IJERST

International Journal of Engineering Research and Science & Technology

ISSN : 2319-5991
Vol. 4, No. 3
August 2015

www.ijerst.com

Email: editorijerst@gmail.com or editor@ijerst.com

International Journal of Engineering Research and Science & Technology

ISSN 2319-5991 www.ijerst.com
Vol. 4, No. 3, August 2015

Research Paper

INVESTIGATION OF FATIGUE LIFE AND SAFETY FACTOR IN ARM TYPE ROTATING FLYWHEEL

Rakesh[1*], Somvir Arya[1] and Subodh Siwach[1]

Corresponding Author:* ***Rakesh* ✉ *jangrarakesh13@gmail.com*

There are many causes of flywheel failure. Among them, maximum tensile and bending stresses induced in the rim and tensile stresses induced in the arm under the action of centrifugal forces are the main causes of flywheel failure. Due to these causes there is a definite Fatigue Life and Safety Factor of the flywheel. Hence in this work, evaluation of fatigue life and safety factor of flywheel are studied using finite element method. The models of flywheel having four, six and eight no. arms are developed for FE analysis. The FE analysis is carried out for different cases of loading applied on the flywheel and the minimum fatigue life and safety factor are determined. From this analysis it is found that fatigue life and safety factor both increases as the number of arms increases.

Keywords: Fatigue life, Flywheel, FE analysis

INTRODUCTION

Fatigue analysis is the study of fatigue behavior of the specimen which is under study. In order to improve the quality of the product and to have safe and reliable design, it is necessary to investigate the fatigue life of the component during its working condition. Flywheel is an inertial storage device which acts as reservoir of energy. When the flywheel rotates, centrifugal forces acts on the flywheel due to which tensile and bending stress are induced in a rim of flywheel.

This paper deals with FE analysis of flywheel having 4,6 and 8 number of arms. The fatigue analysis of the flywheel is carried out under different cases such as (1) Keeping constant angular velocity; (2) Increasing angular velocity; (3) Combined loading of angular velocity and gravity; (4) Increasing angular velocity with effect of gravity; and (5) Providing larger fillet size at the both ends of the arm. FE analysis is carried using ANSYS.

GEOMETRICAL DIMENSIONS OF FLYWHEEL

It is intended to use the same geometric model of flywheel under identical loading condition for FE analysis and analytical estimation of stresses. The major dimensions of flywheel considered for present analysis are as follows:

[1] Department of Mechanical Engineering, I.I.E.T, Kinana, Rohtak Road Jind, Haryana, India.

Outer Diameter of flywheel rim D_o= 1.1 m

Inner Diameter of flywheel rim (D_i) = 0.904m

Mean Diameter of flywheel rim (D_m) = 1 m

Mean radius of flywheel rim (R) = 0.5 m

Thickness of rim (H) = 0.098m

Width of rim (B) = 0.147 m

Diameter of shaft (d) =0.265 m

Diameter of hub (d_h) =0.340m

Radius of hub (r) =0.170

Hub length (L) = 0.147m

Major axis of arm at hub end (a) = 0.102 m

Minor axis of arm at hub end (b) = 0.051 m

Major axis of arm at rim end (c) = 0.082 m

Minor axis of arm at rim end (d) = 0.041 m

MATERIAL PROPERTIES OF FLYWHEEL

The material properties considered for the flywheel with above geometric dimensions are given in Table 4.1.

FINITE ELEMENT ANALYSIS OF FLYWHEEL

For FE analysis, the FE models of 4, 6 and 8 number of arms are considered. A SOLID 72 element and tetrahedral meshing is used for FE analysis. The various cases considered for the analysis are given in forth coming sections.

Case 1: Analysis by considering constant angular velocity of flywheel

Figure 4.1 shows the Life contour in flywheel having 4, 6 and 8 no. of arms. Table 4.2 shows life and factor of safety in the rim of flywheel with 4,6 and 8 no. of arms at an angular velocity of 250 rad/s. The variation of safety factor and life w.r.t. number of arms of flywheel are shown Figures 4.2 and 4.3 respectively.

Table 4.1: Material Properties

Material	Gray cast iron
Ultimate strength	S_{ut} =214 MPa, S_{us} =303 MPa
Modulus of elasticity & modulus of rigidity	E=101 GPa, G=41 GPa
Density	7510 (Kg/m^3)
Poisson's Ratio	0.23

Case 2: Analysis by increase in angular velocity of flywheel

Table 4.3 shows the Life and Safety factor by varying angular velocity and no. of arms of flywheel. The Figures 4.4 and 4.5 shows variation of the Life and Safety factor w.r.t. increase in angular velocity of flywheel.

