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Structural Analysis of a Aluminum Alloy Wheel

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ABSTRACT

In the present project a detailed static and fatigue analysis of aluminum alloy wheel under a radial loads has been done.

Analysis of aluminum alloy wheel A356.2 was carried out using FEA package. The 3 dimensional model of the wheel was designed using CATIA. Then the IGES format 3-D model was imported into ANSYS.

The present thesis summarizes the application of finite element analysis technique for analyzing stress distribution and fatigue life of Aluminum alloy wheels subject to radial loads. Alloy wheels intended for use on passenger cars stipulate two types of fatigue tests, the dynamic cornering fatigue test and the dynamic radial fatigue test. As wheels undergo inconsistent, varying loads during their service life, fatigue behavior is a key consideration in the design and performance evaluation. But since alloy wheels are designed for styling and have more complex shapes than regular steel wheels, it is difficult to assess fatigue life by analytical methods. So, finite element analysis has been used to evaluate the performance of wheels over their life.

MATERIAL PROPERTIES ANDMANUFACTURING OF ALUMINUMALLOY WHEEL

ALUMINUM ALLOY 356.2

Category	–	aluminum alloy
Class	--	cast

COMPOSITION:

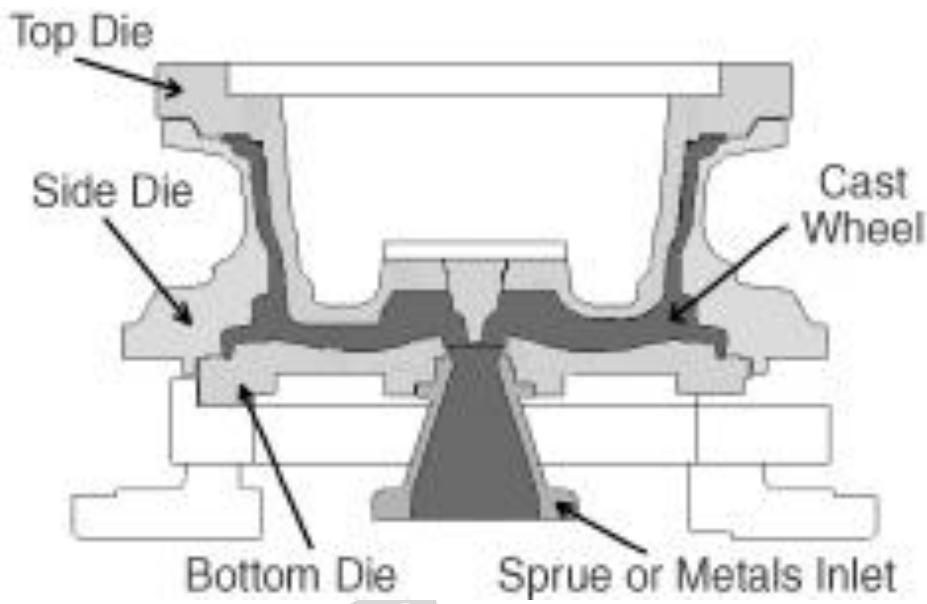
Aluminum	-	92.4 %,
Silicon	-	6.5 to 8 %,
Magnesium	-	0.25 to 0.4 %,
Titanium	-	0.2%,
Iron	-	0.12%,
Manganese	-	0.14%,
Strontium	-	0.2%

MECHANICAL PROPERTIES:

Young's modulus (mpa)	-----	6.9*e4
Density (*1000kg/m)	-----	2.68*10-9
Poisons ratio	-----	0.33
Elastic modulus (g.pa)	-----	70 – 80
Tensile strength (m.pa)	-----	175
Yield strength (m.pa)	-----	140
Elongation %	-----	2.0

MANUFACTURING PROCESS OF ALLOY WHEEL

A DIE TOOL ASSEMBLY:



A DIE TOOL ASSEMBLY DIE TOOL FOR TPYPICAL LPDC PROCESS **8**

PROCEDURE FOR MANUFATURING:

DESIGN PROCESS:

- Sketching using basic sketch entities.
- Converting the sketch into feature and parts.
- Assembly different parts and analysis them
- Manufacturing of the final parts and assembly

