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Development of Prototype-Model and DesignModification,Analysis of Aircraft Wheelhub

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Abstract-*Design and implementation of new aerospace elements which requires the use of 3D-CAD modeling techniques and rapid prototyping, which makes it possible to significantly accelerate the deployment of new solutions. In this paper we demonstrate, one of the rapid prototyping techniques FDM is used to produce the working model of Aircraft Wheel hub. Meanwhile the task is to reduce the stress concentration in the Wheel Hub due to body weight of aircraft and other loads on the wheel hub. For design of the wheel hub Catia V5 is used. It is analysed by using the ANSYS. While analyzing the stress, stress concentration is found in the fixed regions (location of its bolts). The stress concentration is checked in three ways and selecting the one which gives the optimum stress concentration. The three ways are Design modification, Material changing without design modifications, material changing with design modification. From these three ways we will find out optimum changes in stress concentration. After selecting the best design and converting that 3D-CAD file into STL file or saving file in STL form. That STL file is used for direct developing of prototyping model by using FDM process.*

Keywords- *Rapid prototyping, Additive manufacturing, aerospace.*

I. INTRODUCTION

A wheel hub is the central portion of a wheel through which the axle passes. The wheel hub is the main part of wheel and consists of bearings and axle. The axle is connected the wheel hub.

BASIC DEFINITIONS OF WHEEL HUB

Axle: An axle is a central shaft for a rotating wheel or gear

Bearings: A bearing is any of various machine elements that constrain the relative motion between two or more parts to only the desired type of motion.

Wheeltug: Wheeltug is a fully integrated ground propulsion system for aircraft which puts a high torque electric motor into the hub of the nose wheel to allow for backwards movement without the use of pushback tugs and to allow for forward movement without using the aircraft's engines.

Fig.1 wheelhub position

II. PROBLEM DEFINITION

Wheel hub is the important component of wheel, it has to with withstand to the load acting over on it. When the wheel rotating the wheel hub has to bear the load acting on the wheel hub and the torque developed by wheel while takeoff or take. By this the high stress will be developed in the wheel hub, this caucusing to breakages of wheel hub. Due to this the wheel hub is to be with stand to load acting on it.

Coming to the problem, wheel hub is made up of AZ91D material, the load acting on the wheel hub, the torque and factors which are influencing wheel hub Specification and Loads acting on wheel hub are shown below

Wheel hub outer diameter (max) =134.049mm

Wheel hub outer diameter of base (min) = 70.775mm

Wheel hub inner diameter (max) =67.749mm

Wheel hub inner diameter (min) =40.62mm

Wheel diameter = 762mm

Input Power = 1634 kW

Speed = 18797 rpm

Torque = 2988 N-m

Load Force = 17407 N

With respect to above values, applying all factors which are influencing on wheel hub on the Existing AZ91D material component the analysis is generated Maximum amount of Stress is 154.27Mpa. This is analysis shows Maximum amount of Stress 154.27Mpa is Concentrated at one particular curvature. The Presence of stress concentration cannot be totally eliminated but it may be reduced to some extent.So we are considering three methods to reduce stress, by design changing, material changing and both of them changing.

METHODS OF REDUCING STRESS CONCENTRATION

To reduce the stresses which are developed in the wheel hub cover three methods had considered. They are:

1.Design modification in existing model

2.Material change in existing model

3.Design modification and material change in existing model

Under design modification, where ever Maximum Stress is concentrated at that particular cross-section only design modification had considered. In Existing component Maximum Stress is concentrated at one particular at key hole and upper part, by modifying its thickness of hub at upper part and changing diameter of key hole gradually stress also reduce.Under material change within the place of existing material new material had considered. This new material mechanical properties are very less compared to existing material mechanical properties. With this weight and cost of the component is reduced.In third method above two methods had considered simultaneously.

OBJECTIVE OF THE WORK:

- Model was created in CATIA V5 R20.
- Meshing and Analysis by using ANSYS.
- Evaluation of stress under static analysis for Existing Wheel hub.
- 3D module is convicting into STL for by using CATIA and generating STL code by using RP Viewer.
- Production of prototypes.

Importance of Rapid Prototyping in Aerospace Industry The advantage of using rapid prototyping includes:
Design freedom , Low-quantity economy , Material efficiency .

COMPOSITION:
Copper 1.2-1.6%
Magnesium 2.1-2.5%
Iron (max) 0.5%
Aluminium-remaining
Zinc 5.6-6.1%

Manganese 0.15-0.3% ,
Silicon 0.4%,Other-metallic 0.15%

III DESIGN OF EXISTING MODEL

Following flowchart will shows the different types of steps involved in Design modification in existing model.

