}{S.F} = \frac{450 \ MPa}{2}$$

$\sigma_{all} = 225 \ MPa$ therefore $\sigma_c < \sigma_{all}$ then the barrel is safe with injection pressure

Radial stress ($\sigma_r$) is calculated as follow

$$\sigma_r = \frac{R_i^2 P}{R_o^2 - R_i^2 \left( 1 - \frac{R_o^2}{R_i^2} \right)}$$

$$\sigma_r = \frac{(60.5)^2 x 117.2}{(115)^2 - (60.5)^2 \left( 1 - \frac{(115)^2}{(60.5)^2} \right)}$$

$\sigma_r = -117.2$
**Dimensions**

The magnitude of $\sigma_i$ is less than allowable stress of mild steel, therefore design is safe.

**ii. Elbow design**

a) This is used to transfer the melt polymer from barrel of screw to plunger

In order to withstand that temperature and pressure its thickness must be large internal diameter is more less.

- Inner diameter=60mm
- Outer diameter=100mm
- Thickness =30mm
- Height of elbow=100mm

The figure below shown is elbow for this design.

**Figure 21. Elbow Barrel Heater**

The heat profile of conductive heat generated with heater bands is probably the most important and perhaps least understood factor in successful plastics processing or design of plastic molding machine.

An incorrect heat profile is the most frequent case of wear in barrel and screw, because the natural tendency is cool down the heater bands when a heat override condition occurs. Since most heat overrides are caused by excessive shear heat, the best way to decrease shear is to apply more, not less conductive heat. It will not increase the temperature of the melt but instead, changes the source of heat energy used to melt the plastic.

For this design the barrel heater is selected based on the standard listed below table

| Heater internal diameter (mm) | Heater width (mm) | Maximum barrel temperature ($^\circ$C) | Maximum sheath temperature ($^\circ$C) | Nominal W/in$^2$ | Barrell Type |
|------------------------------|-------------------|--------------------------------------|--------------------------------------|----------------|-------------|
| 23.8 to 156                  | 15.9 to 51        | 399                                  | 482                                  | 19-48          | MB Mica Insulated 1 Piece |
| 76 to 305                    | 51                | 482                                  | 649                                  | 24-44          | HBT Tubular Barrel |
| 89 to 254                    | 38 to 51          | 399                                  | 482                                  | 20-40          | MB Mica Insulated 2 Pieces |
| 23.8 to 63.5                 | 427               | 649                                  | 29-36                                 |                | DBW         |

Let the barrel type is HBT Tubular Barrel then from the table we can select inner diameter depending the outer diameter of the barrel which is 230mm

Therefore, inner diameter of heater = 230mm

Outer diameter of heater = 270mm

Thickness of heater = 20mm

Width of heater = 51mm

Assuming the space between two heaters as 50mm

Then we can calculate the number of heater coil needed

\[
2 \times (\text{number of heater} \times 51 + \text{number of heater} \times 50) = \text{length of barrel} 
\]

202mm * number of heater = 2405mm

2405mm

number of heater = 11 barrel heater is needed 202mm

**Figure 22(a). barrel heater**

**iii. Design of plunger barrel**

This barrel like that of the screw barrel but it has no heater. It simply cylinders with high pressure.

**Dimension**

The inner diameter is equal to plunger diameter with considering clearance maximum 0.3mm and minimum 0.2mm (table-8) taking minimum 0.2mm since plunger needs minimum clearance

Therefore, inner diameter $D_p = 80.4mm$

The outer diameter $D_o = 180mm$ taken from above table-7

Length of $L = 1480\text{mm} = 1.48m$

**iv. Design of mold cavity**

Cavity design is depending on the product, so in this project two product at a time is produced.

Mold cavity is design by CATIA software as follow

In addition to cavity there are also other features like ejector hole, guide pin hole, runner and cooling systems.
All necessary dimensions are shown on the drawing above and the mold temperature is 93°C given at the above table 6.

IV. MANUFACTURING PROCESSES

4.1. Prototype manufacturing process

Prototype manufacturing has a great contribution in order to make feasible this work and understand the working mechanism of the designed machine. In addition to this prototype manufacturing, it helps develop practical work skill on different machine works, like welding, grinding, cutting machine, drilling. After design and proper material selection the next steps are carried out in prototype manufacturing process.

To manufacture this project prototype there are various processes such as:

During cutting process measurement have great contribution in order to cut materials at specific measurement because materials must be cut economically.

Surface Finishing: During the prototype manufacturing by using grinding and filing surface finish was achieved.

3. Assembly: In this project final assembly is done to understand the working principle of the study most components are join and assembled by using pin.

