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FINITE ELEMENT ANALYSIS OF LATHE MACHINE TUMBLER GEAR MECHANISM

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Abstract

Gear is the special division of Mechanical Engineering concerned with the transmission of power and motion between the rotating shafts. In this study, a lathe machine tumbler gear mechanism used for threading purpose is taken and applied finite element analysis methodology on each metallic spur gears. Main purpose of this study is to compare FEA stresses of metallic spur gears with the AGMA standard stress. Modelling of gears is done in PRO-ENGINEERING and analysis is done using ANSYS workbench v11.

Keywords*: Spur Gear, FEM, Bending Stress, AGMA, PRO-ENGINEERING, ANSYS V11*.

1. Introduction

Gears are the most useful and common means of transmitting motion and power in the today modern engineering field. They vary from tiny size used in watches to the large gears used in the lifting devices and speed reducers. Gears are the valuable mechanical element of mechanism such as rolling machinery, metal cutting machinery and automotive machinery. Gears with toothed shape generally used to vary or change speed- power ratio also to change the direction of input and output shaft. Gears are used in pairs and each gear is usually attached to a rotating shaft.

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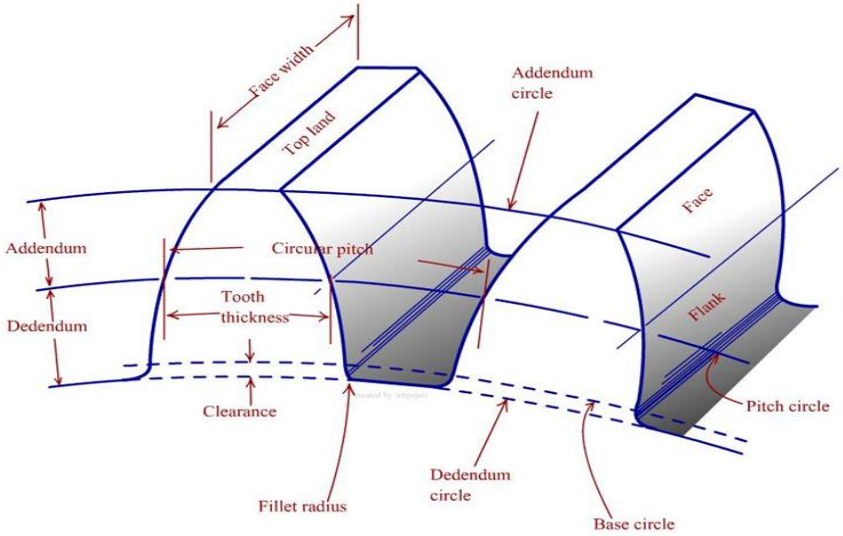

Figure-1.1:- Gear Terminology

There are different materials used as a gear material. Gear materials are used as per the type of application of power transmission and loading condition. All material are not providing similar properties during working condition due to their different structure and bonding nature. Materials are to be required to check under loading conditions to find their beneficial properties and remove unnecessary properties during the selection of material. When gears are in a loading condition, mainly two types of failure are produced in gear material like as bending failure due to low bending strength of material and pitting or contact failure due to lower strength of contact area of gear teeth.

For analysis purpose of spur gears, **Lathe Machine Tumbler Gear Mechanism** is selected for material analysis.

1.1 Objectives of the Work

- Check comparative stress in conventional metallic material of spur gears using a static finite element method.
- Check stress analysis of metallic spur gears of a lathe machine tumbler gear mechanism with AGMA standard stress for specific loading condition.