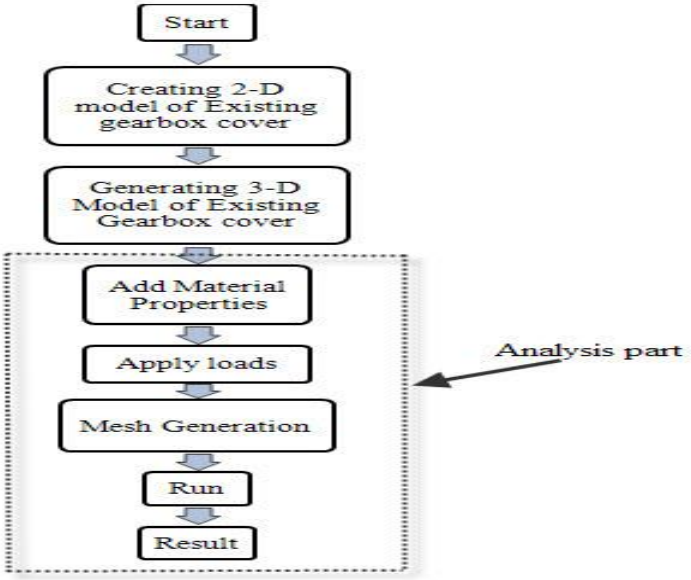

Fig.2 : Flowchart for Existing Model Modeling and analysis

2D Model Existing Wheel Hub Data

The existing wheel hub data .the top view and side view are shown in the fig 3 and fig 4

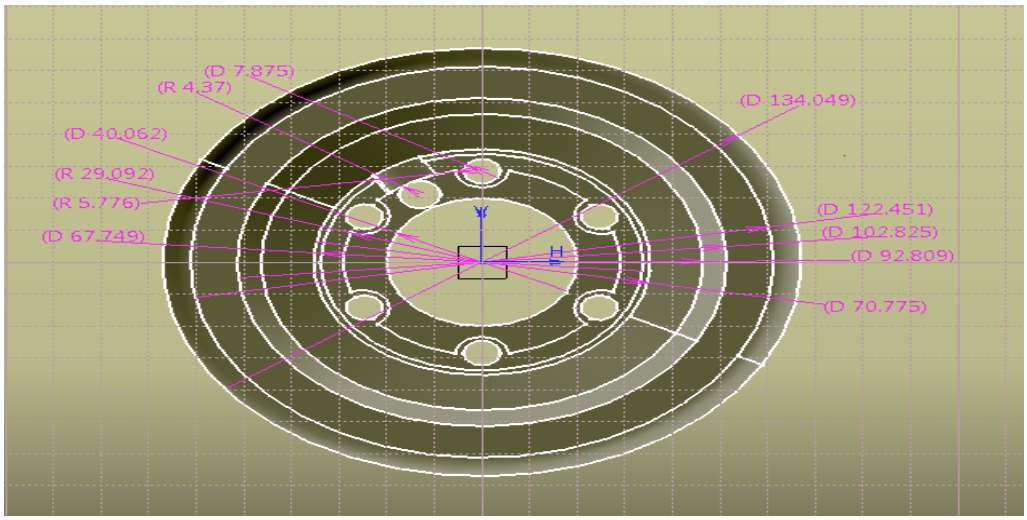

Fig.3 existing wheel hub data in Top view

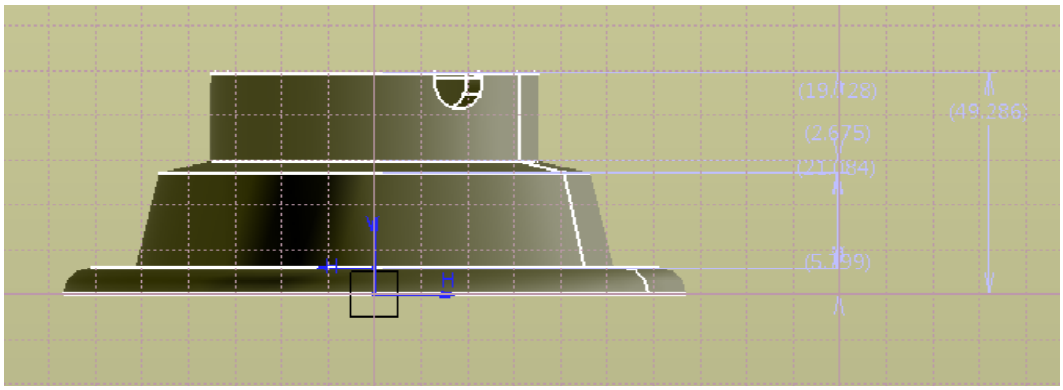

Fig.4 Existingwheel hub in side view

DESIGN

Creating 2-D Model Of Existing wheel hub-With the help of Catia software 2D representation of Existing component will takes place. In Catia, sketcher is the main tool used to represent 2D models. A sketcher is a 2D section of the feature being created. It is a basic 2D shape, and is created on a planar reference. Almost all the models designed in Catia, consist of Datum's, Sketched features, and placed features. However, in this case need a sketch to create any sketched feature, such as Extrude.