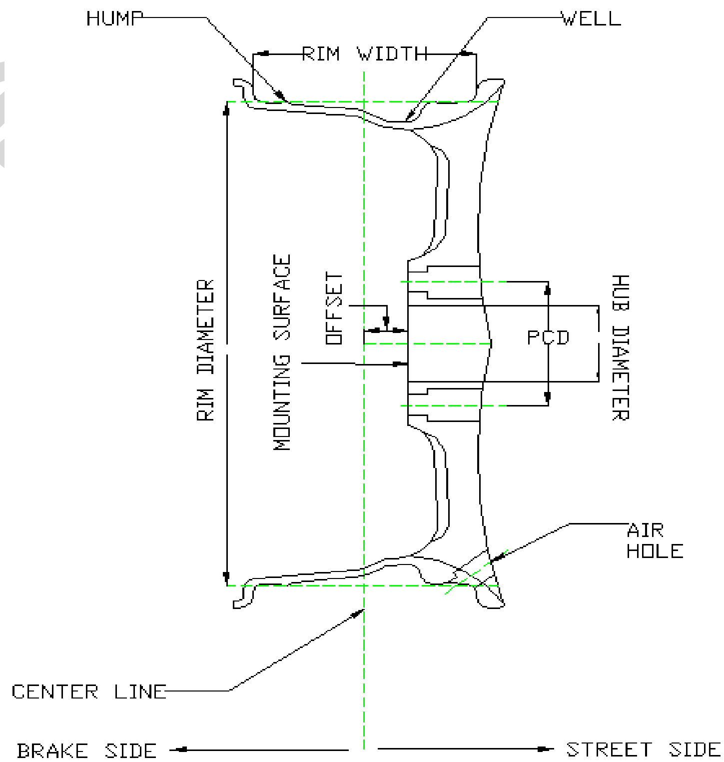
STATIC AND FATIGUE ANALYSIS PROCEDURE

The present work deals with estimating the fatigue life of aluminum alloy wheel by conducting the tests under radial fatigue load and comparison of the same with that of finite element analysis. Fatigue life prediction using the stress approach is mostly based on local stress, because it is not possible to determine nominal stress for the individual critical areas. The necessary material data for fatigue life prediction with the stress concept is the well known S–N curve. Therefore, S–N curves are required for each specimen which reflects the stress condition in the critical area of the component. To find out the fatigue properties of the aluminum.

In the fatigue life evaluation of aluminum wheel design, the commonly accepted procedure for passenger car wheel manufacturing is to pass two durability tests, namely the radial fatigue test and cornering fatigue test. Since alloy wheels are designed for variation in style and have more complex shapes than regular steel wheels, it is difficult to assess fatigue life by using analytical methods. In general, the newly designed wheel is tested in laboratory for its life through an accelerated fatigue test before the actual production starts. Based on these test results the wheel design is further modified for high strength and less weight, if required.

PROCEDURE OF THE FATIGUE ANALYSIS USING ANSYS

WHEEL SPECIFICATION



3.1 MODELDESCRIPTION

The 3-diemensional modal of the wheel was created in CATIA and the file was exported in the IGES (international graphics exchange specification) format into ANSYS. The 3-diemesional modal that was developed is shown below.

FIG 6.2.2 A 3-D MODEL OF ALLOY WHEEL

3.2 MESHINGOFTHEWHEEL

The mesh was meshed with 10- node tetrahedral structural solid elements. The wheel was meshed using an element edge length is 5mm. The total number of nodes and elements is212319 and 117243 respectively. The finite element realization of the wheel obtained is shown in below.

The meshing was performed using the mesh generate option in the ansys workbench.

