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DESIGN AND STRUCTURAL ANALYSIS OF ROTARY CURING MACHINE

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Abstract

Rotary curing machine finds its applications in extracting compost out of the vegetable waste or the restaurants wastage, which will be fed into the machine and will be processed for at least 7 days to form the compost. The compost obtained will be further used as a fertilizer in the farming lands or to decompose hotel wastes. The existing rotary curing machines were made of steel material. The problems in rotary curing machine made of steel is found to be corrosion of walls of the machine, cost involved for manufacturing and maintenance is too high. As the rotary curing machines are huge in nature, in order to reduce the cost of manufacturing an attempt is made to use polyethylene materials In this project work major emphasis is laid on designing of rotary curing machine and manufacturing it using linear low density polyethylene (LLDPE) material through Rotomoulding technology. We are focusing on usage of LLDPE material as it is corrosion resistant and cost effective. Rotomoulding technology is used to produce drum cost effectively. The detailed analysis of rotating drum and base frame is carried and results were compared with manual calculations. The results were almost matching and hence the analysis work is acceptable. The analysis of rotating drum and base frame has been carried out using Ansys Workbench 14.0.

Keywords: Rotary curing machine, LLDPE

Introduction

In the last few decades waste management has evolved into an industry, mainly focusing on waste treatment and its disposal. In this project work we mainly focus on hotel waste management i.e. how to extract compost from the hotel waste or vegetable waste. This compost can be further used as fertilizers or as a decomposer. Rotary curing machine finds its applications in extracting compost out of the vegetable waste or the restaurants wastage, which will be fed into the machine and will be processed for at least 7 days to form the compost. The compost obtained will be further used as a fertilizer in the farming lands or to decompose hotel wastes. The existing rotary curing machines were made of steel material. The problems in rotary curing machine made of steel is found to be corrosion of walls of the machine, cost involved for manufacturing and maintenance is too high. Since the manufacturing and maintenance costs of rotary curing machines made of steel are high, the selection of material and manufacturing process are key parameters in designing a rotary curing machine

2.0 literature survey

The scientific basis for the development of modern composting systems can be traced to the work of Sir Albert Howard (1873–1947). A British government scientist knighted in 1934 for his contributions to agriculture, he spent the bulk of his career in the colonial service in India, first (1905–24) as an economic botanist at the Agricultural Research Institute at Pusa, and later (1924–31) as the director of the Institute of Plant Industry at Indore as per information given by Hershey (1992). The composting procedure developed by Sir Albert known initially as the Indore method. After additional improvements, the Bangalore method given by Gotaas (1956) employed layered mixtures of high carbon to nitrogen ratio (C:N) feed stocks like leafy plant material with low C:N materials like animal manure in an approximate 3:1 ratio [4]. The N.V. Vuilafvoer Maatschappi (VAM), a nonprofits utility formed by the Netherlands government, began composting municipal waste in 1932 in Wijster, Netherlands. This system was an adaptation of the Indore system, with modifications including the use of mechanized equipment, such as trains that delivered the composting material and grappling hooks that removed the finished compost material from the open compost bins. This system is noteworthy as one of the earliest that composted municipal solid waste, rather than just agricultural crop residues. Numerous VAM systems were operated in northern Europe, but this technology was supplanted by more efficient systems; the last VAM plant was closed in 1989 [4].

3.0 MODEL PREPARATION

The existing rotary curing machines were made of steel. The problems in rotary curing machine made of steel is found to be corrosion of walls of the machine, cost

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involved for manufacturing and maintenance is too high, difficult for transportation and installation and also difficulties in disassembling and cleaning. In order to overcome the problems associated with existing machines, an attempt is made to design a rotary curing machine by using LLDPE (linear low density polyethylene) material and manufacturing it using Rotomoulding method. Iteratively Design of the Rotating drum structure which could be easily Roto Moulded. Drum should have enough structural strength to take the entire possible load. In this view the project demands identifying the load cases coming on to it, gearbox selection for rotating the drum, Iterative design studies, weight optimization, and cost reduction. Designing of rotating drum and base frame in CAD Package

Design of drum depends upon its inner volume; the inner volume can be calculated from the mass of the input material. The information about the mass, density is obtained from the customer requirements as given below.

Customer requirements

- Mass of the compost input = 1000 kg
- Density of the waste or compost input = 0.5 to 0.6 gm/cm^3
- Material to be used is linear low density polyethylene material
- Drum has to rotate for 5 to 6 times per day

<u>To find volume of Drum</u>

As the input to the drum has to be filled to half of the portion, we take input material as 2000kg instead of 1000kg given by the customer.