Case 3: Analysis by considering combined loading of angular velocity and gravity of rotating flywheel

Figure 4.6 shows Life contour for 4, 6 and 8 no. of arms. Table 4.4 shows Life and Safety Factor in the rim of flywheel with 4, 6 and 8 no. of arms. Variation of Life and Safety Factor for 4, 6 and 8 number of arms of flywheel are shown in Figures 4.7 and 4.8.

Case 4: Analysis by increasing angular velocity and considering effect of gravity

Table 4.5 shows the Life and Safety Factor by increasing angular velocity with effect of gravity for varying number of arms. Figures 4.9 and 4.10 shows variation in the life and Safety Factor w.r.t. angular velocity with effect of gravity respectively.

Case5: Analysis by providing fillet size (0.02 m) at both ends of arm

Table 4.6 shows Life and Safety Factor by

Figure 4.1: Snapshot of Safety Factor in 4, 6 and 8 Arm Flywheel Without The Effect Of Gravity

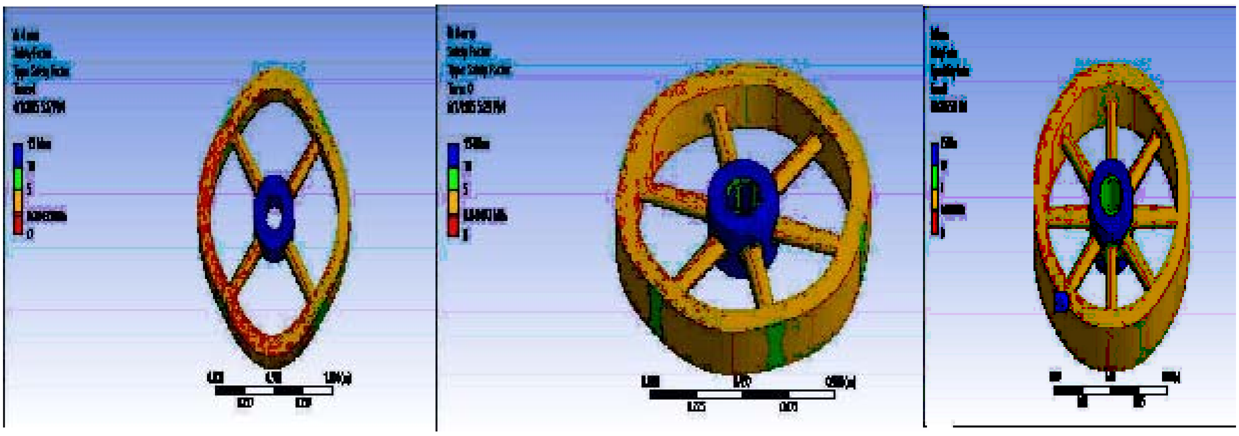

Table 4.2: Life and Factor of Safety in the Rim of Flywheel With 4,6 and 8 No. of Arms			
No. of Arms	**Angular Velocity**	**Life**	**Safety Factor**
4	250 rad/	54464	0.78435
6	250 rad/s	2.03 x10^5	0.84497
8	250 rad/s	1x10^7	1.0167

Table 4.3: The Life and Safety Factor with Increase in Angular Velocity			
No. of Arms	**Angular Velocity**	**Life in Revolutions**	**Safety Factor**
4	250	54464	0.7843
	255	28762	0.7538
	260	15931	0.7251
	265	0	0.6980
6	250	2.03 x10^5	0.8449
	255	98699	0.8121
	260	50991	0.7812
	265	27680	0.7520
8	250	1x10^7	1.0167
	255	5245392	0.9772
	260	1950909	0.9399
	265	813132	0.9048