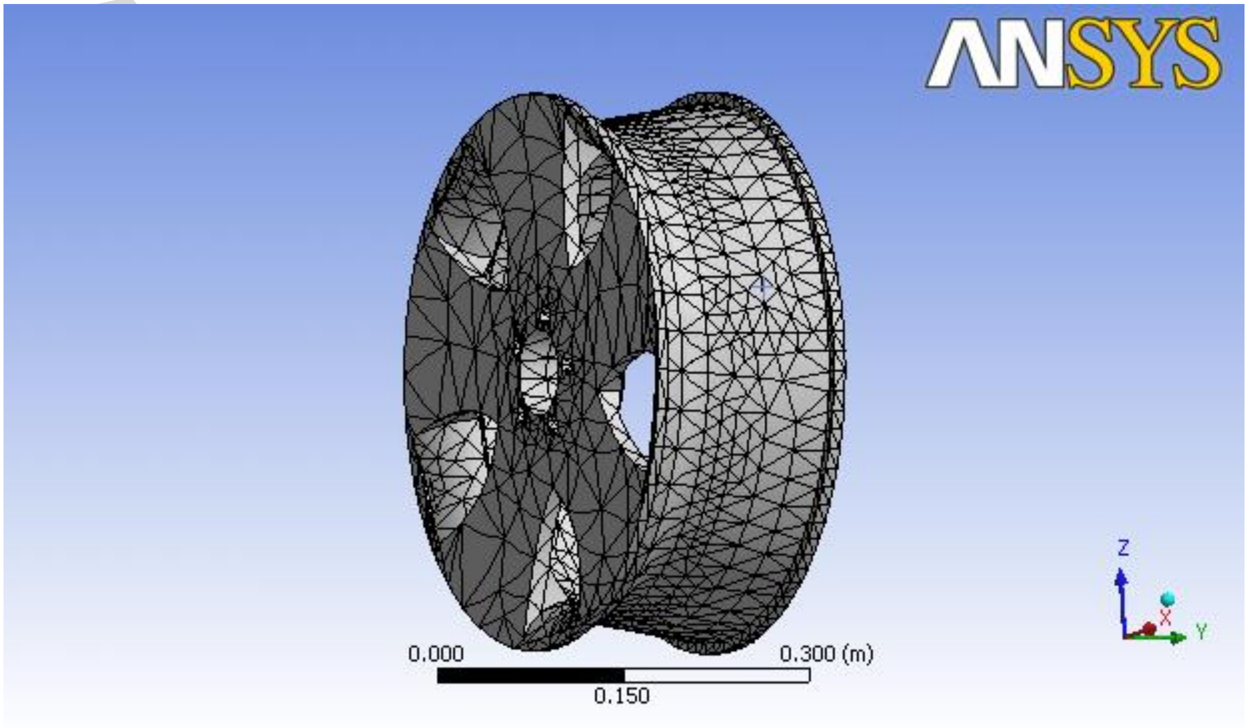


FIG 6.2.3 MESHING OF ALLOY WHEEL

ANALYSIS:

Fatigue analysis is used to determine the life, safety and damage of any component. The present work involves the determination of the life, safety factor and damage of alloy wheel and corresponding deformation, shear stress and alternative stress.Inansys work bench we had added tools of static analysis and fatigue tool.

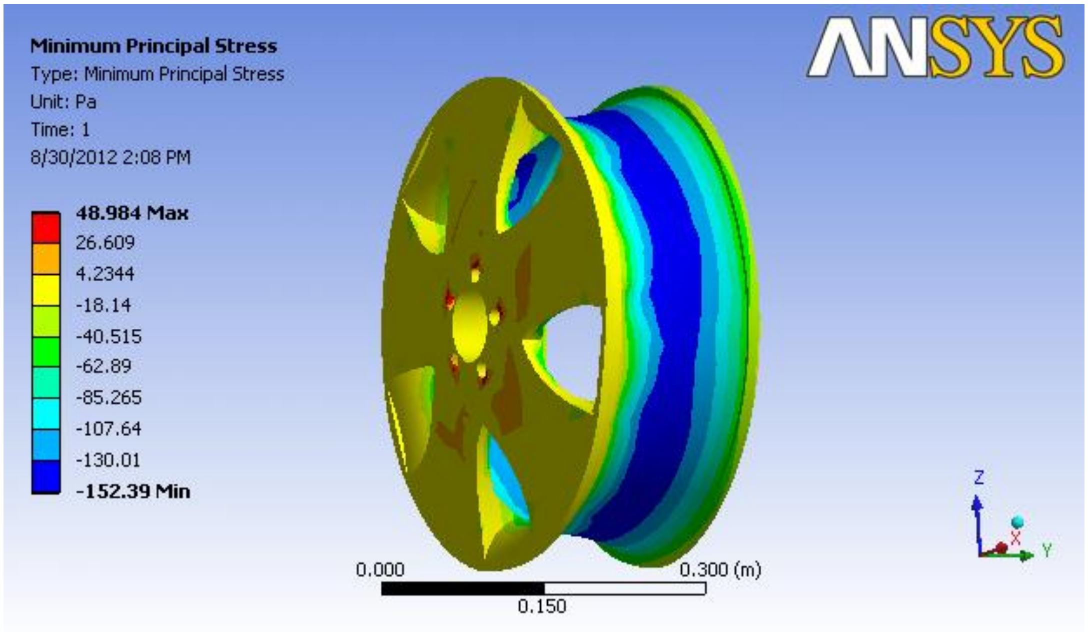
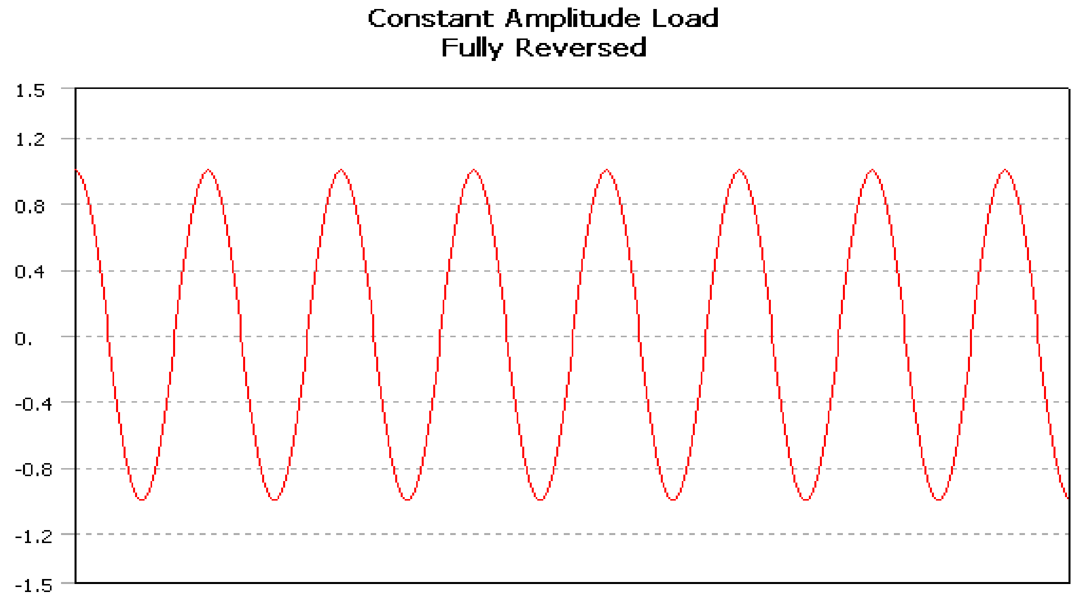


