International Journal of Latest Engineering and Management Research (IJLEMR)
ISSN: 2455-4847
www.ijlemr.com || Volume 01 - Issue 10 || November 2016 || PP. 44-50

MODELING & STATIC ANALYSIS OF DIFFERENTIAL SPIRAL CROWN WHEEL

A V Hari Babu[1] and M G Sai Pavan Kumar[2]
1, 2: faculty of SVR Engg College,Nandyal.
**Corresponding Author: 1. A V Hari Babu*

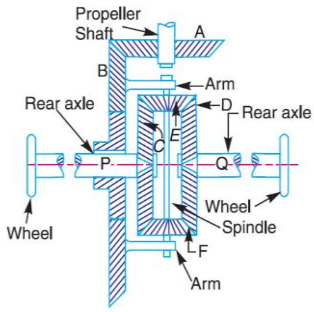
Abstract: In a human life everyone should depends on the automobiles for going one place to another place & to transport goods and accessories to the industries as well as from the industries. In an automobiles (buses, Lorries, trucks, cars etc.,) differential place important role to transfer motion from engine to the rear wheels. It is a medium to transfer motion through itself from engine to rear wheels. In actual practice number of vehicles are there among them ashok layland tippers are places important role in the roads, railways& building to carry maximum amount of sand or sail which is helpful to reduce the construction cost and time.

So here it is focused on the modeling and static analysis of differential crown wheel of medium size tipper. The present project work contains design with the help of CATIA/HYPER MESH. and analysis is done by the ABAQUS software it is proposed to find the effect of deformation, strength variations of the crown wheel. By identifying the true design and the extended service life, long term stability can be increased

Key words: Crown Wheel, CATIA, HYPERMESH& ABAQUS.

INTRODUCTION

At the point when a vehicle takes a turn either left or right, the external wheels must travel more separation than the inward wheels. In a vehicle the front wheels can pivot openly on their front hub. However both back wheels are driven by the motor through equipping. There fore some kind of programmed gadget is essential with the goal that two back wheels are driven at somewhat unique speeds by differential rigging box



The differential gear used in the rear drive of an automobile is shown in Figure. Its function is
(*a*) To transmit motion from the engine shaft to the rear driving wheels, and
(*b*) To rotate the rear wheels at different speeds while the automobile is taking a turn.

For whatever length of time that the vehicle is running on a straight way, the back wheels are driven straightforwardly by the motor and speed of both the wheels is same. However, when the vehicle is going ahead, the external wheel will run quicker than the internal wheel on the grounds that around then the external back wheel needs to cover more separation than the inward back wheel. This is accomplished by epicyclic rigging train with angle equips as appeared in Figure. The slant outfit A (known as pinion) is keyed to the propeller shaft driven from the motor shaft through all inclusive coupling. This apparatus A drives the rigging B (known as crown apparatus) which turns openly on the pivot P. Two equivalent riggings C and D are mounted on two separate parts P and Q of the back axles individually. These apparatuses, thus, work with equivalent pinions E and F which can turn openly on the axle gave on the arm connected to rigging B.
At the point when the car keeps running on a straight way, the riggings C and D must turn together. These apparatuses are pivoted through the shaft on the rigging B. The riggings E and F don't pivot on the axle. In any case, when the car is going ahead, the inward back wheel ought to have lesser speed than the external back haggle to relative speed of the internal and external riggings D and C, the apparatuses E and F begin turning about the axle hub and in the meantime spin about the hub pivot. Because of this epicyclic impact, the speed of the inward back wheel diminishes by a specific sum and the speed of the external back wheel increments, by a similar sum.