Figure 4.2: Variation of Safety Factor w.r.t. No. of Arms

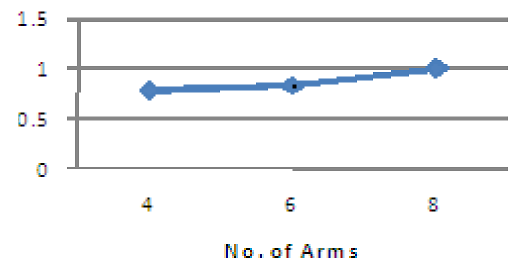

Figure 4.3: Variation of Life w.r.t. No. of Arms

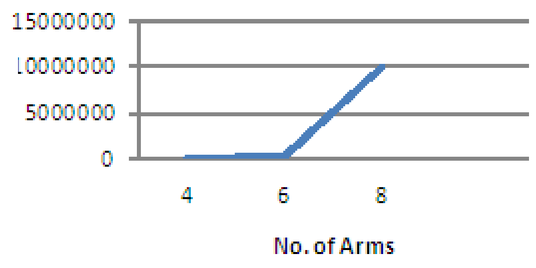

Figure 4.4: Variation of Safety Factor w.r.t Angular Velocity

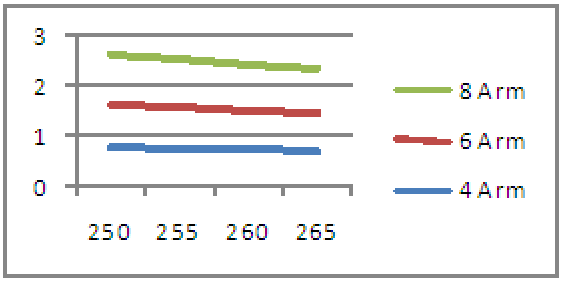

Figure 4.5: Variation of Life w.r.t . Angular Velocity

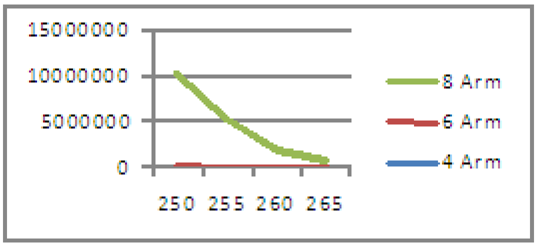

Figure 4.6: Snapshot of Fatigue Life With Combined Loading of Angular Velocity and Gravity in 4, 6 and 8 Arm Type Flywheel

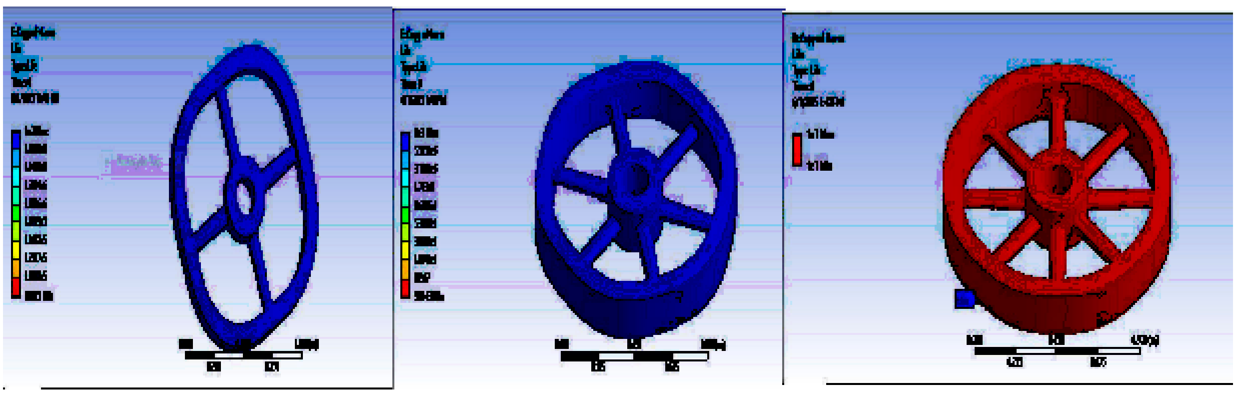

Table 4.4: Life and Safety Factor with Combined Loading of Angular Velocity and Gravity

No. of Arms	Loads (g)	Life	Safety Factor
4	250rad/sec	56820	0.7863
	Gravity z -9.81 m/s²		
6	250 rad/s	208265	0.8461