FIG 6.2.4 ALLOY WHEEL IN ANSYS WORK BENCH



ALTERNATIVE STRESSES VS CYCLES

Model

Geometry

TABLE 2
Model > Geometry

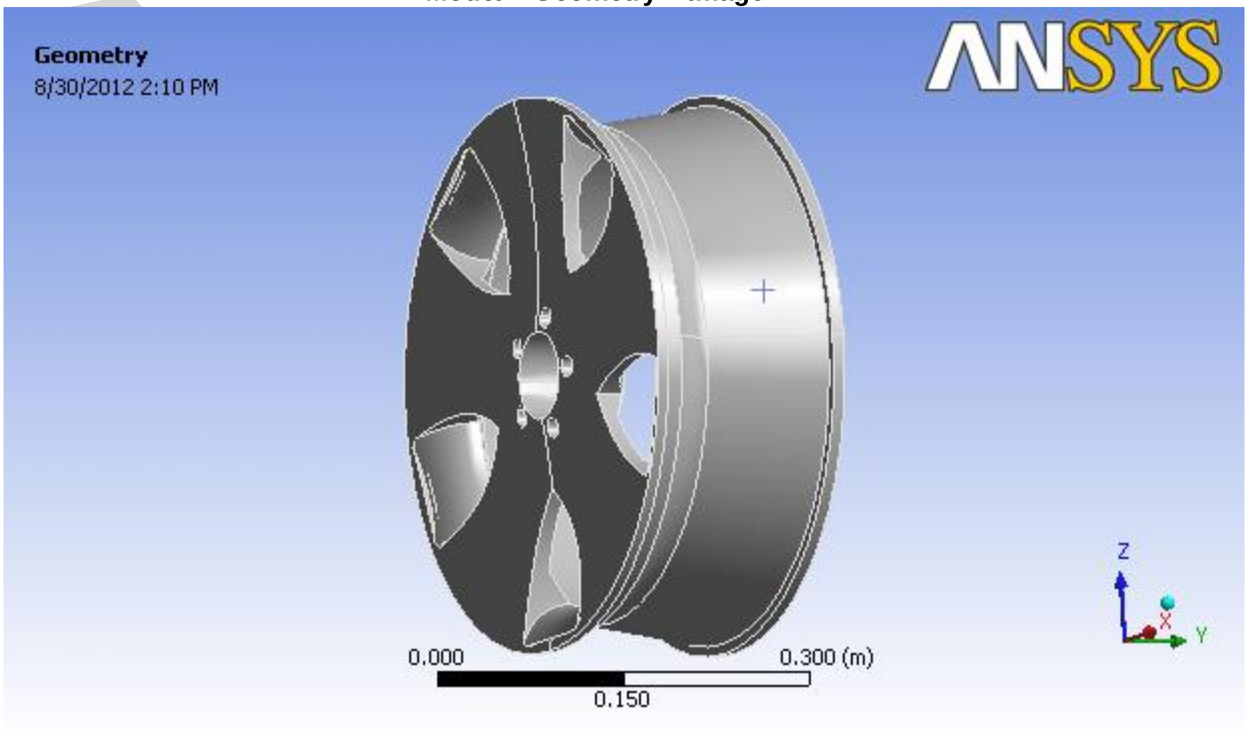
Object Name	*Geometry*
State	Fully Defined
Definition	
Source	C:\Documents and Settings\Administrator\Desktop\alloy wheel.igs
Type	Iges
Length Unit	Meters
Element Control	Program Controlled
Display Style	Part Color
Bounding Box	
Length X	0.4518 m
Length Y	0.16781 m
Length Z	0.4518 m
Properties	
Volume	3.9079e-003 m³
Mass	10.825 kg
Statistics	
Bodies	1
Active Bodies	1
Nodes	13170
Elements	6428

