Design and manufacturing of experimental setup to determine Moment of inertia of axi-symmetric bodies.

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Abstract – *Mass moment of inertia is a measure of an object's resistance to changes to its rotation. As there are not many known practical methods to find moment of inertia of objects which differ from basic shapes therefore in this project we have determined the moment of inertia of axi-symmetric bodies by using the principle of conversion of energy. We concluded that the deviation we got in our results were due to dimensional inaccuracies of test rig, human error and friction losses. Further the results could be perfected by eliminating these limitations by using electronic sensors and automations for future scope.*

Keywords: **Mass moment of inertia, axi-symmetric body, test rig, design, manufacturing, theoretical and actual.**

1. INTRODUCTION

When a body is free to rotate around an axis, torque must be applied to change its angular momentum. The amount of torque needed to cause any given angular acceleration (the rate of change in angular velocity) is proportional to the moment of inertia of the body. Moment of inertia may be expressed in units of kilogram meter squared (kg•m2) in SI units.

Moment of inertia plays the role in rotational kinetics that mass (inertia) plays in linear kinetics - both characterize the resistance of a body to changes in its motion. The moment of inertia depends on how mass is distributed around an axis of rotation, and will vary depending on the chosen axis. For a point-like mass, the moment of inertia about some axis is given by mr^2, where r is the distance of the point from the axis, and m is the mass. For an extended rigid body, the moment of inertia is just the sum of all the small pieces of mass multiplied by the square of their distances from the axis in question. For an extended body of a regular shape and uniform density, this summation sometimes produces a simple expression that depends on the dimensions, shape and total mass of the object.

For simple objects with geometric symmetry, one can often determine the moment of inertia in an exact closed-form expression. Typically this occurs when the mass density is constant, but in some cases the density can vary throughout the object as well. In general, it may not be straightforward to symbolically express the moment of inertia of shapes with more complicated mass distributions and lacking symmetry. When calculating moments of inertia, it is useful to remember that it is an additive function and exploit the parallel axis and perpendicular axis theorems.

2. METHODOLOGY

a. Market survey

During this period detailed market survey has been done to learn which of the available material should be used for shaft, flange and frame.

b. Problems in existing systems

The problems regarding the existing system have been found such as in horizontal type system we needed much of devices and objects to calculate.

c. Conceptual Design.

Taking problem statement from above and studying different theories about moment of inertia a new conceptual design is been developed.

d. Modeling in CATIA.

Putting the ideas on the modeling software for visualization of the prototype and making it more and more compatible so that there will be less complexity in designing

e. Material Selection and Procurement

In this phase material selection is done and also its procurement as per need the dimensions are taken from CATIA model.

f. Fabrication

This phase includes fabrication of prototype in the workshop from the procured material and preparing the Prototype model from the software model.

g. Assembly & Testing

This phase include Assembly of all the sub parts such as shaft, flange, bearing on frame by using operations such as turning, drilling, welding, threading, finishing, cutting.
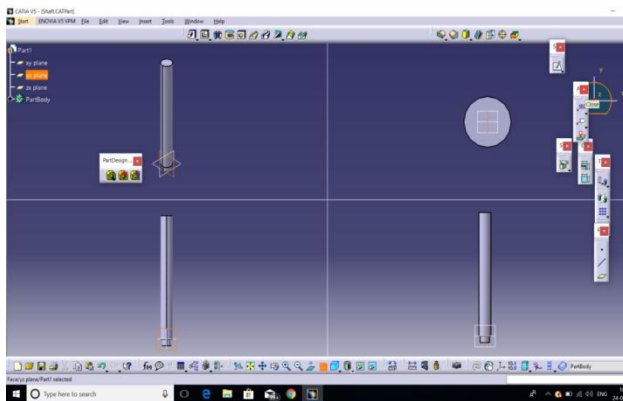
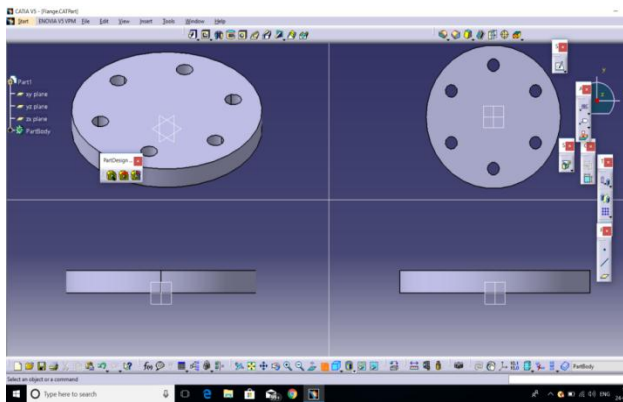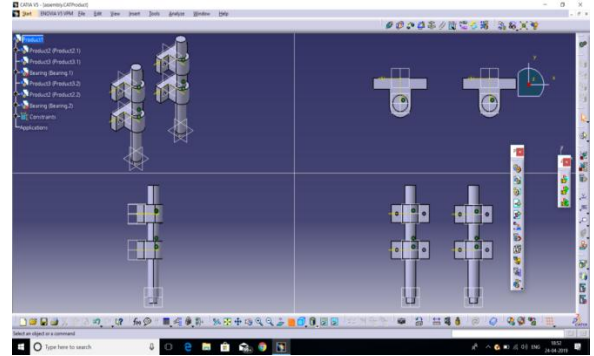## 3. MODELLING BY USING CATIA AND ACTUAL IMAGES