Figure 4.7: Variation of Life w.r.t. No. of Arms with the Effect of Gravity

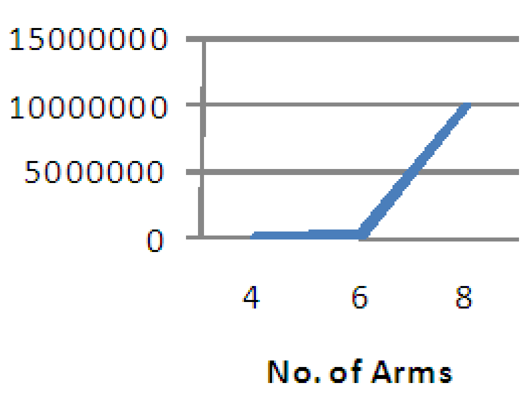

Figure 4.8: Variation of Safety Factor w.r.t. No. of Arms with the Effect of Gravity

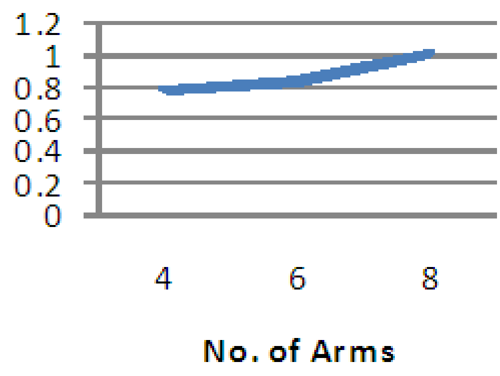

Table 4.5: Life and Safety Factor with Increase in Angular Velocity with Effect of Gravity

No. of Arms	Angular Velocity	Life	Safety Factor
	250 rad/s	56820	0.7863
	Gravity_z-9.81 m/s²		
4	255 rad/sec	29882	0.7557
	Gravity_z-9.81 m/s²		
	260 rad/sec	16506	0.7268
	Gravity_z-9.81 m/s²		
	265 rad/sec	0	0.6996
	Gravity_z-9.8m/s²		
	250 rad/s	208265	0.8461
	Gravity_z -9.81 m/s²		
6	255 rad/sec	100971	0.8132
	Gravity _z-9.81 m/s²		
	260 rad/sec	52042	0.7821
	Gravity_z-9.81 m/s²		
	265 rad/s	28194	0.7529
	Gravity_z-9.81 m/s²		
	250 rad/s	1×10^7	1.0177
	Gravity_z-9.81m/s²		
8	255 rad/s	5388246	0.9781
	Gravity_z -9.81 m/s²		
	260 rad/s	1995916	0.9408
	Gravity_z-9.81 m/s²		
	265 rad/s	829776	0.9056
	Gravity_z -9.81m/s²		

Table 4.6: Life and Safety Factor by Providing Fillet Size (0.02 m) for 4, 6 and 8 Number of Arms			
No. of Arms	**Angular Velocity**	**Life**	**Safety Factor**
4	250 rad/s	63094	0.79133
6	250 rad/s	6.82	0.9867
8	250 rad/s	1	1.0387

Figure 4.9: Snapshot of Flywheel with Fillet

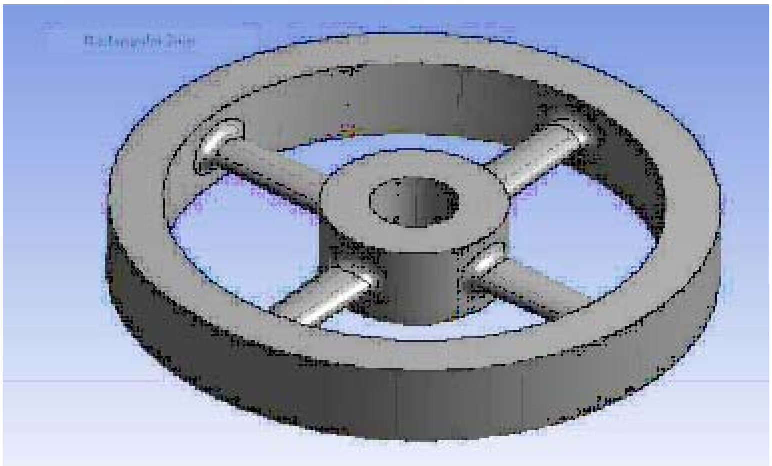

Table 4.7: Life and Safety Factor by Providing Fillet Size(0.02 m) for 4,6 and 8 Number of Arms			
No. of Arms	**Angular Velocity**	**Life**	**Safety Factor**
4	250 rad/s	3.364	0.96093
6	250 rad/s	1	1.0681
8	250 rad/s	1	1.2668

providing a fillet for 4, 6 and 8 number of arms at constant angular velocity.