Therefore

- M = 2000kg
- ρ = 0.5 to 0.6 gm/m^3
- ρ = 500 to 600 kg/m^3

As we know that

Density = mass/volume

$\rho = M/V$

$V = M/\rho$

We consider density as 500 kg/m^3 as it gives the maximum possible conditions

V = 2000/500

V = 4 m^3

The obtained volume of drum from the design is

Volume of drum including ribs V_r = 4.75 m^3

By removing ribs and joining parts we get the actual volume of the drum in which the input fits exactly

Length of drum L = 2350 mm

Diameter of drum D = 1500 mm

Volume of the drum is $V = \pi * r^2 * L$

$$V = \pi * 750^2 * 2350$$

$$V = 4.1 m^3$$

As 1000kg of mass fills half portion of the drum of inner volume 4.1m^3 the drum design is acceptable.

Calculation for number of teeth on gear

Customer requirements

- Rotating drum speed must be 1rpm

According to the given requirements

- Speed of driven gear N_1 = 1rpm
- Speed of driver gear N_2 = 6.7rpm
- Diameter of the driven gear D_1 = 1640mm

If D_1 and D_2 are the pitch circle diameter of driven gear and driver gear having teeth T_1 and T_2 respectively then the velocity ratio $\acute{\omega}_1/\acute{\omega}_2$ is given as

$$\frac{\acute{\omega}1}{\acute{\omega}2} = \frac{D2}{D1} = \frac{T2}{T1}$$

$$\acute{\omega}1 = \frac{2\pi N_1}{60} = \frac{2 * \pi * 1}{60}$$

$$\acute{\omega}1 = 0.104 \text{ rad/sec}$$

$$\acute{\omega}2 = \frac{2\pi N_2}{60} = \frac{2 * \pi * 6.7}{60}$$

$$\acute{\omega}2 = 0.702 \text{ rad/sec}$$

From $\acute{\omega}_1$ and $\acute{\omega}_2$ values, we can calculate D_2

$$\frac{\acute{\omega}_1}{\acute{\omega}_2} = \frac{D_2}{D_1}$$

$$\frac{0.104}{0.702} = \frac{D_2}{1640}$$

D_2 = 243mm

Now according to CMTI data handbook we have to assume number of teeth on driver gear or pinion. The number of teeth on pinion can be ranged from 17 to 25 teeth.

Hence we assume number of teeth on pinion as 20teeth.

Therefore Z_2 = 20 teeth

According to gear ratio

$$\frac{D_1}{D_2} = \frac{Z_1}{Z_2}$$

$$Z_1 = \frac{Z_2 * D_1}{D_2} = \frac{20 * 1640}{243}$$

$$Z_1 = 134.42$$

Hence we take Z_1 = 135 teeth

Table 1: Dimensions of driven gear

Sl.NO.	Parameter	Symbol	Unit	Description/Values
	Diametral pitch	P_d	per mm	$P_d=Z_1/D$ $P_d=0.0823$
	Module	m	mm	$m=D/Z_1$ m=12.15
	Addendum	a	mm	a=1*m a=12.15
	Dedendum	b	mm	b=1.25*m b=15.175
	Tooth thickness	t	mm	t=1.5708*m t=19.0695
	Tooth space		mm	=1.5708*m =19.0695
	Working depth		mm	=2*m =24.28
	Whole depth		mm	=2.25*m =27.315
	Clearance	c	mm	c=0.25*m c=3.035
	Pitch diameter	d	mm	$d=Z_1*m$ d=1640
	Outside diameter	d_a	mm	$d_{a=}(Z_1+2)*m$ $d_a=1663.18$
	Root diameter	d_f	mm	$d_f=(Z_1-2.5)*m$ $d_f=1608.55$
	Fillet radius		mm	=0.4*m =4.86

