STRUCTURAL ANALYSIS OF A ROTOMOLDED WATER TANK

Omkar Edlabadkar
PVG'S COET and GKPIOM
Mechanical Engineering
Pune

Shubhankar Potdar
PVG'S COET and GKPIOM)
Mechanical Engineering
Pune

Himanshu Kumar Jha
PVG'S COET and GKPIOM
Mechanical Engineering
Pune

Prof.Dr. N.G. Jaiswal
PVG'S COET and GKPIOM
Project Guide
Pune

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***Abstract*—Water tank is a structure used to store water for domestic and industrial purposes. These water tanks are mainly produced using rotational molding process. The material, thickness of the tanks and the number of layers vary according to the purpose of the tank. In this project, analysis of a water tank has been done for various materials and by simulating the various forces acting on it, optimum material combination is selected.**

I. Introduction

The majority of the water tanks are manufactured using the rotational molding process. The materials considered in this project are in accordance with their suitability for rotational molding. In this project, a 5000L and 2-layered water tank is considered. The materials considered for this project are linear low density polyethylene (LLDPE), low density polyethylene (LDPE) and high density polyethylene (HDPE).

II. Literature Review

A. Rotational Molding Process

Rotational molding incorporates a multi-step process using pulverized polymer materials, typically as a powder, which is loaded into a mold, which in turn is sent into an oven. It is then rotated slowly in effort to achieve a uniform wall thickness. The rotational molding process is used to produce hollow, seamless, one-piece plastic products for a never ending list of industry and applications. This manufacturing process does not induce any pressure into the manufacturing process unlike other plastics molding processes and hence the products formed are more durable.

B. Polyethylene

Polyethylene is a polyolefin made from the polymerization of ethylene (or ethene) monomer. It is a thermoplastic polymer having excellent impact strength and offer near-zero moisture absorption. It is classified on the basis of its density into low, medium and high density polyethylene. For this study, only low and high density polyethylene is considered.

C. Low Density Polyethylene

Low Density Polyethylene or LDPE is a soft, tough and light-weight polymer belonging to the Polyethylene branch of thermoplastics. It has a branched out structure because of which it has low density and low volume. It is often used where strength and stiffness of the structure are an important requirement. Following are its properties:

Properties	Value
Density (kg/m^3)	920
Young's Modulus (Mpa)	300
Poisson's Ratio	0.44

TABLE I
Properties of LDPE

D. Linear Low Density Polyethylene

Linear Low Density Polyethylene or LLDPE is a linear polymer with significant short branches. LLDPE structurally differs from LDPE, because LLDPE has shorter branches. It is used where there is a need of high impact strength and high flexibility. Following are its properties:

Properties	Value
Density (kg/m^3)	930
Young's Modulus (Mpa)	360
Poisson's Ratio	0.40

TABLE II
Properties of LLDPE

E. High Density Polyethylene

High Density Polyethylene or HDPE has a high strength-density ratio. It has little branching, giving it stronger tensile strength than LDPE. It is harder and opaque and can withstand higher temperatures. It is characterized by high ductility, high corrosion resistance and it is non-toxic. Following are its properties:

Properties	Value
Density (kg/m^3)	950
Young's Modulus (Mpa)	1860
Poisson's Ratio	0.46

TABLE III
Properties of HDPE

III. Methodology

Various materials were studied and on the basis of their properties, suitability for rotational molding and their availability, three polyethylene types were selected. A three- dimensional model of the two-layered water tank was created using a modeling software. The dimensions and other param- eters of the tank were obtained from the actual model. The model was then uploaded to a software where further analysis was done. The materials LLDPE,LDPE and HDPE were added to the database of the software and assigned to the tank model in several combinations. The forces considered were gravitational force and hydro static pressure, for which the water level was considered up to the lid of the tank. Meshing was carried out by using the appropriate mesh properties. The final results were calculated and results were obtained.