1.2 Specification of Gear Mechanism

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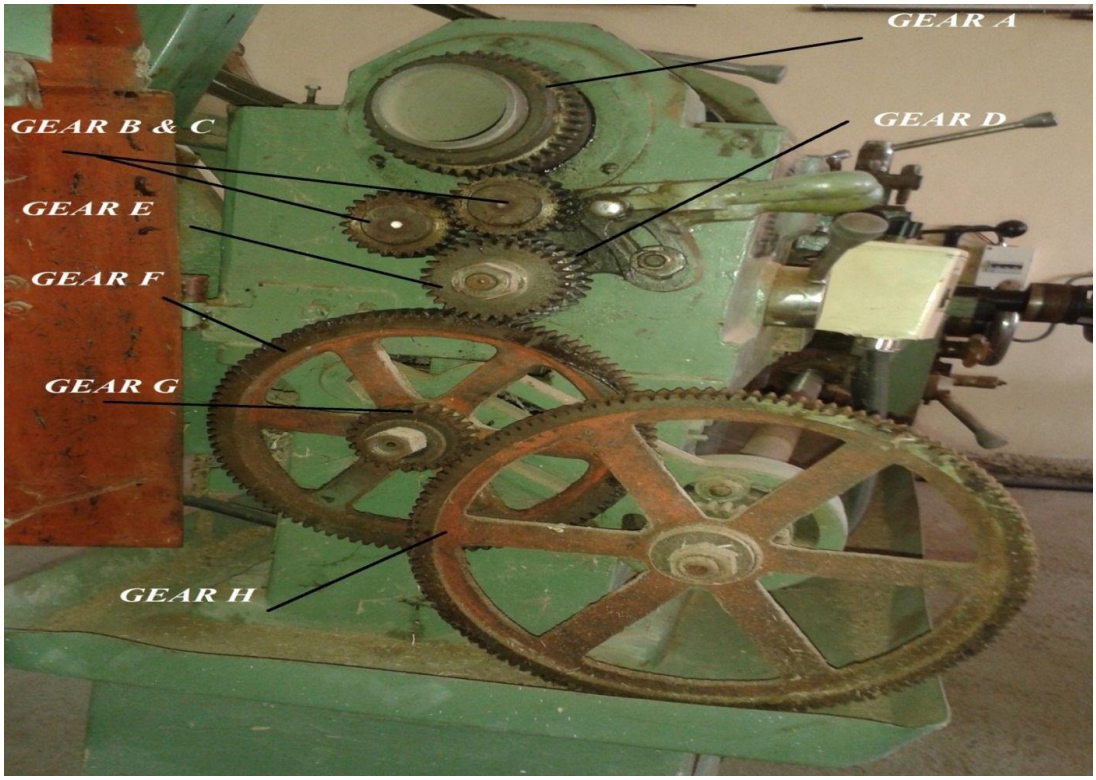

Figure-1.2:- Lathe machine gear mechanism

Table-1.1:- Lathe Machine Specification

Manufacture Name	Natraj Brand
Electric motor	2 HP, 3PH, 1440 rpm
Gear type	Parallel spur gear
Pressure angle	20^0
Module	2
Material	Nodular Cast Iron

There are eight gears in this gear mechanism and minimum speed of first input gear A is 200 rpm that I have measured with digital tachometer.

Table-1.2:- Gear Parameter

GEAR NAME	NUMBER OF TEETH	OUTSIDE DIA.	P.C.D
A	44	92	88
B	25	54	50
C	25	54	50
D	33	70	66
E	30	64	60
F	100	204	200
G	55	114	110
H	127	258	254