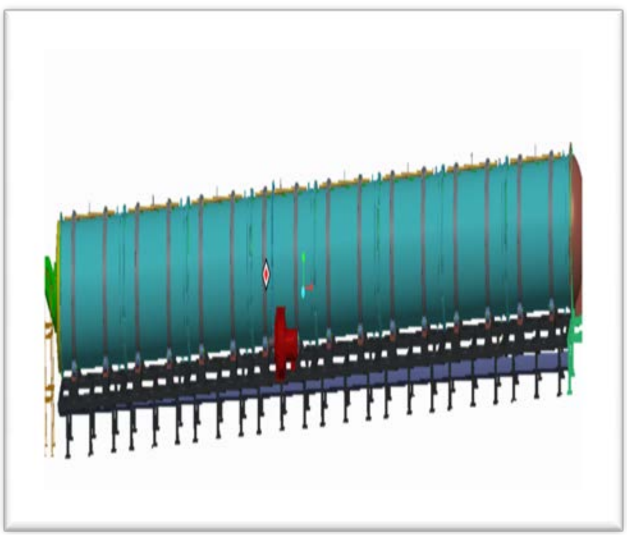

Figure 1: Rotary curing machine

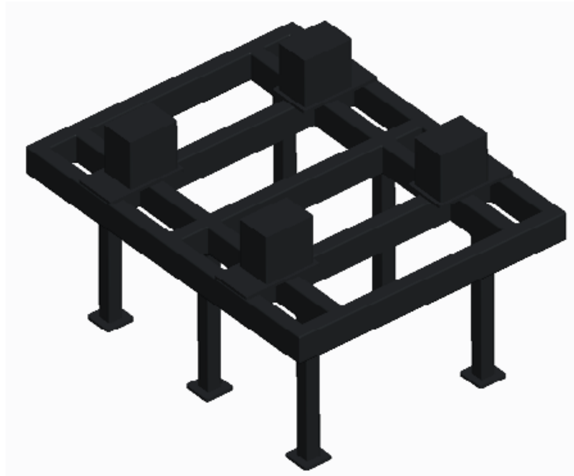

Figure 2: Base frame, stand

4.0 FINITE ELEMENT ANALYSIS

In this section the analysis work of different parts of rotary curing machine will be carried out. The different parts of machine includes rotating drum, stand. Firstly analysis of drum is carried out. Depending upon the results of the drum we carry on with the analysis of base frame (stand), as the design of base frame depends upon the dimensions of drum.

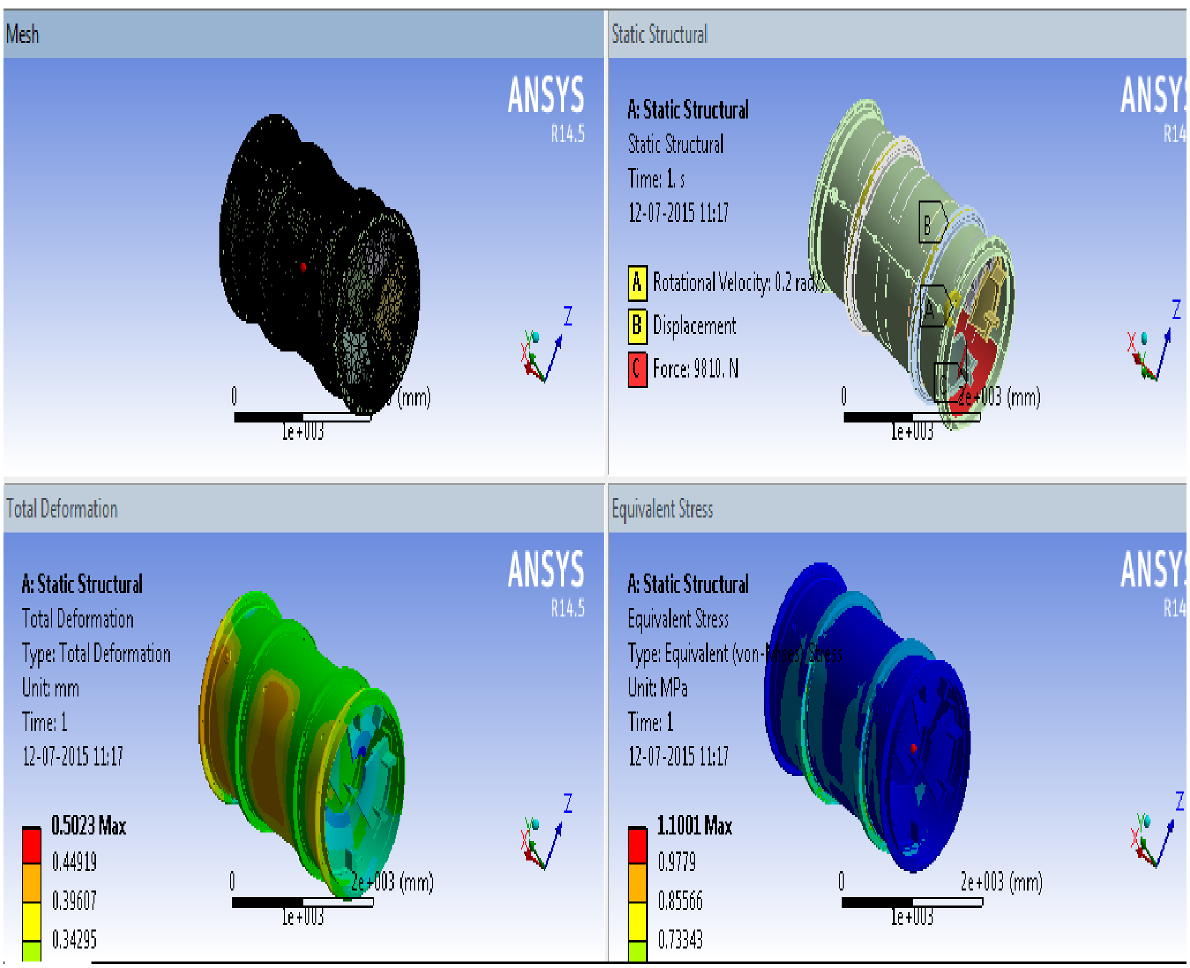

Figure 3: Drum analysis

Table 2: LLDPE material properties

Material thickness mm	10
Density kgm^3	943
Young's Modulus Mpa	700
Poisson's Ratio	0.42
Bulk Modulus Mpa	1458.3
Shear Modulus Mpa	246.48
Thermal Conductivity (W mm^-1 C^-1)	3.4e-004