V. RESULTS AND DISCUSSION

5.1 Results

Based on an amount of experimentation, several conclusions can be made regarding the use of extruder and shredder for combustion research. The PC is high flow rate because of low density. The large particles of plastic need to be broken down into small pieces to melt simply, reduce storage and transportation space requirement. Shredder machine; - product/mass flow rate (HDPE) increase when speed of motor is rise. Extruder machine; - product increases when the die geometry is great and the density of polymers are low.

There are several ways of determining efficiency of the machine. The efficiency of the machine is calculated as follows:
efficiency = Output weight (Kg)/Input weight (Kg) X100%
Input = 12.8 Kg
Output= 10.2 Kg
Therefore; Efficiency = 80%
After testing the plastic shredder machine, it shredded the plastic waste into the desired chips or raw materials. Conclusively, the efficiency of the machine is about 80% which is an indication that the machine will be able to serve its purpose. Having a capacity of delivering up to 20.4 kg of finished plastic blocks per hour. It has the working capacity of almost three full cycle per minutes, which gives the production rate of 180 products per hour.

5.1.1. Results from analytical data
A. Aniases and analytical analysis of shaft
   (1) Static structural analysis
   Total deformation, total equivalent stress and equivalent elastic strain are obtained for this analysis and maximum shear stress. A static analysis is performed over a structure when the loads & boundary conditions remain stationary and do not change over time it is assumed that the load or field conditions are applied gradually, not suddenly. Solved for three factors:
   1. von Mises Stress
   2. total Static displacement
   3. Stress strain

Table 5. Static Structural result summary

| Name      | Type            | Min          | Max          |
|-----------|-----------------|--------------|--------------|
| Stress1   | VON: von Mises Stress | 2923.69 N/m² | 1.95923e+007 N/m² |
|           | Node: 3703     | Node: 9085   |              |

Analytical result of shaft
Diameter of shaft is 20mm
Shear stress of material τ = 11.17 kJ

(2) Discussion of shaft
From the analytical and analysis is some difference this difference is generated from analysis software; so the design is safe.

(3) 5.1.2 Analysis and analytical analysis of barrel

(4) Static structural analysis

(5) Statically analysis of barrel

Solved for three factors:
- Vons stress
- Total deformation
- Equivalent stress static strain strain

Table 6. Static Structural analysis of barrel Results summary

| Name      | Type            | Min          | Max          |
|-----------|-----------------|--------------|--------------|
| Stress1   | VON: von Mises Stress | 0.0145753 N/m² | 4.96497 N/m² |
|           | Node: 12782     | Node: 12833  |              |
| Displacement1 | URES: Resultant Displacement | 0 mm | 2.54789e-009 mm |
|           | Node: 73        | Node: 289    |              |
| Strain1   | ESTRN: Equivalent Strain | 7.55887e-014 | 1.52531e-011 |
|           | Element: 3064   | Element: 3838 |            |
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Thermal analysis of barrel

Figure 34. thermal analysis

Analytical analysis

Let the barrel type is HBT Tubular Barrel then from the table we can select inner diameter depending the outer diameter of the barrel which is 230mm
Therefore, inner diameter of heater = 230mm
Outer diameter of heater = 270mm
Thickness of heater = 20mm
Width of heater = 51mm
Assuming the space between two heaters as 50mm
Then we can evaluate the number of heater coil needed
2(number of heater×51 + number of heater×50) = length of barrel
202mm × number of heater = 2405mm
2405mm
number of heater = 11 barrel heater is needed 202mm

b) Desiccation

From the analytical result of working maximum stress is 235.88Mpa and the anysis maximum stress is 263.5Mpa from this result we conclude that the design is safe because from the anysis figure indicates the result is at safe level.

1. Temperature range

2. Total heat flux

From the result temperature range is minimum 96°C and maximum result is 295°C and minimum total heat flux of the mold is 2,210.1e-010 W/m² and maximum total heat flux is 1,6489e-005 W/m² this indicates this material and design is safe from the figure indicated above.

VI. CONCLUSIONS AND RECOMMENDATION

6.1. Conclusions

This waste plastic recycling machine has been developed using locally available materials. The flakes can be re-extruded for production of colored plastic products and composites. The actual motivation behind this is to increase the awareness of recycling and make it accessible to the public. The machine is fairly low power consuming. If implemented and developed properly, there is a definite potential for its application in the improvement of the environment.

6.2. Recommendation

The results obtained from the waste plastic recycling and designing that involved in this project in addition to other advantages which list on the above. For who are interested to work on this area we recommended that; To review the design in general and blade part specifically. To manufacture the real machine as per design and test the machine. To design the machine with alternative power source.

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