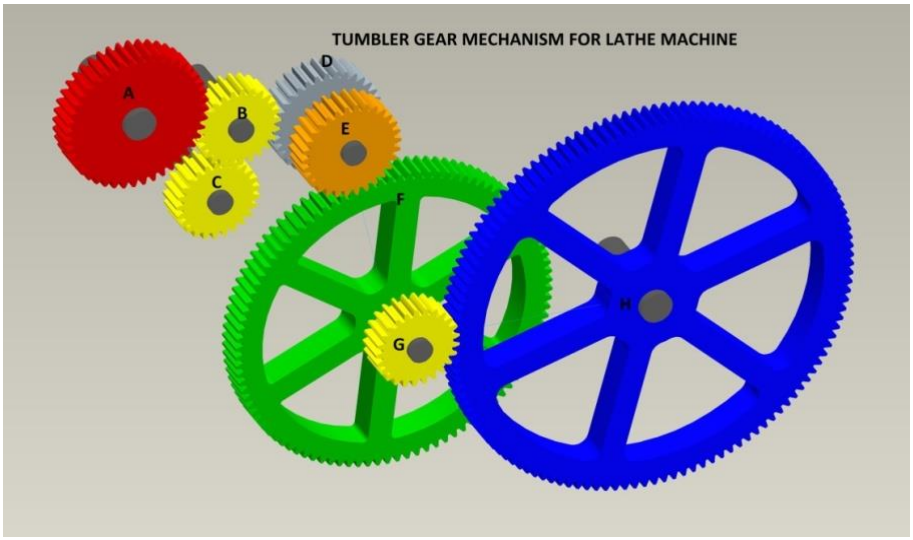

Figure-1.3:- Modelling of Lathe Gear Mechanism

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2. Design Calculation

2.1 Material Data

Table-2.1:-Material Data

Material			Nodular Cast Iron(Ductile)		
Density	Compressive Ultimate Strength MPa	Tensile Ultimate Strength MPa	Young's Modulus MPa	Poisson's Ratio	
7300 kg/m^3	840	700	35000	0.28	
Chemical Composition					
Carbon	Manganese	Silicon	Phosphorous	Sulphur	Magnesium
3.40 - 3.85 %	0.10 – 0.30 %	2.30 – 3.10 %	0.10 %	0.02 %	0.07

2.2 Design Input for Gear A

Table-2.2:- Input Parameters Gear A

Power	1492 watt
Pitch circle diameter	88 mm
Module	2 mm
Gear Rpm	200
No. of teeth	44

- Input power:

$$\text{POWER} = \frac{2 \times \pi \times N_A \times T_A}{60}$$

$$1492 = \frac{2 \times \pi \times 200 \times T_A}{60}$$

T_A = 71273.88 N.mm

- Tangential force:

$$W_{tA} = \frac{T_A}{(\text{P.C.D.}/2)}$$

$$= \frac{71273.88}{88/2}$$

= 1619.86 N

- AGMA Stress

$$\sigma(AGMA) = \frac{W_{tA}}{b \times m \times J} K_v K_o K_m$$

$$= \frac{1619.86}{20 \times 2 \times 0.4} \times 1 \times 1 \times 1.25$$

= 126.55 MPa

Table-2.3:- Gear Calculation Data

Gear Name	Tangential force (W_t) N	Torque N.mm	stress (AGMA) (Mpa)
A	1619.86	71273.88	126.55
B	1619.86	40496.52	126.55
C	1619.86	40496.52	146.72
D	1619.86	53456.75	142.59
E	1781.89	53456.75	150.49
F	1781.84	178184.71	150.49
G	3239.72	178184.71	204.48
H	3206.92	407279.34	202.39

3. FEA Analysis

Bending stress of spur gear teeth is generally calculated by analytically and finite element method. Analytical bending stress is calculated by two formula Lewis formula and AGMA formula. Analytical result is compared with the finite element method result for validation. For above purpose, the solid model of spur gear is imported in a fem software ANSYS as an IGES file. Result of bending stress is obtained after the meshing and boundary condition are applied on the spur gear geometry. Nodes and element generated in meshing of gear are 26518 and 4851 respectively.

Von-Mises stress is equal to the tension stress and generally it is main cause of crack in the gear teeth if the applied load is greater than strength of the gear teeth so gear teeth is crack from tensile force.