<u>Roller material:</u> Structural steel

<u>Material properties:</u>

Table 3: Material properties of structural steel [12]

Density	7.85e-006 kg mm^-3
Coefficient of Thermal Expansion	1.2e-005 C^-1
Specific Heat	4.34e+005 mJ kg^-1 C^-1
Thermal Conductivity	6.05e-002 W mm^-1 C^-1
Resistivity	1.7e-004 ohm mm
Septic Tank Type	Cylindrical septic tank
Compressive Yield Strength Mpa	250
Tensile Ultimate Strength Mpa	460
Tensile Yield Strength Mpa	250

Base Frame Analysis

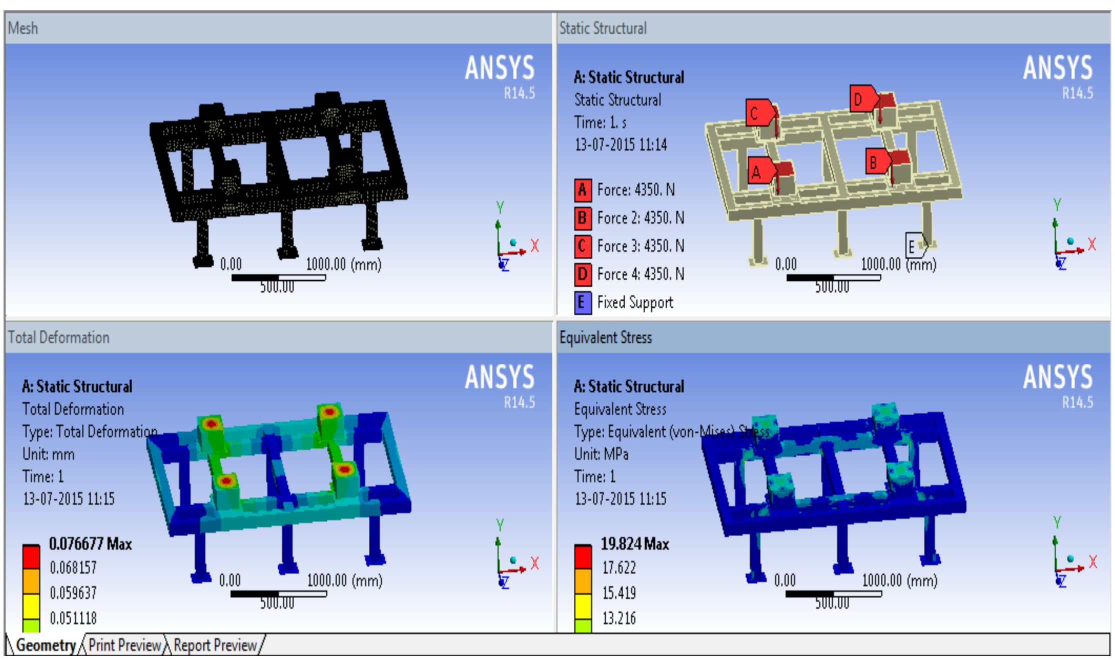

Figure 4: Base frame

5.0 RESULTS AND DISCUSSION

In the present paper analysis work has been carried out, where there was a continuous effort to find out the boundary conditions and solving techniques. The necessary calculations required for validation were also presented in the previous chapter. In this chapter the results obtained are compared with manual calculations and brief discussions about the results are made. The below table shows comparison of results of rotating drum obtained from Ansys and Manual calculation.

Table 4: Tabulated results of rotating drum

Analysis Type	Maximum stress (Mpa)	Deformation (mm)
Static analysis	1.1001	0.5023
Thermal analysis	110.35	0.4817
Manual	-8.075	-0.37

The analysis results shown above are almost close to each other hence the values are acceptable and drum design can be accepted.

Also we have noticed that deformation results of thermal analysis is less when compared to static analysis this is because of material properties i.e. LLDPE material is a thermoset material which will become hard upon heating. The hardness will be there till temperature reaches its softening point after that material starts to deform. Hence deformations obtained from all three types of analysis are acceptable and rotating drum design is said to safe at thickness of 10mm.

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