Preferences	
Import Solid Bodies	Yes
Import Surface Bodies	Yes
Import Line Bodies	Yes
Parameter Processing	Yes
Personal Parameter Key	DS
CAD Attribute Transfer	No
Named Selection Processing	No
Material Properties Transfer	No
CAD Associativity	Yes
Import Coordinate Systems	No
Reader Save Part File	No
Import Using Instances	Yes
Do Smart Update	No
Attach File Via Temp File	No
Analysis Type	3-D
Mixed Import Resolution	None
Enclosure and Symmetry Processing	Yes

TABLE 3
Model > Geometry > Parts

Object Name	*Part 1*
State	Meshed
Graphics Properties	
Visible	Yes
Transparency	1
Definition	
Suppressed	No
Material	Aluminum Alloy
Stiffness Behavior	Flexible
Nonlinear Material Effects	Yes
Bounding Box	
Length X	0.4518 m
Length Y	0.16781 m
Length Z	0.4518 m
Properties	
Volume	3.9079e-003 m³
Mass	10.825 kg
Centroid X	-5.3344e-006 m
Centroid Y	-3.6986e-002 m
Centroid Z	-4.032e-005 m
Moment of Inertia Ip1	0.17896 kg·m²
Moment of Inertia Ip2	0.31792 kg·m²
Moment of Inertia Ip3	0.17899 kg·m²
Statistics	
Nodes	13170
Elements	6428

