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OPTIMIZATION OF LOCOMOTIVE WHEEL BY USING FINITE ELEMENT TECHNIQUE

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ABSTRACT

Damage mechanisms such as surface cracks, plastic deformation and wear can significantly reduce the service life of rolling stock. They also have a negative impact on the rolling noise as well as on the riding comfort. A proper understanding of these mechanisms requires a detailed knowledge of physical structure and specifications of wheel.

New specifications are being imposed on railway wheel wear and reliability to increase the time between wheel re-profiling operations, improve safety and reduce total wheel set lifecycle costs. In parallel with these requirements, changes in railway vehicle missions are also occurring. These have led to the need to: operate rolling stock on track with low as well as high radius curves; increase speeds and axle loads and contend with a decrease in track quality due to a reduction in maintenance. These changes are leading to an increase in the severity of the wheel/rail contact conditions.

So there is a need to optimize the wheel through several considerations such as material properties, shape, design features etc. The optimization is done by preparing a model in PRO/E and analysis in ANSYS.

Introduction:

Since the wheel is the main part, which is subjected to most vibrations and stresses, choice of the material should withstand these effects. Generally in India, plain carbon steels are used due to its low cost, excellent strength etc. Even though plain carbon steel has good properties, there is a need to introduce new materials to compete with advanced technology of other countries. New age always demands fast speed, riding comfort etc. so there is definitely a need of introducing new materials. As the speed increases, automatically vibrations increases and which in turn leads to more wearing in the wheels. To withstand these vibrations, generally alloy steels are proposed for the wheel material.

Three materials are chosen for the wheel material and modal analysis is done using ANSYS

Materials chosen are

a. AISI 8640

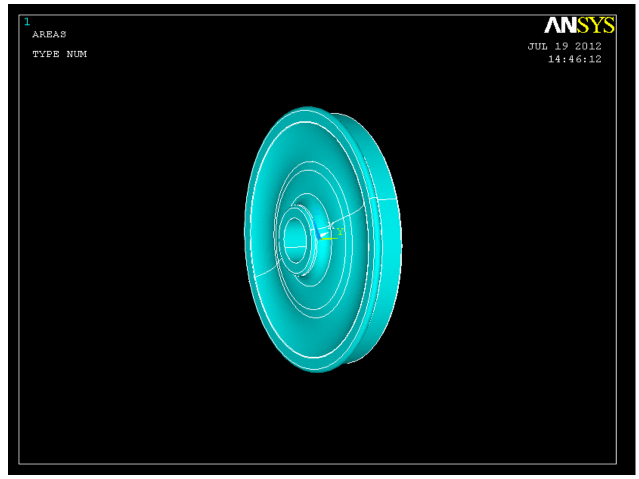
b. AISI 1050

c. C50-PLAIN CARBON STEEL

MODELLING PROCEDURE:

Modeling of wheel is done in PRO/E (wild fire3). The procedure is as follows

- First the half sectional view of the wheel profile is drawn according to Indian railways standard dimensions using sketcher module.
- The half sectional sketch is rotated along a horizontal axis using rotate option and part model is constructed.



ANSYS PROGRAM

BOUNDARY CONDITIONS:

Surface area of roller contact area(shaft bearing area) is selected and then

Apply boundary conditions.

U_x, U_y components are fixed.

MATERIAL PROPERTIES:

AISI 8640

PROPERTY	VALUES	VALUES TAKEN
1. DENSITY:	7.7-8.03X10^3 Kg/m^3	7.9x10^3 Kg/m^3
2. POSSION'S RATIO:	0.27-0.3	0.28
3. YOUNGS MODULUS:	190-210x10^9 N/m^2	200x10^3 N/m^2

AISI 1050

PROPERTY	VALUES	VALUES TAKEN
1. DENSITY:	2.6-2.8X10^3 Kg/m^3	2.7x10^3 Kg/m^3
2. POSSION'S RATIO:	0.31-0.33	0.32
3. YOUNGS MODULUS:	70-80X10^9 N/m^2	200x10^3 N/m^2

PLAIN CARBON STEEL(C-50)

PROPERTY	VALUES	VALUES TAKEN
1. DENSITY:	7.85X10^3 Kg/m^3	7.85x10^3 Kg/m^3
2. POSSION'S RATIO:	0.3	0.3
3.YOUNGS MODULUS:	205x10^3 N/m^2	205x10^3 N/m^2

ANSYS PROCEDURE:

Model analysis of the wheel is carried out for each of the above mentioned materials. Ansys is used for this analysis.