DESIGN OF CROWN WHEEL OF ASHOK LEYLAND TIPPER WITH 37 TEETH

Specification of crown wheel with 37 teeth

	Pinion(mm)	**Gear(mm)**
Pitch cone diameter	D_p=60mm	D_g=380mm
	Inner radius=20mm, outer radius=40mm	Inner radius=155mm, outer radius=225mm.
Number of teeth	T_P=6	T_G=37
Module	m= 5mm	m= 5mm
Pitch angle	$\theta_p = 17.5^0$	$\theta_g = 73.5^0$
Cone distance	A_0=55mm	A_0=55mm
Face width	b=60	b=60
Addenda	h_a=8mm	H_a=8mm
Dedenda	h_d=10mm	H_d=10mm
Clearance	C=2mm	C=2mm

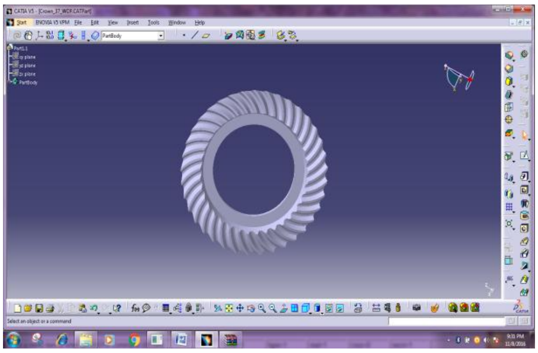
Introduction to CATIA

CATIA stands for Computer Aided Three dimensional Interactive Application. As a new User of this software package, you will join hands with thousands of users of this high-end CAD/CAM/CAE tool worldwide. If you are already familiar with the previous release, you can upgrade your designing skills with the tremendous improvement in this latest release. CATIA V5, developed by Dassault Systems, France is a completely re-engineered, next-generation family of CAD/CAM/CAE Software solutions for product lifecycle management, through its exceptionally easy-to –use and state-of-the-art user interface, CATIA V5 delivers innovative technologies maximum productivity and creativity, from the inception concept to the final product. CATIA V5 reduces the learning curve, as it allows the flexibility of using feature-based and parametric designs.

CATIA V5 Workbenches

CATIA V5 serves the basic design tasks by providing different workbenches. A workbench is defined as a specified environment consisting of a set of tools that allows the user to perform specific design task. The basic workbenches in CATIA -V5 are

1. Part design
2. Wire frame
3. Surface design
4. Assembly design
5. Drafting
6. Generative sheet metal design
7. DMU Kinematics



Creating geometry in CATIA

1. Open CATIA V5 Software.
2. Go to start, select Mechanical Design and select Part Design.
3. Select one plane from specification tree and select sketcher.
4. Draw the cross sectional area of the model
5. Give the constraints (dimensions) as per the crown wheel specification table and exit from the sketching workbench.

6. Select shaft tool for to revolve the sketch in 360^o about its vertical axis.
7. Create a plane by selection offset from plane option
8. Draw a rectangle by selecting newly created plane and exit from sketcher
9. Select pocket-1, pocket-2 and pad-1 from specification tree then click on mirror tool by selecting mid plane as a reference for to mirror the object.
10. Save the model with name crown wheel 37 teeth

Geometry file importing to Hypermesh

1. Open HyperMesh software select ABAQUS profile
2. Go to import option select geometry, browse piston geometry file which is created in CATIA
3. Click on solid shape option and topo
4. Save the file with name crown wheel 37 teeth

Geometry clean up and meshing

1. Create a centre node with arc option by selecting piston outer arc
2. Cut the piston into four quarter part by selecting trim with plane option
3. Delete three quarter parts and you will get a quarter part of a piston as shown in following figure
4. Trim the geometry bi using surface option and by line sweep option so that we can get six face volume blocks as shown in following figure
5. Go to 3-d page select solid map, select one volume option give the element size as 1 pick the six face volume click on mesh
6. Repeat step 5 till whole quarter part of piston get meshed
7. A mapped mesh of mixed elements of 8 node hexahedral and 6 node prism elements will appear as shown in following figure
8. Go to tool page select reflect option
9. Reflect all elements one time about vertical axis and second time with horizontal axis
10. Select edge option from tool page Give connectivity between all elements by choosing equivalence option
11. A complete meshed model shown in following figure
12. Save the file with name complete mesh

This FEA model consist of mixed elements of 8 node hexahedral, 6 node prism, 4 node quad element and 3 node tria elements

Material selection

In this report three materials are selected for to do a comparison for to get best material selection for the crown wheel for the differential of Ashok Leyland tipper. Those two materials are

1. Cast iron
2. Chrome steel

1. Cast iron

An alloy of iron that contains 2 to 4 percent carbon, along with varying amounts of silicon and manganese and traces of impurities such as sulfur and phosphorus. It is made by reducing iron ore in a blast furnace. The liquid iron is cast, or poured and hardened, into crude ingots called pigs, and the pigs are subsequently re-melted along with scrap and alloying elements in cupola furnaces and recast into molds for producing a variety of products.