FIGURE 1
Model > Geometry > Image

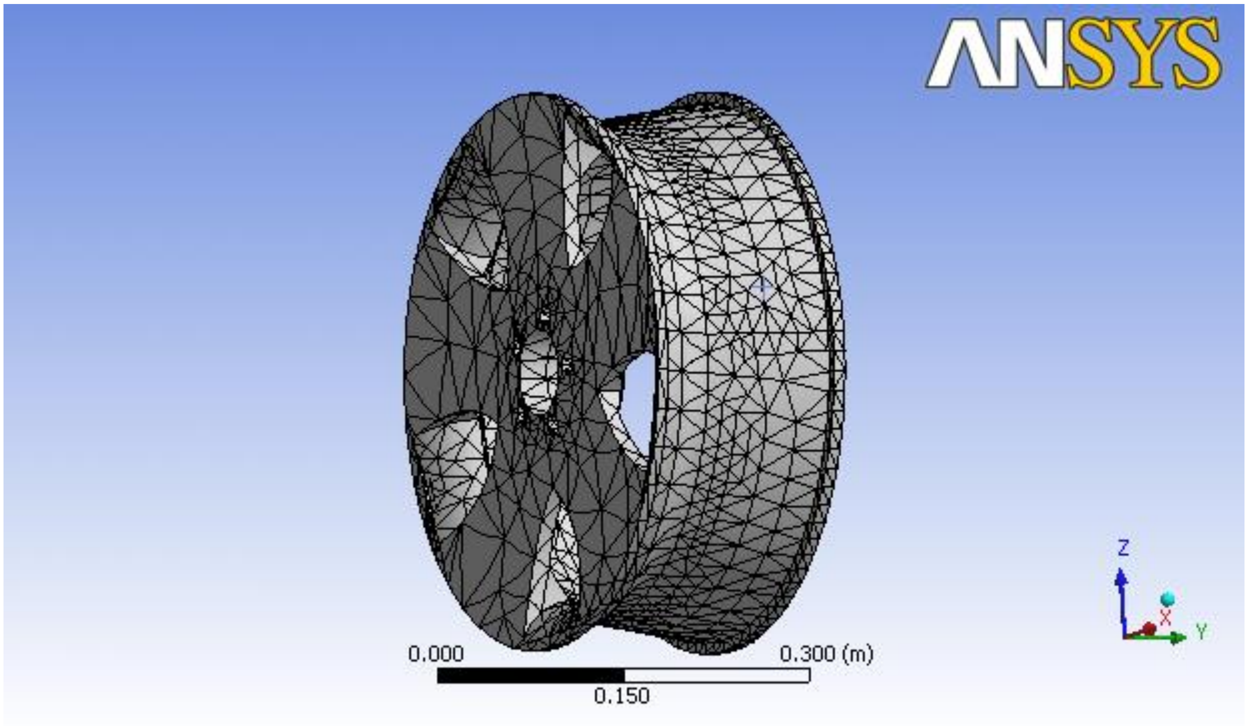


Mesh

TABLE 4
Model > Mesh

Object Name	*Mesh*
State	Solved
Defaults	
Physics Preference	Mechanical
Relevance	0
Advanced	
Relevance Center	Coarse
Element Size	Default
Shape Checking	Standard Mechanical
Solid Element Midside Nodes	Program Controlled
Straight Sided Elements	No
Initial Size Seed	Active Assembly
Smoothing	Low
Transition	Fast
Statistics	
Nodes	13170
Elements	6428

FIGURE 2
Model > Mesh > Image



Static Structural

TABLE 5
Model > Analysis

Object Name	*Static Structural*
State	Fully Defined
Definition	
Physics Type	Structural
Analysis Type	Static Structural
Options	
Reference Temp	22. °C

TABLE 6
Model > Static Structural > Analysis Settings

Object Name	*Analysis Settings*
State	Fully Defined
Step Controls	
Number Of Steps	1.
Current Step Number	1.
Step End Time	1. s
Auto Time Stepping	Program Controlled
Solver Controls	
Solver Type	Program Controlled
Weak Springs	Program Controlled
Large Deflection	Off
Inertia Relief	Off
Nonlinear Controls	

Force Convergence	Program Controlled
Moment Convergence	Program Controlled
Displacement Convergence	Program Controlled
Rotation Convergence	Program Controlled
Line Search	Program Controlled
Output Controls	
Calculate Stress	Yes
Calculate Strain	Yes
Calculate Results At	All Time Points
Analysis Data Management	
Solver Files Directory	C:\DOCUME~1\ADMINI~1\LOCALS~1\Temp\Project Simulation Files\Static Structural\
Future Analysis	None
Save ANSYS db	No
Delete Unneeded Files	Yes
Nonlinear Solution	No

Model > Static Structural > Loads

Object Name	*Pressure*	*Displacement*	*Displacement 2*	*Displacement 3*	*Displacement 4*
State	Fully Defined				
Scope					
Scoping Method	Geometry Selection				
Geometry	2 Faces				
Definition					
Define By	Normal To	Components			
Type	Pressure	Displacement			
Magnitude	2.866 Pa (ramped)				
Suppressed	No				
X Component		0. m (ramped)			
Y Component		0. m (ramped)			
Z Component		0. m (ramped)			

Model > Static Structural > Loads

Object Name	*Displacement 5*
State	Fully Defined
Scope	
Scoping Method	Geometry Selection
Geometry	2 Faces
Definition	
Define By	Components
Type	Displacement
X Component	0. m (ramped)
Y Component	0. m (ramped)

Z Component	0. m (ramped)
Suppressed	No

Solution

Model > Static Structural > Solution

Object Name	*Solution*
State	Solved
Adaptive Mesh Refinement	
Max Refinement Loops	1.
Refinement Depth	2.