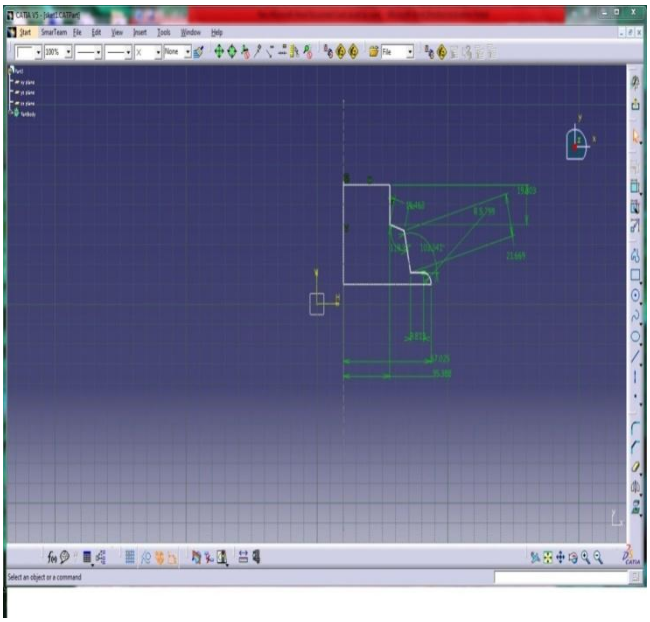

Fig.5 2D Drawing of wheel hub

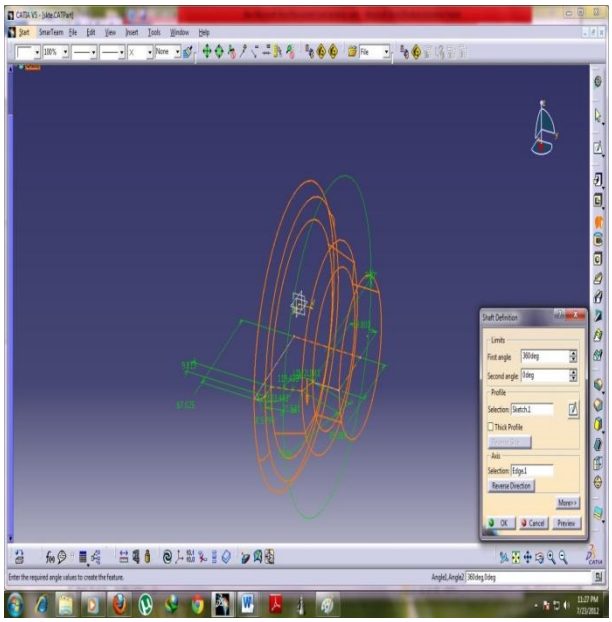

Fig.6 3D Drawing of wheel hub

Generating 3D Model Of Existing wheel hub Cover

3D model of Existing wheel hub cover is shown in Fig 5,6. By applying number of options in Catia entire 3D model is build; some of those options are described below.Linear diameter dimensions are applied to the sketches of features that need to create by revolving the sketch using shaft key.

Exit workbench - The workbench is place where 2d drawing is drawn.

Shaft tool -Shaft tool is used to get shaft feature to refer to figure.show in Fig.7

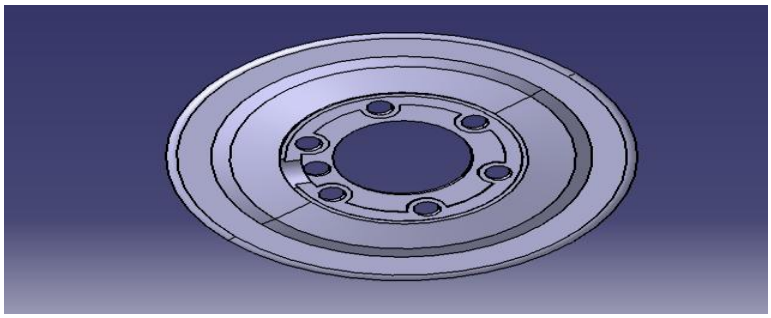

Fig.7 3D model of Existing wheel hub

Typical composition (wt%) of some cast and wrought magnesium alloys

Alloy	Form*	Al	Zn	Mn	Si	RE	Zr	Th
AM60A	CD	6		>0.13				
AM60B**	CD	6		>0.25				
AS41A	CD	4		0.3	1			
AZ31B	WB+ WS	3	1	0.3				
AZ61A	WF	6	1	0.2				
AZ80A	WB	8	0.5	0.2				
AZ81A	CS	7.5	0.7	0.2				
AZ91B	CD	9	0.7	>0.13				
AZ91D**	CD	9	0.7	>0.15				
AZ91E**	CS	9	0.7	0.2				
EZ33A	CS		3			3	0.8	
HK31A	WS						0.7	3
ZE41A	CS		4			1	0.7	
ZK60A	WB		6				>0.45	

* CS - sand casting; CP - permanent mold casting; CD - die casting; WS - sheet or plate; WF - forging; WB - bar, rod, shape, tube, or wire.
** High-purity alloys.

Fig.8 Different material composition

ANALYSIS

Add Material Properties - From this step analysis part of the Existing wheel hub component is going to start. In this case, with the help of software properties of materials are added. Loads acting, meshing and plotting of results will takes place in analysis part itself . Existing component material type isAZ91D.

- **Apply loads**

Whatever the loads applied in existing wheel hub same type of lodes also used in modified mode.

- **Mesh generation**

Procedure followed in Existing wheel hub Mesh generation same procedure also followed in modified model also. But meshing parameters may vary. This is mainly depending on the model profile.

- **Run** -In this case Entire model will deflect with respect to given factors.
- **Results** -After completion of Experiment different types of results are developed, out of these results only Stress results are considered.
- **Stress developed in Existing model < Stress developed in Modified model**

After plotting results each and every stress are compared with existing model developed stress. Which design will give less stress with seatrain material that design is selected as best one.

