ISSN: 2277-9655
Scientific Journal Impact Factor: 3.449
(ISRA), Impact Factor: 2.114

IJESRT

INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

Enhancement of Frequencies of Spur Gear by Mass Reduction

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Abstract

Present paper covers modal analysis of gears by reduction of mass. Effort is to increase the fundamental frequencies of existing gear and pinion at optimum weight and to improve performance of existing gear without compromising on the performance.Result of FEM analysis is compared with the experimental and analytical results.

Keywords: modal analysis

Introduction

Gear noise and vibration is a major problem in many power transmission application .this problem becomes more significant in applications with higher operating speeds the where vibratory excitation which is related to the gear transmission error.[1]

Now a days most of the mechanical systems are subjected to dynamic loading which causes & shortens of the usable time, crack, noise and fatigue, in general the total effect of work for the mechanical system is lowered. Reasons for such behavior are type of loading, construction and conditions of work where the mechanical systems operate.

We have done modal analysis of two different material and existing material.In this paper we modified the geometry then modal analysis of modified gears for EN9 andEN353 material.[5]

Objectives

1. To improve the performance of exiting gear without compromising on the performance.
2.To increase the fundamental frequencies of gear & pinion at optimum weight.

Promblem definition

Improvement of existing gear with the use of FEM (modal analysis).

Model of modified gear

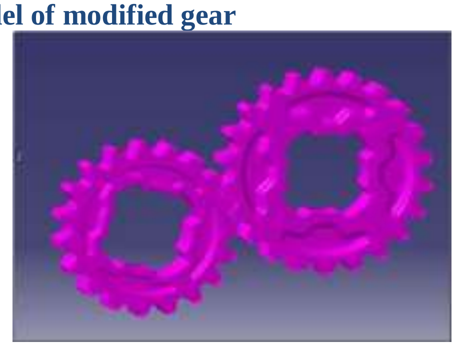

Fig1.3D model modified of spur gear.

we can save material and cost by improving the stiffness of the gear with the help of stiffness.so we redesign the geometry.parameters are same only mass is removed from the central region and stiffness is increased by changing the geometry In exiting gear resonance condition is not found hence considered for weight optimization.Weight optimisation is carried out by reducing material from exiting gear.

Tabel 1 : Gears parameters

Parameter	**Pinion**	**Gear**
Thickness	2.884 mm	2.8 mm
width	9.842 mm	9.842 mm
Root radius	16.271 mm	19.558 mm
Addendum radius	19.05 mm	22.225 mm
Pitch Circle radius	17.646 mm	20.350 mm
Pitch	5.8 mm	5.956 mm
module	1.85	1.52
No. of teeth	19	22

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1. Material Used: EN9/ EN353
2. Type Spur Gear
3.Application for case Study: Automotive.

Modal analysis of modified gears

Modal analysis, which means the study of the structure mode shape under excitation to its natural frequency, is important in the design stage.[2]

The finite element program Nastran was used to calculate the natural frequencies & mode shape of spur gear.

Modal analysis can predict the resonance of structure excited by the dynamic input.

Vibration (modal analysis)is a very effective technique for gear box health monitoring & fault detection .Health monitoring for gearbox is an improvement aspect to avoid failure of the machine .Using the free vibration analysis one calculates critical parameters such as natural frequencies & vibration modes that are essential for almost all dynamic investigations.[3]

Mesh setting of the gear in nastran

Tabel 2: material property

Material (steel)	Young's moduluse5 mpa	Poisons ration	Density Kg/mm3e-4
EN9	2.06	0.3	7.8
EN353	2.2207	0.264	7.8

The gear designs are imported .In modal analysis using FEM ,gear model is meshed with tetrahedral elements .The model consist of 101501 nodes & elements 62081.[2]

Boundry condition of exiting gear

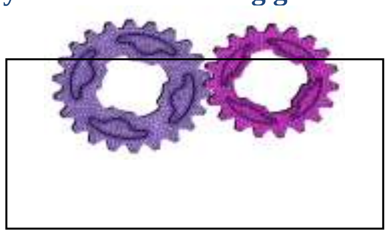

Fig.2 Mesh model with boundary Condition

The mode shape of the gear in FEM are calculated independently of the excitation, means that the structure is only mass and stiffness distribution dependent.

Mode shapes and frequencies of existing gears with two different material (en19b and en353)

Table 3 Two Modes Of Frequencies for EN9 material

Operating Mode	Frequency (Analytical)	Frequency (nastran)	Percentage Difference
Mode (pinion)	33742	34840	3
Mode (gear)	47334	46680	1

The percentage difference is calculated by normalizing the nastran data with the analytical values. As seen in TableI, the values of the frequencies computed by the analytical formulas agree well with the values obtained in nastaran. For the nastran analysis, spur gear was meshed with RBE2 elements with the guided boundary conditions applied at the centre at SPC .