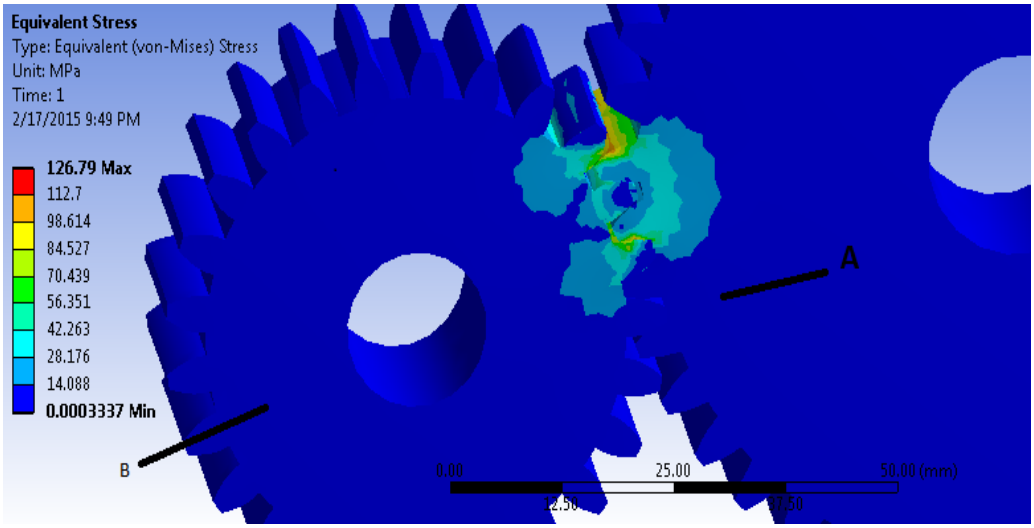

Figure-3.1:- Von mises stress distribution in gear A

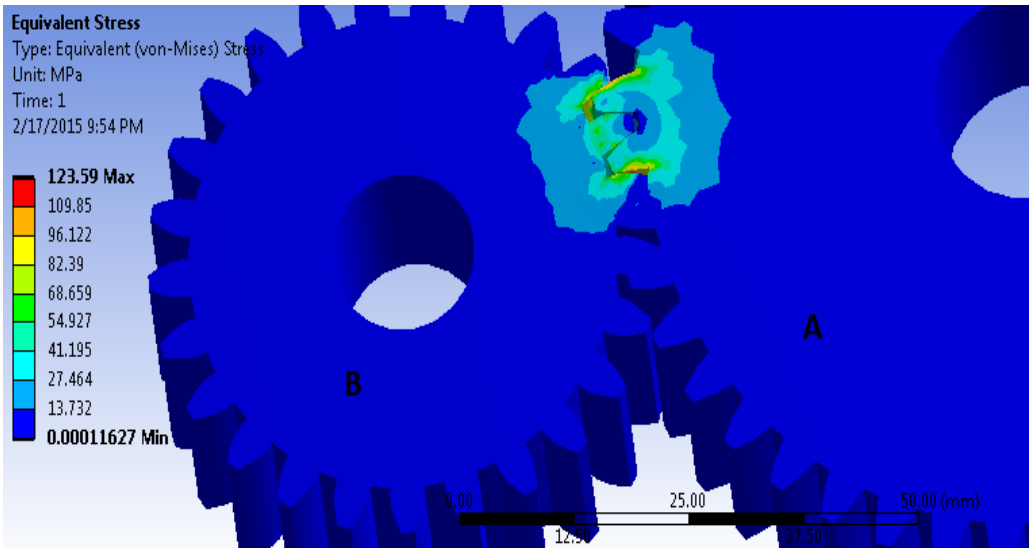

Figure-3.2:- Von mises stress distribution in gear B

3.1 Comparison of Fem Result with AGMA Standard

All metallic gears of a lathe machine gear mechanism are analyzed for a stress analysis under loading condition. The study is applied in to finite element method software ANSYS V11. Here FEA stress for metallic spur gears is compared with AGMA stress and a table is formed.

Table-4.1:- Comparison of AGMA and ANSYS stress of existing metallic gears

Gear Name	σ (AGMA) [Mpa]	σ (ANSYS) [Mpa]	Difference % ±
Gear A	126.55	126.79	0.18
Gear B	126.55	123.59	2.30
Gear C	146.72	144.85	1.29
Gear D	142.59	135.52	5.21
Gear E	150.49	149.08	0.94
Gear F	150.49	157.25	4.49
Gear G	204.48	195.38	4.65
Gear H	202.39	195.24	3.66

COCLUSION

In this research, FEA analysis of metallic spur of lathe machine gear mechanism is done. FEA stresses in all metallic gears are similar to the AGMA stress for all gears and are within their allowable strength limit and are within 6 % difference.

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