IV DESIGN MODIFICATION IN EXISTING MODEL

Design modification is the important point in this project. Where ever Maximum stress is developed in Existing model at that place design modification had done. The Existing model is shown in Fig 4.10. Inner diameter and key hole of hub modification had done. Existing Inner diameter and key hole of hub are D40.062mm and D8mm. By changing Inner diameter and key hole of hub design modification had done. Inner diameter and key hole are D39.78mm-D7.5mm, 40.062mm –D7mm, D41.06mm- D8mm,

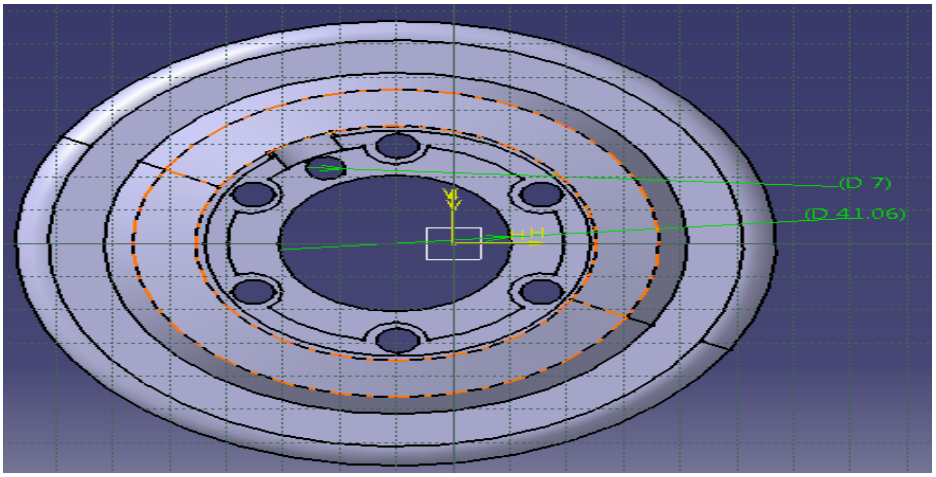

Fig.9: Modified model

Modify the inner diameter of D39.78mm-D7.5mm, then converted it into 3D model. Its 3D model is shown in Fig8. After applying static analysis Stress distribution is shown in Fig10, Fig 11. Minimum and maximum stress distributed values with their nodes are shown in Table 1.Here maximum developed stress is 139.49Mpa and fos 1.147

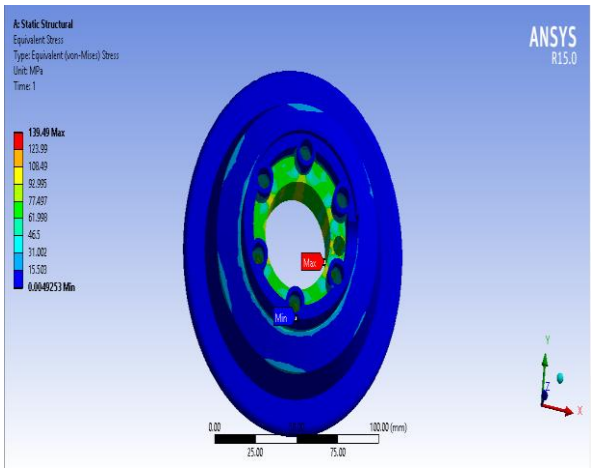

Fig.10 Stress distribution

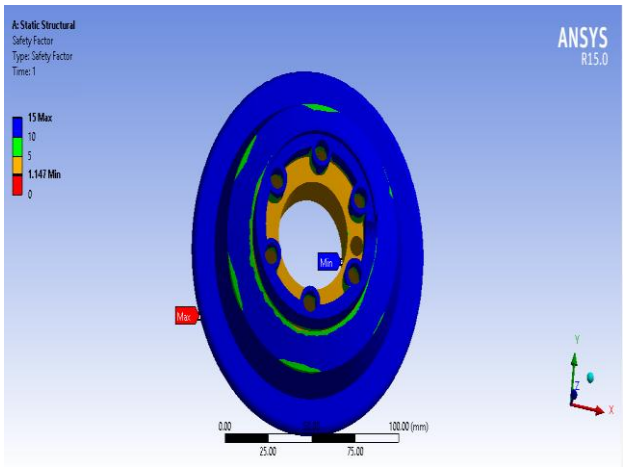

Fig.11fos

Modify the inner diameter of 40.06mm-D7mm, then converted it into 3D model. Its 3D model is shown. After applying static analysis Stress distribution is shown in Fig 5.8, Minimum and maximum stress distributed values with their nodes are shown in Table 1.Here maximum developed stress is 154.27Mpa and fos 1.037

Modify the inner diameter of 41.062mm-D8mm, then converted it into 3D model. Its 3D model is shown. After applying static analysis Stress distribution is shown in Fig 5.8, Minimum and maximum stress distributed values with their nodes are shown in Table 1.Here maximum developed stress is 135.6Mpa and fos 1.179

V MATERIAL CHANGE IN EXISTING MODEL

The second method is change in material type. This material should consist less mechanical properties compared existing material AZ91D.Initially Existing wheel hub is made up of AZ91D material. Number of steps involved in finalizing the best model with respect to its results by modifying its design. They are ANALYSIS OF EXISTING WHEEEL HUB Existing wheel hub model is developed in Catia software. At the time of saving this model save it format of IGES. By saving in this format at the time of analysis profiles dimensions will not disturb. Coming to the results, after completion of analysis Stress developed in the Existing wheel hub is 154.27 Mpa. Second factor in the design modification is usage of Low properties material. In this project except existing material 3 types of materials had considered. Properties of these materials are less than Existing material AZ91D.