Model > Static Structural > Solution > Solution Information

Object Name	*Solution Information*
State	Solved
Solution Information	
Solution Output	Solver Output
Newton-Raphson Residuals	0
Update Interval	2.5 s
Display Points	All

Model > Static Structural > Solution > Results

Object Name	*Equivalent Stress*	*Normal Stress*	*Shear Stress*	*Maximum Principal Stress*	*Minimum Principal Stress*
State	Solved				
Scope					
Geometry	All Bodies				
Definition					
Type	Equivalent (von-Mises) Stress	Normal Stress	Shear Stress	Maximum Principal Stress	Minimum Principal Stress
Display Time	End Time				
Orientation		X Axis	XY Plane		
Results					
Minimum	1.6464 Pa	-147.47 Pa	-25.131 Pa	-14.309 Pa	-152.39 Pa
Maximum	159.37 Pa	108.51 Pa	30.177 Pa	136.14 Pa	48.984 Pa
Information					
Time	1. s				
Load Step	1				
Substep	1				
Iteration Number	1				

Model > Static Structural > Solution > Shear Stress > Image

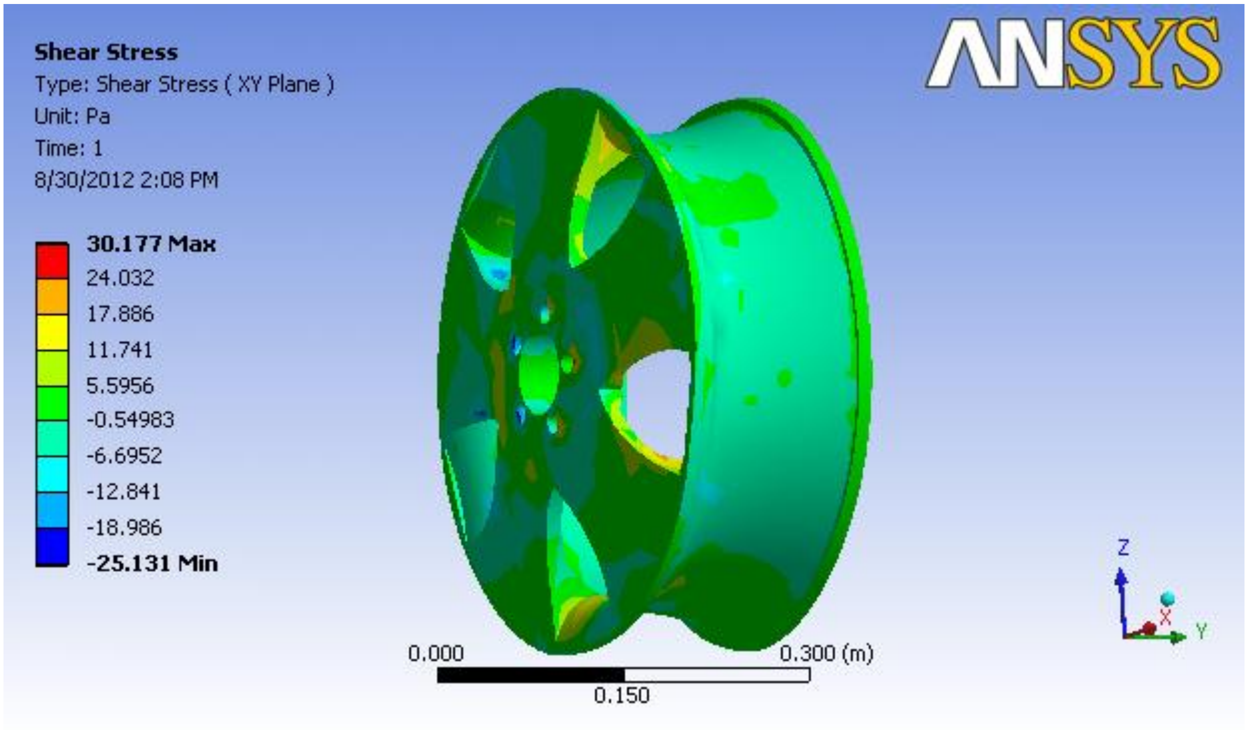
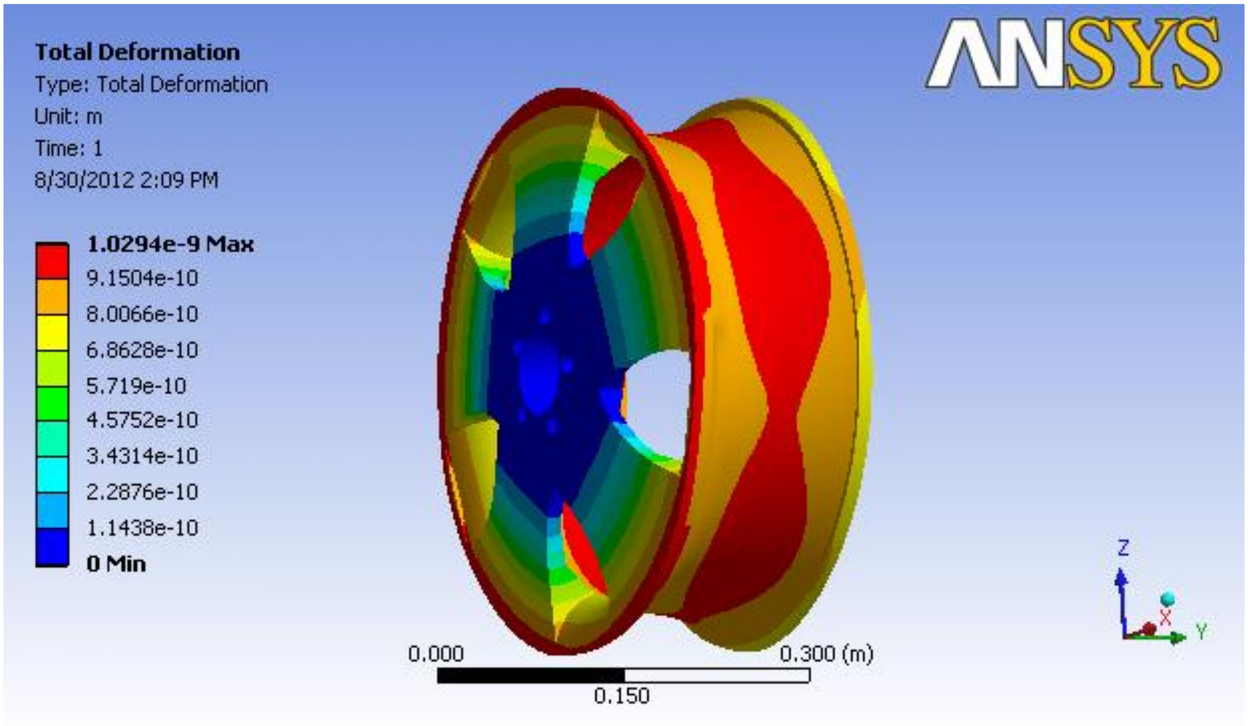