Case6: Analysis by providing larger fillet size(0.025 m) at both ends of arm

Table 4.7 shows Life and Safety Factor by providing a larger fillet for 4, 6 and 8 number of arms at constant angular velocity.

DISCUSSION AND CONCLUSION

It is also seen that as a number of arms increases from 4 to 8, the fatigue life and safety factor in the flywheel goes on increasing. This may be due to sharing of load by larger no. of arms. Table 4.3, it is seen that, with increase in angular velocity the fatigue life and safety factor are decreasing. This is due to larger centrifugal forces acting on the flywheel rim. When the gravity effect along with angular velocity are considered, it is observed from Table 4.3 and 4.5 that the fatigue life and safety factor are more than that of neglecting gravity effect. Thus the gravity effect contributes to rise in the fatigue life and safety factor in flywheel.

Figure 4.10: Variation of Life w.r.t. No. of Arms for Different Fillet Size

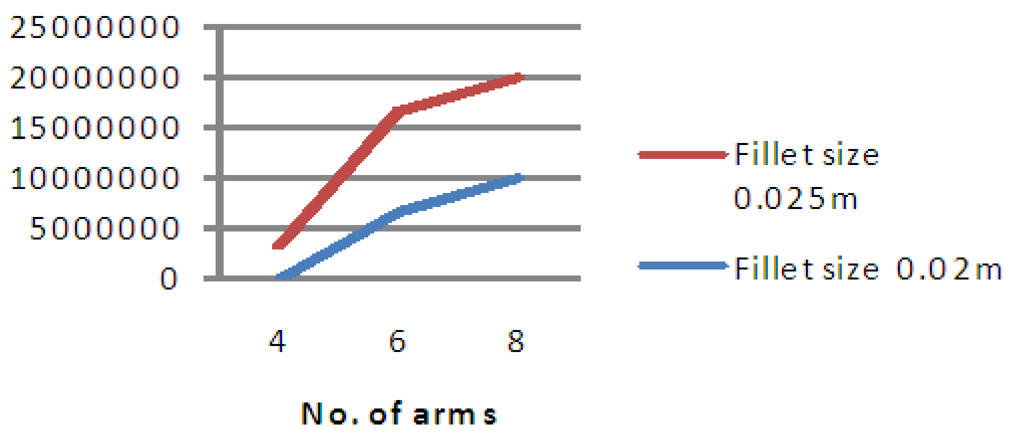

Table 4.6 and 4.7 shows the fatigue life and safety factor evaluated by varying the fillet size at arm and rim junction. It revealed that as fillet size goes on increasing the fatigue life and safety factor are increasing considerably. Thus the suitable fillet size is recommended for higher fatigue life and safety factor.

REFERENCES

1. Addas J S (2005), "Design of flywheel with a moving hole", *American Journals of applied science,* Vol. 2, No. 1, pp. 436-439.
2. Bhandari V B (2001), "Design of machine element", 3rd Edition, McGraw Hill Education, India Pvt. Ltd.
3. Colozza A J (2000), "High energy flywheel contentment evaluation", NASA/CR, 2000-210508, pp. 1-12.
4. Dhengle *et al.* S M (2012), "Investigation of Stresses in arm type rotating flywheel", *International Journal of Engineering Science and Technology* (IJEST).
5. Dilip P N and Kamal R (2010), "An evolutionary approach for the shape optimization of flywheel", *I.E. (I) Journal – MC*, Vol. 90, pp. 8.
6. Wan J (1996), "Optimization design and analysis of a flywheel", A Project for MIE 605, pp. 1-31.
7. Yongming L, Startman B and Mahadevan S (2006), "Fatigue Crack Initiation Life prediction of Railroad Wheels", *International Journal of Fatigue,* Vol. 28, pp. 747-756.
8. Zhao J, Li Q and Shen X (2008), "Finite Element Analysis and Structural Optimisatin for Improving the Fatigue Life of Rubber Mounts", *Journal of Macromolecular Sciience, Part A,* Vol. 45, No. 6, 479-484.

International Journal of Engineering Research and Science & Technology
Hyderabad, INDIA. Ph: +91-09441351700, 09059645577
E-mail: editorijlerst@gmail.com or editor@ijerst.com
Website: www.ijerst.com
ISSN 2319-5991