Analysis of Existing Model with HK31 Material
At the time of analysis HK31 material properties are added for existing model. After completion of analysis distribution of stress is shown in Fig.12,13

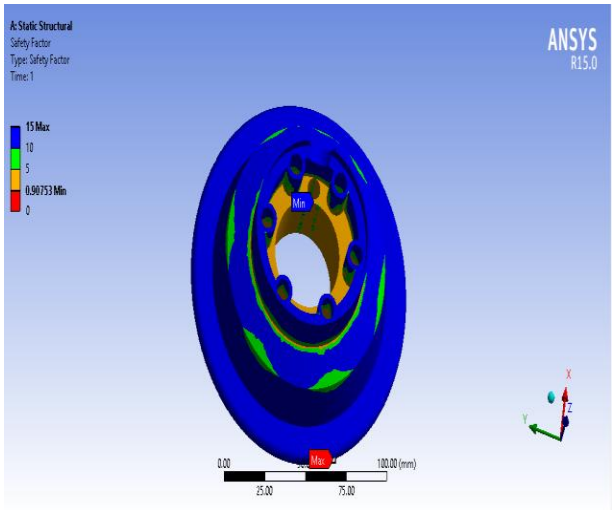

Fig.12 Stress distribution

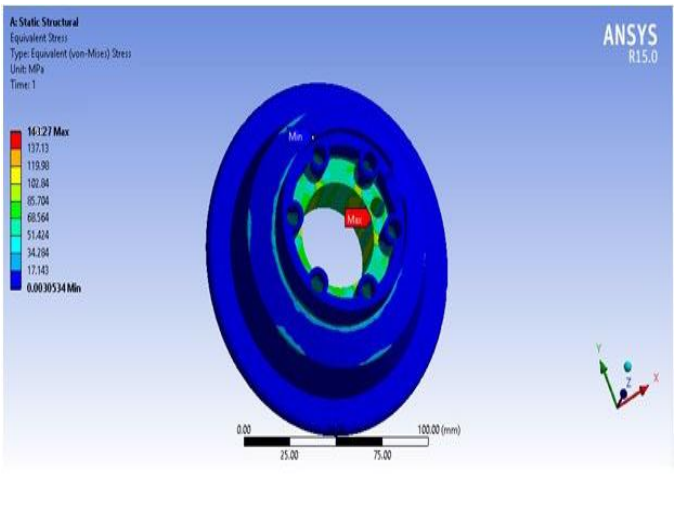

Fig.13fos

At the time of analysis **AZ92A-T6** material properties are added for existing model. After completion of analysis distribution of stress maximum developed stress is 144.7Mpa and fos 0.972 .

At the time of analysis **AL-7075**material properties are added for existing model. After completion of analysis distribution of stress maximum developed stress is 125.9Mpa and fos 3.92.

VI DESIGN MODIFICATION AND MATERIAL CHANGE IN EXISTING MODEL

This method is done by adding above two methods. In this method the main criteria is applying different types of material properties in selected best model. This will produce very less stress compared to other two methods. Out of number of design modified models with D41.06mm-D8.0mmdeveloped less stress. For this model analysis will takes place with different types of materials. This analysis is shown below.

Analysis of Modified Design D41.06mm-D8mmModel with **HK31**Material

At the time of analysis in material selection HK31material properties are added. After completion of analysis distribution of stress is shown in Fig.14,15.

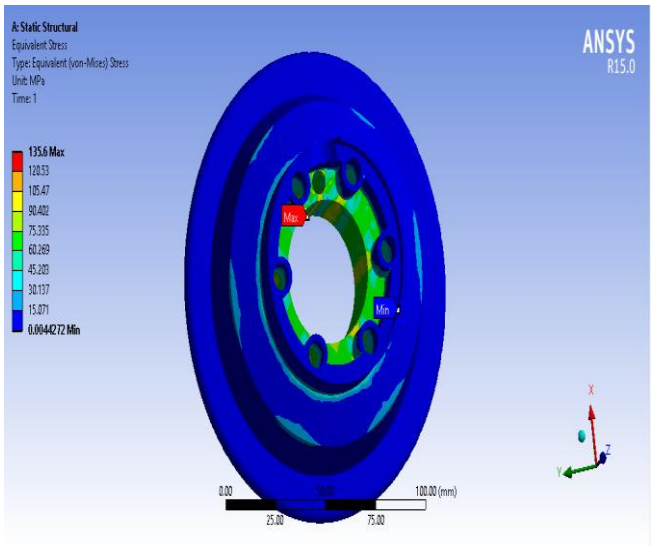

Fig.14 Stress distribution

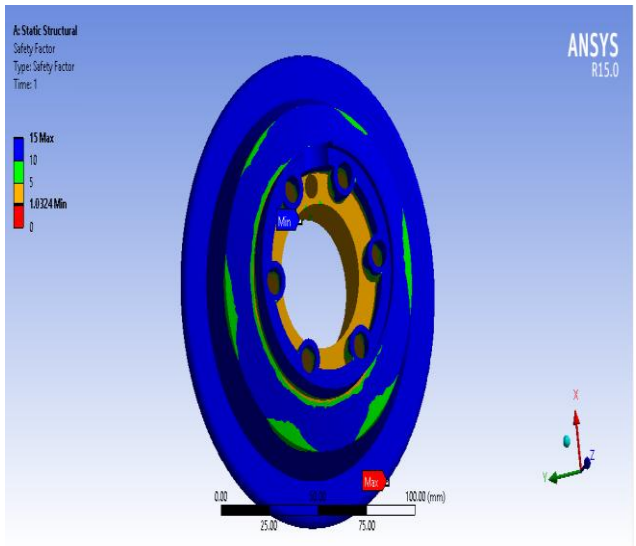

Fig.15fos

At the time of analysis in material selection **AL-7075**material properties are added. After completion of analysis distribution of stress is 109.5 fos is 4.56.