TABLE 12
Model > Static Structural > Solution > Results

Object Name	*Equivalent Stress 2*	*Total Deformation*	*Elastic Strain Intensity*
State	Solved		
Scope			
Geometry	All Bodies		
Definition			
Type	Equivalent (von-Mises) Stress	Total Deformation	Elastic Strain Intensity
Display Time	End Time		
Results			
Minimum	1.6464 Pa	0. m	3.4186e-011 m/m
Maximum	159.37 Pa	1.0294e-009 m	3.3065e-009 m/m
Information			
Time	1. s		
Load Step	1		
Substep	1		
Iteration Number	1		

Model > Static Structural > Solution > Total Deformation > Image



Material Data

Aluminum Alloy

TABLE 13
Aluminum Alloy > Constants

Structural	
Young's Modulus	7.1e+010 Pa
Poisson's Ratio	0.33
Density	2770. kg/m³

CONCLUSIONS

In this study, cast Al wheel production of a big casting plant was investigated. Aim was to improve the quality of production by using the collected data from the process. The results obtained in this present study have allowed the following conclusions to be made:

1. To obtain more detailed and effective feedback control during the production of Al-wheel, a process model for the production line was constructed. By help of this diagram the causes of defects and remedies can be pointed immediately. Quality of the production is improved by determining process parameters. Fishbone diagrams

were applied to the process and by using these diagrams parameters which have influence on the wheel production were clearly defined.

2. According to hydrogen content values which were used within this study and real-time radioscopic inspection results, the hydrogen content interval between 0.02cc/100gr and 0.27cc/100gr have the large number of the defected wheels as the hydrogen content values range between 0 and 0.35cc/100gr.
3. The investigation of the relation between the density index of gas holes and hydrogen content showed that there was a positive relation among these parameters. By using Least Square Method, it was shown that the predicted equation is true.
4. Analysis of variance for single factor shows that the hydrogen content in molten metal decreased by increased degassing time as expected.
5. Hydrogen content change in molten metal was in order between 765°C and 775°C temperature of molten metal. Between these temperature limits hydrogen content changed in the range of 0.15cc/100gr and 0.2cc/100gr as stable.

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