Properties	**Metric**
Density	7.2 gm/cm^3
Young's modulus	140 Gpa
Melting point	1090^{o}C
Ultimate strength	450 Mpa
Yield strength	280 Mpa
Passions ratio	0.26

Mechanical properties of cast iron

Most cast iron is either so-called gray iron or white iron, the colors shown by fracture. Gray Iron contains more silicon and is less hard and more machinable than is white iron

2. Chrome steel

Depending upon strength and stiffness chrome steel is very much preferable material for long term stability.

Properties	**Metric**
Density	7.2 gm/cm^3
Young's modulus	140 Gpa
Melting point	1090^{o}C
Ultimate strength	450 Mpa
Yield strength	280 Mpa
Passions ratio	0.26

Mechanical properties of Chrome Steel

Creating load collectors and applying boundary condition

1. Create load collector by using load collector option from tool bars
2. Give name as fixed, select colour green and image card as initial condition
3. Go to analysis page select constraints select all node at the surface of the teeth
4. Select all DOF click create
5. Create load collector by using load collector option from tool bars
6. Give name as pressure, select colour red and image card as history condition
7. Go to analysis page select pressure, select elements top surface at the piston head and give magnitude as 14.3 MPa
8. Go to analysis page select load steps
9. Give name as static
10. Click on load cols select fixed and pressure
11. Click on create and also on edit
12. Select step parameters, perturbation, analysis processor static, load_op_options, Boundary_op and Dload_op select return
13. Save the file

Exporting to ABAQUS

1. Select export option from tool bar
2. Select export solver deck
3. Set path and name to the file with extension of .inp
4. Click export
5. Open ABAQUS and set working directory
6. Import HyperMesh export file and delete model-1
7. Right click on job and select create job1
8. Right click on job-1 and select submit
9. Wait till it complete the solving after that save the model

Plotting results in ABAQUS

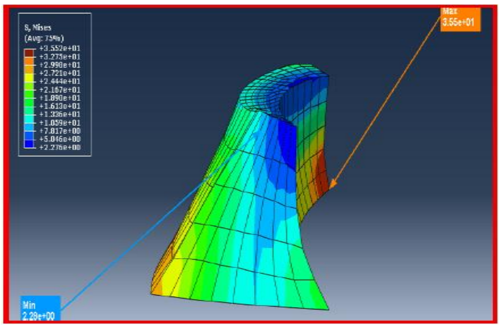
1. After completing the solving right click on job-1 select results
2. Select plot contours on deformation option from tool bar
3. Go to field output and select stress, select Misess
4. Go to field output and select stress, select Max-principle.
5. Go to field output and select spatial displacement at nodes, select magnitude
6. Save the results and exit

RESULTS AND DISCUSSIONS

The following FEA results are got from ABAQUS software, when the crown teeth experience 14.3 MPa outside of the teeth

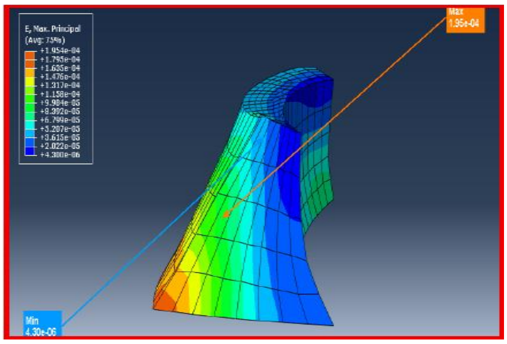
Teeth inner surface area = 1375.106 mm^2
Teeth outer surface area = 1465.921 mm^2
Load applied =21KN
Pressure applied in the teeth (Outer surface) =14.3N/mm^2