At the time of analysis in material selection **AZ92A-T6** material properties are added. After completion of analysis distribution of stress is 135.6 fos is 1.106.

Table.1: Stress developed in different Modified Design models

Diameter	D39.78mm-D7.5mm		D40.062mm &D7mm		D41.062mm&D8mm		Exsisiting	
Stress (Mpa)	Static	Fos	Static	Fos	Static	Fos	Static	Fos
	139.49	1.147	154.27	1.037	135.6	1.179	**154.27**	**1.037**

Table.2: Stress developed in Existing model with different materials

Material	HK31		**AZ92A-T6**		**AL-7075**	
Stress (Mpa)	Static	Fos	Static	Fos	Static	Fos
	143.2	0.907	144.7	0.972	125.9	3.926

Table.3: Stress developed in selected Modified Design (D41.06mm-D8.0mm) model with different materials

Material	HK31		**AZ92A-T6**		**AL-7075**	
Stress (Mpa)	Static	Fos	Static	Fos	Static	Fos
	136.1	1.032	135.6	1.106	109.5	4.562

DYNAMIC ANALYSIS:

To get better results we changing design also. Again we created different models and changing the wheel hub inner diameter and key hole diameter why because from the above results we have maximum stress values at inner diameter and key holes only so we changing those values and redesign our object and again analyzing our object with same material and same boundary conditions .model analysis conduting.