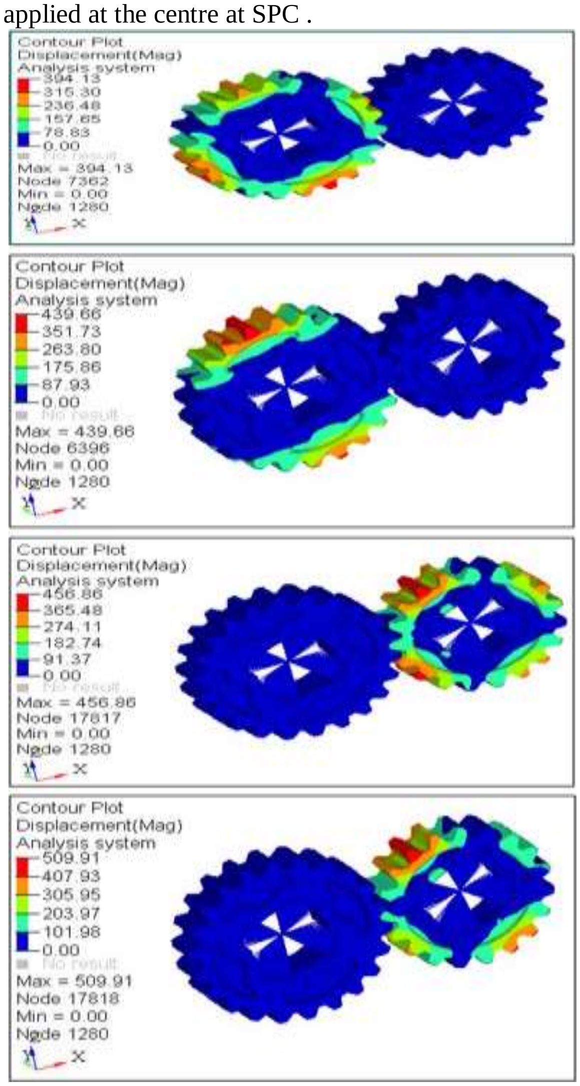

Fig3.mode shapes for EN9 material.

Table 4 Two Modes Of Frequencies for EN353 material

Operating Mode	Frequency (Analytical)	Frequency (nastran)	Percentage Difference
Mode (pinion)	33464	36230	7.6
Mode (gear)	46942	46094	1

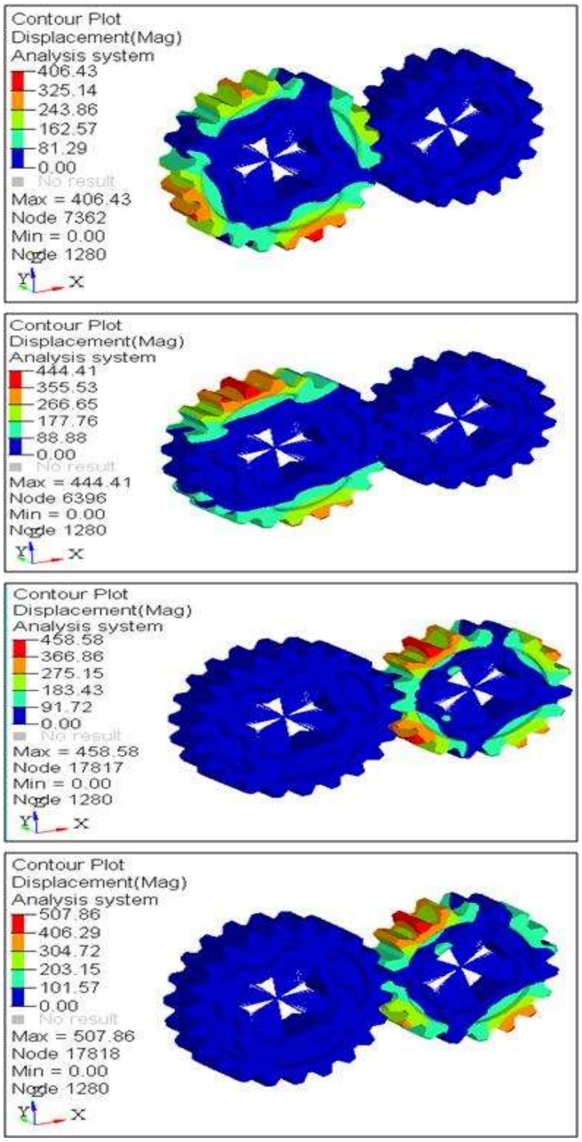

Fig4 .mode shapes for EN353 material.

fig.3 and fig.4 shows that mode 1,2,7and 8 Which having torsional moment and displacement in X direction.

FEA Results and validation

Tabel 5 : Change in natural frequency is observed as follows for the exiting model & modified model

Mode	Existing Model frequency Hz		Modified Model frequency Hz	
	EN9	EN 353	EN9	EN 353
1	32227.6	33354.06	34835.30	36277.70
2	32471.1	33597.41	35854.19	37088.20
3	33491.3	34528.55	36196.80	37431.30
4	34409.5	35882.12	37364.87	38516.80
5	37607.6	39195.74	410272.2	42852.50
6	41561.5	43304.49	44342.19	45917.80
7	49844.7	51783.93	44387.01	46094.80
8	49928.0	51890.16	46677.18	48355.90
9	50227.3	52333.02	46791.05	48471.10
10	50837.5	52665.49	49166.31	50818.20

Tabel 6 : Comparison of Change in mass of Exiting & Modified gears

Types of Model	Material	Mass in Kg	% of reduction
Existing	EN9	0.1510	12.5
	EN353	0.1527	13.09
Modified	EN9	0.1325	12.5
	EN353	0.1327	13.09

Conclusion

We have improved performance of modified gear and increased fundamental natural frequencies at optimum weight.

After modal analysis of modified gears,frequencies and mode shapes for En9 and En353 was found.If mass or geometry is changed then frequencies and mode shapes changes..Reduction in mass increases frequencies increases.we save material and cost by improving the stiffness of the gear with the help of changing geometry.

Acknowledgment

I thanks to Dr. vikrama singh. and prof.p.p.shreshtha for introducing me the amazing culture and philosophy behind modal analysis of spur gear.

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