a) Von misses stress Distribution



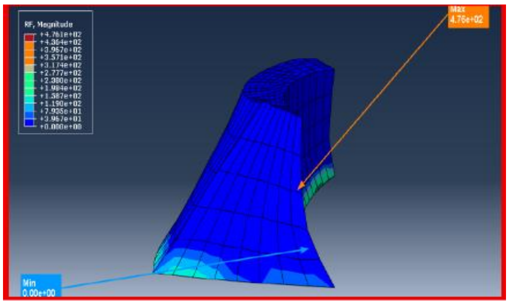
The above figure shows von Mises stress distribution of the crown teeth within cast iron material. The maximum stress is 35.52 MPa and minimum stress is 22.76 MPa, when crown teeth experience a pressure of 14.3 MPa.

b) Maximum Principal stresses of CAST IRON



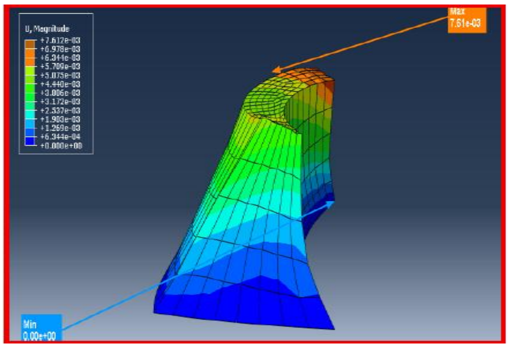
The above figure shows Maximum principal stress distribution in a Cast iron material. The maximum stress is 1.954×10^{-4} N/mm^2 and minimum stress is 4.3×10^{-6} N/mm^2 when teeth experience a pressure of 14.3 MPa.

c) Reaction Forces of Cast Iron



The above figure shows Reaction force in a Cast iron material. The maximum reaction force 476.1N, when Crown teeth experience a pressure of 14.3 MPa.

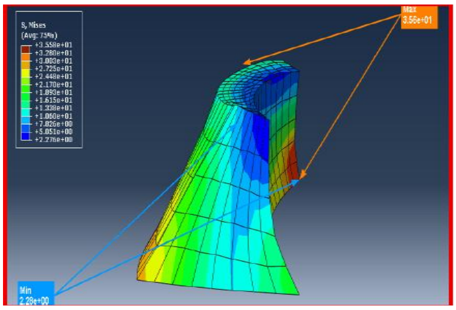
d) **Deformation of CAST IRON**



The above figure shows deformation in a cast iron material. The maximum deformation is 0.07612 mm, when crown teeth experience a pressure of 14.3 MPa.

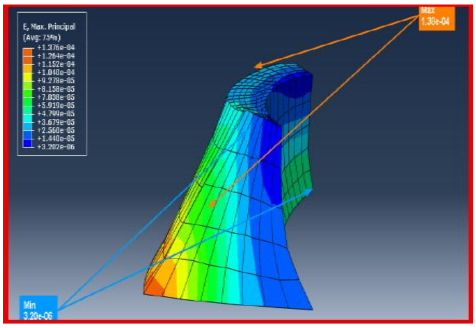
RESULTS OF CHROME STEEL

a) Von misses stress Distribution of CHROME STEEL



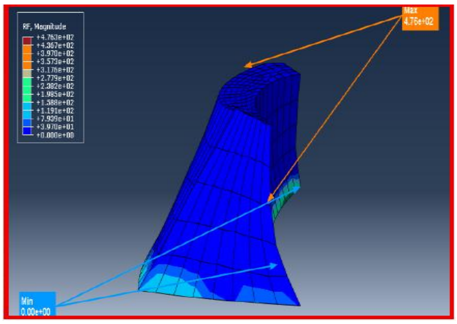
The above figure shows von Mises stress distribution of the crown teeth within chrome steel material. The maximum stress is 35.58 MPa and minimum stress is 22.76 MPa, when crown teeth experience a pressure of 14.3 MPa.