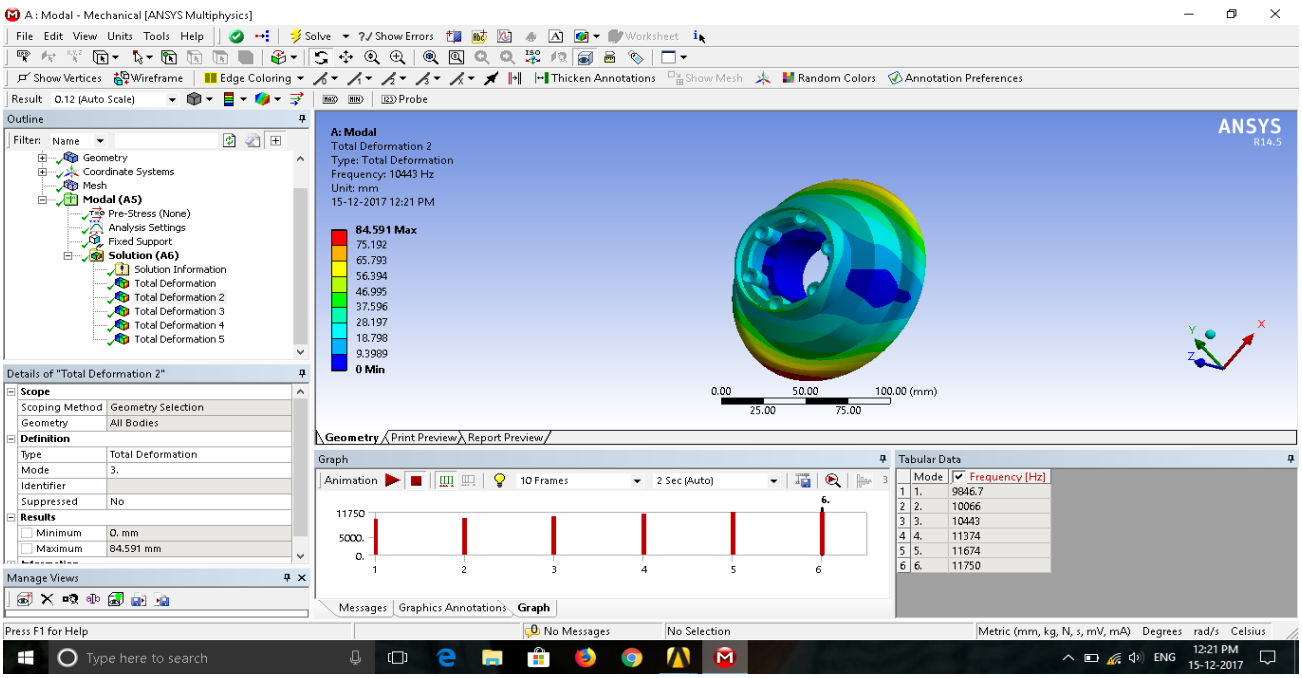

Fig.16 different modeAL-7075

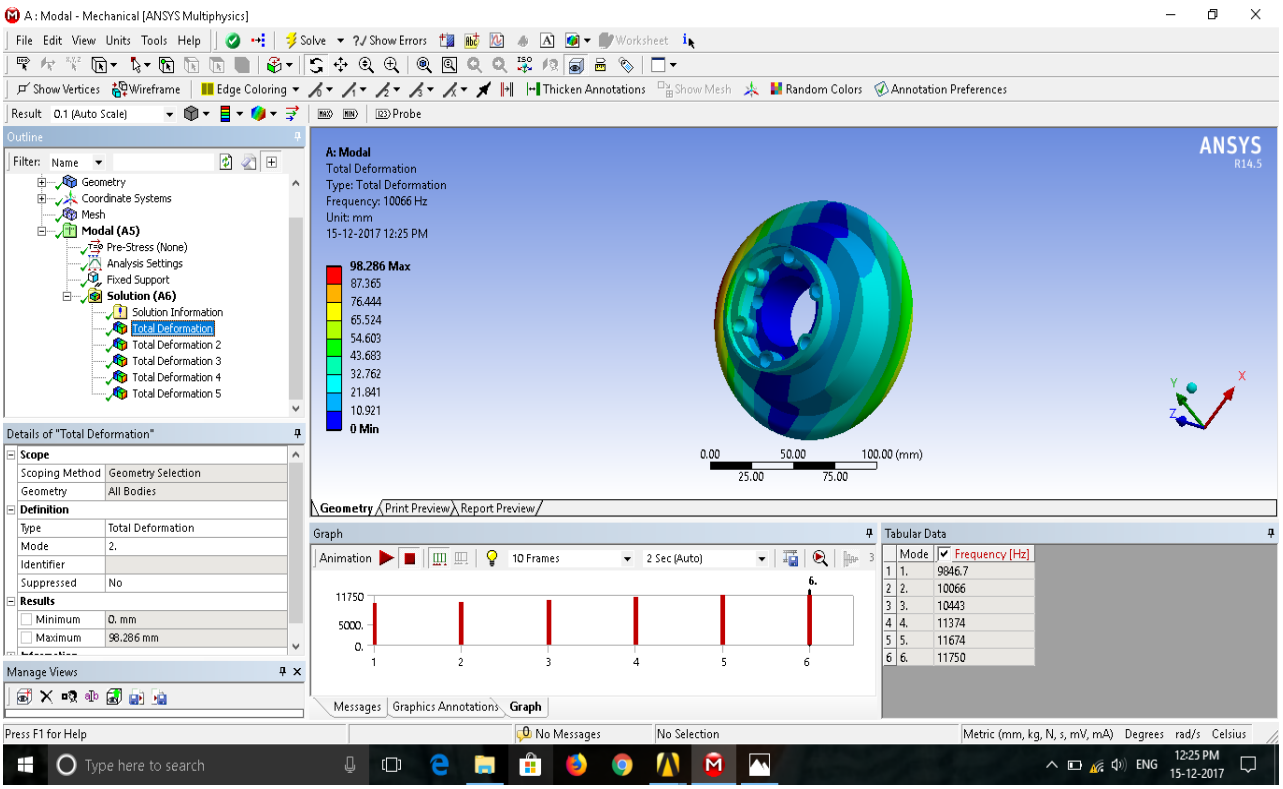

Fig.17 different mode HK31

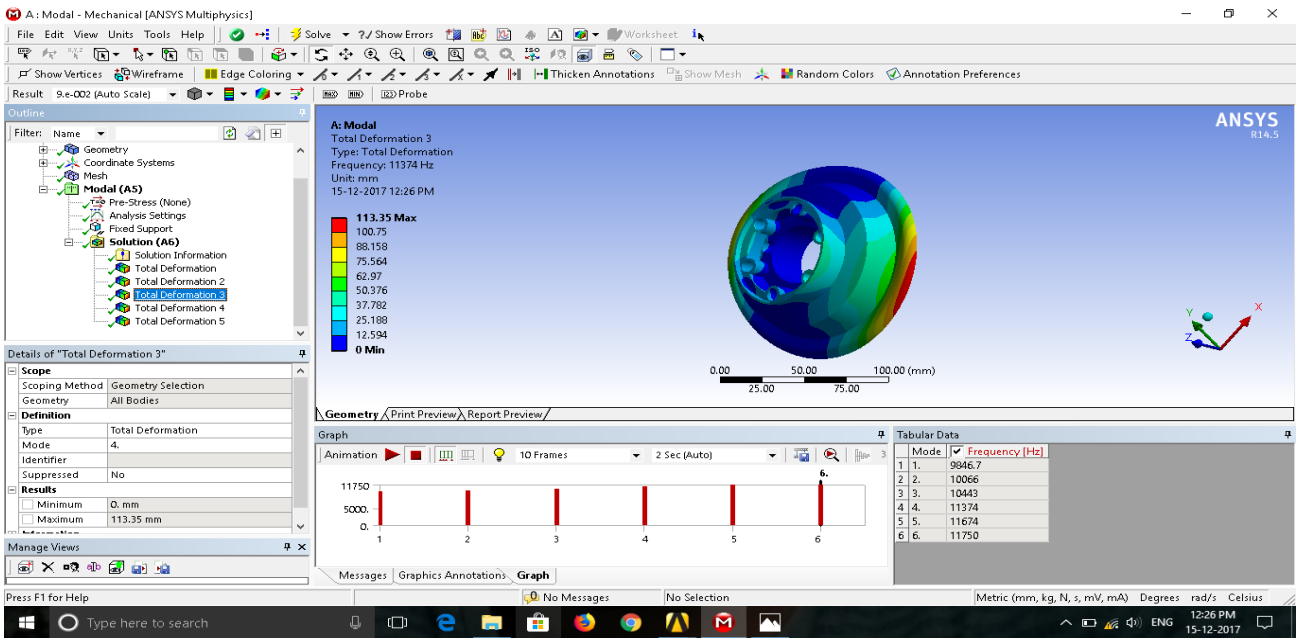

Fig.18 different mode AZ91d

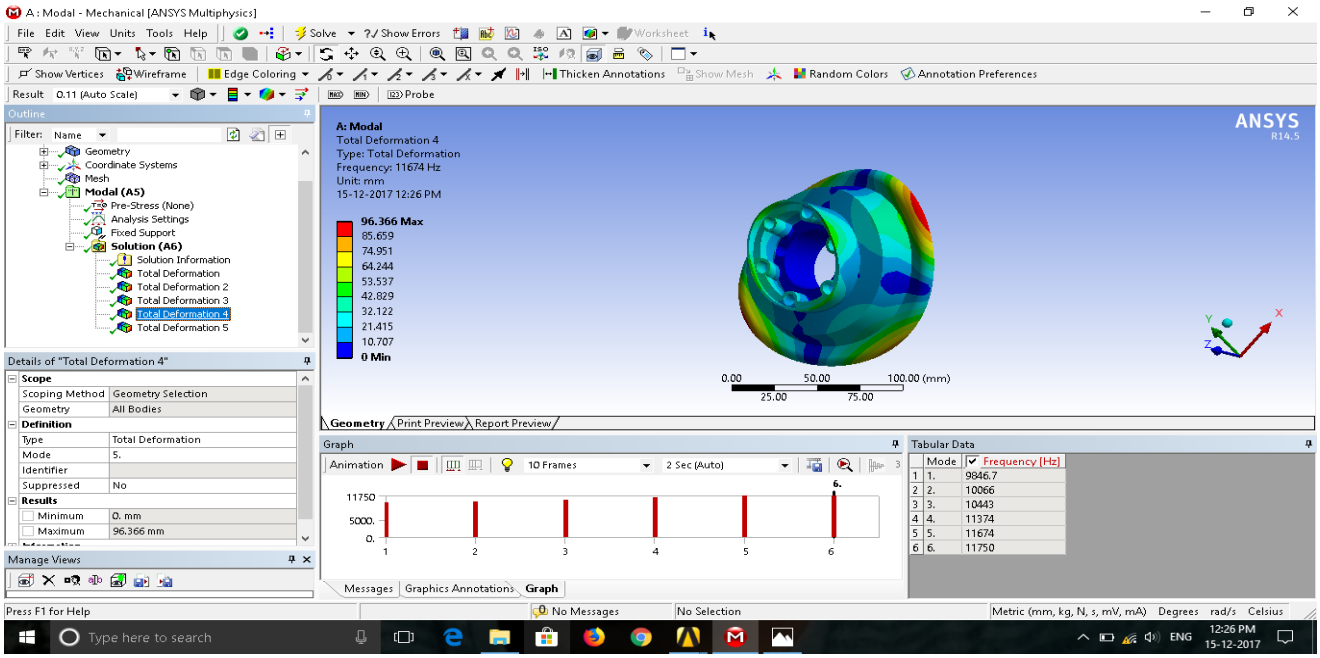

Fig.19 different mode AZ92-T6

Table.4: For the wheelhub hole diameter with 39.78mm for different materials

	AL-7075	HK31	AZ91d	AZ92-T6
Mode1	9695.2	11152	9497	11060
Mode2	9804.4	11213	9548.8	11120
Mode3	10001	11513	9804.2	12463
Mode4	10937	12567	10702	12573
Mode5	11043	12678	10796	11418

Table.5: For the wheelhub hole diameter with 40.062 for different materials:

	AL-7075	HK31	AZ91d	AZ92-T6
Mode1	9686	11142	9488.4	11050
Mode2	9843	11259	9588	11166
Mode3	10043	11563	9846.5	11467
Mode4	10930	12561	10696	12457
Mode5	11051	12688	10805	12583

Table.6: For the wheelhub hole diameter with 41.062mm for different materials

	AL-7075	HK31	AZ91d	AZ92-T6
Mode1	9978	11481	9776.7	11386
Mode2	10196	11662	9931.2	11566
Mode3	10277	11832	10076	11734
Mode4	11097	12754	10860	12648
Mode5	11051	12688	10805	12583

MANUAL LATHE MACHINE

- Take the rawmaterial required size.
- Hold the job in chuck and true it.
- Do the facing operation with selected tool and speed.
- Stepturning operation is done has as per givien dimensions.
- Taper and radius are done in compound slide.
- Counter boring and drilling holes are done in drilling machines, slotting machine cuts the key way.
- Finally surfacefinish is taken check all the dimensions.

VII. RESULTS

Among these three methods third methodhad given best results. In this method out of number of design modified model is D41.062&D8mm model with material AL-7075-T6 will had produced less stress 109.52Mpa and FOS 4.5627 compared to other materials.

This material satisfies two conditions theyare less weight and less cost.The final conclusion of this project isD41.062 &D8mm model with AL-7075-T6material will give very less stress, and havegood safety factor.

In generally we cannot say one object isgood or one material is having good strengthto weight ratio by only single analysis so

here we also checking all these models withdynamic loading conditions and calculatingnatural frequency values.From the results al-7075 has more naturalfrequency values than az91d existingmaterial so that by all these static anddynamic results we can say al-7075 materialcan be used for aircraft wheel hub.

In dynamic analysis for material al-7075 With hole diameter 40.062mm has less vibrations at mode 3 i.e 9843hz.

CONVERTING INTO STL FORM

For the selected D41.06mm-D8.0mm design modified model of wheel hub are extracted. The file has saved in STL data format that file will generate the STL code. That code is generated by using software's THE STL code is used to develop prototype of wheel hub in Repaid prototyping process. In that process FDM is the best process for generating prototype

Fig.20 prototype model

VIII. CONCLUSION

In this work to minimizes the stress. To reduce this stress three methods had considered Among these three methods third method had given best result.using RP method gives less time and cost, more accuracy easily done the complexcity shape comparing to manual lathe

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