The procedure is as follows:

1. PREFERECES > STRUCTURAL > OK

2. FILE > IMPORT > IGES > BROWSE FILE > SELECT > OK

3. PREPROCESSOR > ELEMENT TYPE > ADD > TETRA 10 NODE 92 > OK > CLOSE

4. MATERIAL PROPERTIES > MATERIAL MODELS > STRUCTURAL > LINES > ELASTIC > ISOTROPIC > ENTER DENSITY, YOUNGS MODULUS, POSSION'S RATIO > OK

5. MESHING > SIZE CONTROLS > MANUAL SIZE > LINES > ALL LINES > SELECT THE OBJECT > ELEMENT EDGE LENGTH > 25> OK

6. MESH > VOLUME > FREE MESH > SELECT THE MODEL > OK

7. SOLUTION > ANALYSIS TYPE > NEW ANALYSIS > MODEL > OK

8. ANALYSIS OPTIONS > NO OF MODES TO EXTRACT > 3 > OK

9. LOADS > DEFINE LOADS > APPLY > STRUCTURAL > DISPLACEMENT ON AREAS > SELECT THE AREA > U_X AND U_Y FIXED.

10.SOLUTION > SOLVE CURRENT LINES SOLUTION > OK

11. GENERAL POST PROCESSOR > PLOT RESULTS > DEFORMED SHAPE > DEFORMED +UN DEFORMED SHAPE > OK

12. READ RESULTS > FIRST SET > DEFORMATION > TAKE RESULTS > CLICK NEXT SET > DEFORMATION > TAKE RESULTS > CLICK LAST SET > DEFORMATION > TAKE RESULTS.

13. PLOT RESULTS > CONTOUR PLOT > NODAL SOLUTION > DOF SOLUTION IN X COMPONENT DISPLACEMENT > SAVE.

14. PLOT RESULTS > CONTOUR PLOT > NODAL SOLUTION > DOF SOLUTION IN Y COMPONENT DISPLACEMENT > SAVE.

15. PLOT RESULTS > CONTOUR PLOT > NODAL SOLUTION > DOF SOLUTION IN Z COMPONENT DISPLACEMENT > SAVE.

16. GENERAL POSTPROCESSOR > RESULTS SUMMARY > OK.

RESULTS

RESULTS for AISI 8640:

INDEX OF DATA SETS ON RESULTS FILE:

MODE 1:

SET	TIME/FREQ	LOAD STEP	SUBSTEP	CUMULATIVE
1	0.000	1	1	1
2	0.15948	1	2	2
3	0.16886	1	3	3

MODE 2:

SET	TIME/FREQ	LOAD STEP	SUBSTEP	CUMULATIVE
1	0.000	1	1	1
2	0.15948	1	2	2
3	0.16886	1	3	3

MODE 3:

SET	TIME/FREQ	LOAD STEP	SUBSTEP	CUMULATIVE
1	0.000	1	1	1
2	0.15948	1	2	2
3	0.16886	1	3	3

RESULTS for AISI 1050:

INDEX OF DATA SETS ON RESULTS FILE:

MODE 1:

SET	TIME/FREQ	LOAD STEP	SUBSTEP	CUMULATIVE
1	0.000	1	1	1
2	0.16846	1	2	2
3	0.17863	1	3	3

MODE 2:

SET	TIME/FREQ	LOAD STEP	SUBSTEP	CUMULATIVE
1	0.000	1	1	1
2	0.16846	1	2	2
3	0.17863	1	3	3

MODE 3:

SET	TIME/FREQ	LOAD STEP	SUBSTEP	CUMULATIVE
1	0.000	1	1	1
2	0.16846	1	2	2
3	0.17863	1	3	3

RESULTS for C-50 PLAIN CARBON STEEL:

INDEX OF DATA SETS ON RESULTS FILE:

MODE 1:

SET	TIME/FREQ	LOAD STEP	SUBSTEP	CUMULATIVE
1	0.000	1	1	1
2	0.16263	1	2	2
3	0.17232	1	3	3

MODE 2:

SET	TIME/FREQ	LOAD STEP	SUBSTEP	CUMULATIVE
1	0.000	1	1	1
2	0.16263	1	2	2
3	0.17232	1	3	3

MODE 3:

SET	TIME/FREQ	LOAD STEP	SUBSTEP	CUMULATIVE
1	0.000	1	1	1
2	0.16263	1	2	2
3	0.17232	1	3	3

CONCLUSIONS

1. I had done the model analysis for three types of materials for the model.
2. The frequencies obtained for the material AISI 8640 are less when compared to other two materials.
3. Therefore AISI 8640 can be preferred as a material for the railway wheel.
4. Due to its high cost and other factors, it is not being used by Indian railways.
5. So plain carbon steel is being used by Indian railways.

Scope for future work:

1. There is a need for replacing traditional plain carbon steel with alloy steel, which will reduce wear rate up to some extent.
2. Study for better and economic alloy steels is needed to improve wheel life.
3. Also study should be conducted in wheel profile for increasing the wheel life.
4. Research should be concentrated on wheel tread since it is the part which will be always in contact with rail.