b) Maximum Principal stresses of CHROME STEEL



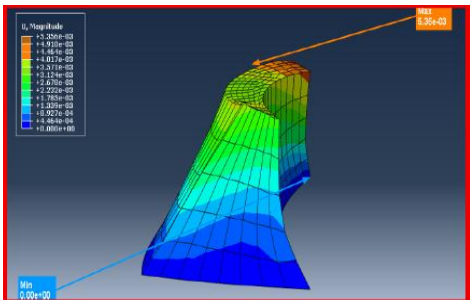
The above figure 6.2 shows Maximum principal stress distribution in a chrome steel material. The maximum stress is $1.376x10^{-4}$ N/mm^2 and minimum stress is $3..202x10^{-6}$ N/mm^2 when teeth experience a pressure of 14.3 MPa.

c) Reaction forces of CHROME STEEL



The above figure shows Reaction force in a chrome steel material. The maximum reaction force 476.3N, when Crown teeth experience a pressure of 14.3 MPa.

d) Deformations of Chrome Steel



The above figure shows deformation in a chrome steel material. The maximum deformation is 0.05356 mm, when crown teeth experience a pressure of 14.3 MPa.

The following table shows the result comparison between two materials

s.no	Material name	Young's modulus (MPa)	Poisson's ratio	Density (kg/mm^3)	Mises Stress (MPa)	Max-Principle strain (mm)	Deformation (mm)
1	Cast iron	1.4 x10^5	0.28	7.2xe-6	35.52	1.95 xe-4	7.612xe-3
2	Crome steel	2.1 x10^5	0.30	7.8xe-6	35.58	1.376xe-4	5.356xe-3

CONCLUSION

The following results are compared to both materials such as chrome steel, Cast Iron because most of the gear materials are used by cast iron and chrome steels due to good machining conditions. Among them chrome steel gives better results as per the calculations even though the stress induced in the teeth (35.58MPa) is slightly more than as compared to Cast iron (35.52MPa) but displacement or deformation of the chrome steel is very less which is 0.005356mm as compared to the cast steel 0.0076mm and prescribed value of stress is having within the prescribed stress (56 Mpa). Then the design is in safe condition.

REFERENCES

[1]. Rikard Mäki Luleå "Friction Characteristics in Limited Slip Differentials" University of Technology Department of Applied Physics and Mechanical Engineering Division of Machine Elements Lulea University of Technology Division of Machine Elements Sweden 2005

[2]. Rafel Triviño Flores "Additive Technology for Limited Slip Differentials" Department of Applied Physics and Mechanical Engineering Division of Machine Elements 2004

[3]. Tony Scelfo "Lightweight Torsen Style Limited Slip Differential and Rear Driveline Package for Formula SAE" Department of Mechanical Engineering in Massachusetts Institute of Technology 2006

[4]. Kada Hartani, Mohamed Bourahla, Yahia Miloud, Mohamed Sekour "Electronic Differential with Direct Torque Fuzzy Control for Vehicle Propulsion System" 1Electrotechnic Department, University center of Saida, 2009

[5]. Saleem Merkt & Terrence Gilbert Electronic Differential and Hybrid Powertrain Design for NCSU Formula Hybrid North Carolina State University 2009.

[6]. Haddoun& M.E.H. Benbouzid "Design and Implementation of an Electric Differential for Traction Application"University of Brest, France 2010

[7]. Samaneh Arabi, Mohammad Behroozi "Design of an Integrated Active Front Steering and Active Rear Differential Controller using Fuzzy Logic Control" Proceedings of the World Congress on Engineering Vol II WCE London, U.K. 2010

[8]. Giulio Panzani, Matteo Corno Combined performance and stability optimization via central transfer case active control in four-wheeled vehicles 28th Chinese Control Conference Shanghai, P.R. China 2009

[9]. "Design Data", PSG College of Technology, „Materials page 1.9 – 1.15, „Rolling Element Bearings page 4.1 – 4.32, „Seals page 5.110, „Couplings page 7.108, „Ring Nuts page 5.85, „Locking Washer page 5.86