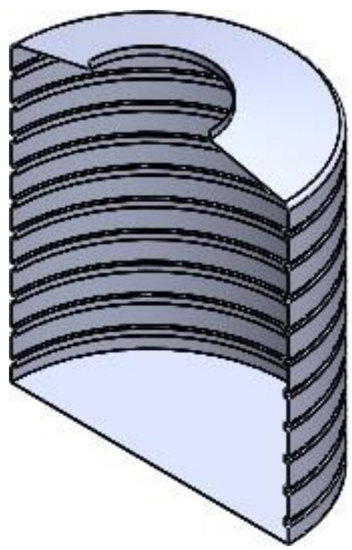

Fig. 1. Isometric Sectional view of the water tank model

IV. Results

Different material combinations were assigned to the water- tank layers and values like stress, strain and deformation were obtained.

Fig.2 shows the normal stress induced in a LLDPE-LDPE tank. A LLDPE-LDPE tank means LLDPE was assigned to outer layer and LDPE was assigned to the inner layer. Sim- ulations and analysis were done for each combination of the materials and their results are summarized in table 4.

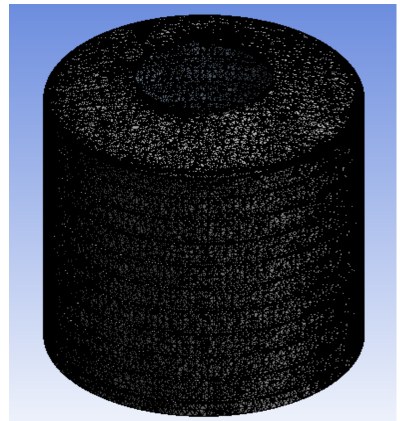

Fig. 2. Meshed model

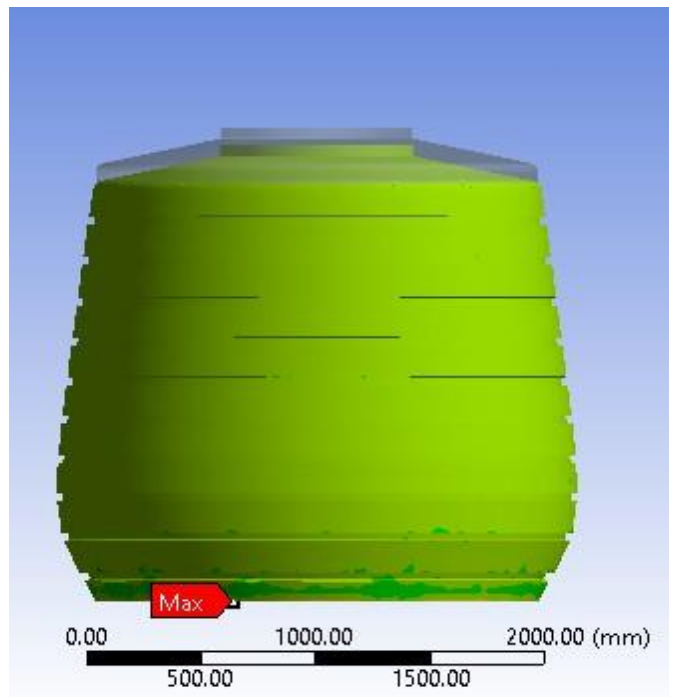

Fig. 3. Normal stress generated in a LLDPE-LDPE tank

TABLE IV

Tanks	Total Deformation(mm)	Normal Stress(MPa)	Strain Energy(mJ)
LLDPE-LLDPE	7.9	2.46	64.74
LLDPE-LDPE	8.26	2.82	64.05
LLDPE-HDPE	3.83	10.32	41.18
LDPE-LLDPE	9.05	2.78	74.15
LDPE-LDPE	9.46	3.19	74.51
LDPE-HDPE	4.1	10.99	47.18
HDPE-LLDPE	2.18	1.95	11.78
HDPE-LDPE	2.23	1.89	12.18
HDPE-HDPE	1.52	3.56	11.74

V. Conclusion

- From the Table IV, it is seen that the normal stress for LDPE-HDPE water tank is the least among the combinations.
- It can also be seen that the LLDPE-HDPE tank can bear a normal stress marginally lesser than that of the LDPE-HDPE tank.
- Hence, it can be concluded that the tank with outer layer made up of LDPE and the inner layer made up of HDPE tank is the most optimum structure.

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