Fig.1 Shaft

Fig.2 Flange

Fig.3 Assembly

Fig.4 Bearing

Fig.5 Experimental Setup
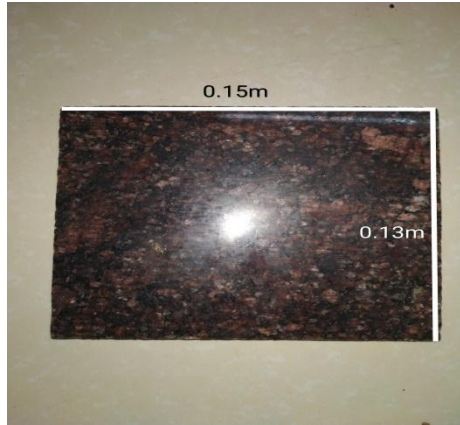

Fig.6 Circular disk (Object-1)

Fig.7 Rectangular plate (Object-2)

4. RESULTS & DISCUSSION

Result validation for disk (Object-1)

$$I = \frac{1}{2} \times m \times r^2$$

$$I = \frac{1}{2} \times 0.350 \times 0.0535^2$$

$$\therefore I = 0.0005009 \ kgm^2$$

Result validation for rectangular plate (Object-2)

$$I = \frac{1}{12} \times m \times (l^2 + b^2)$$

$$I = \frac{1}{12} \times 0.876 \times (0.15^2 + 0.13^2)$$

$$\therefore \ I = 0.002876 \ kgm^2$$

With the help of these theoretical calculations we can validate our experimental readings by comparing the mean reading taken from the setup and actual theoretical values

Result Table

Object	I Theoretical	I Experimental	Deviation
Disk	0.0005009	0.000578	13.33%
Rectangular plate	0.002876	0.003324	13.47%

Rectangular plate and a disk, the experimental values were fairly close to the theoretical values. The deviation in values in disk was found to be 13.33% and for rectangular plate the deviation came about 13.47%. Moreover, the deviation obtained was because of frictional losses and human error

which cannot be avoided but was minimalized as much as possible by using lubricants and having multiple readings.

The major reasons for deviations are as followed:

- Frictional Losses
- Dimensional Accuracy
- Human error

Deviation can be minimalized are listed below:

- By using proper lubricants and keep the setup lubricated.
- By avoiding small calculation errors.
- By using electronic sensors.
- By using different types of electronic devices.

6. CONCLUSION

We researched various journals based on Moment of Inertia and came up with said solution for determining Moment of Inertia of axi-symmetrical objects. By further carrying out modifications on the design the final test rig was manufactured considering minimal cost and for obtaining optimum results. We determined mass moment of inertia of two object viz. Rectangular plate and a disk. The experimental values were fairly close to the theoretical values. The deviations in values in disk were found to be 13.33% and for rectangular plate the deviation came about 13.47%. Moreover, the deviation obtained was because of frictional losses, dimensional inaccuracies and human error which cannot be avoided but was minimalized as much as possible by using lubricants and having multiple readings.

Further the design can be modified for having much more dimensional accuracy and also by using electronic sensors for accurate values of different parameters and also determining frictional losses would give more accurate results.

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