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Fatigue based Design and Validation of Automobile Wheel Hub

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Abstract

The hub is one of the main parts of automobile wheel that is mounted on the center to wheel. When the axle rotates along with it the wheel hub also rotates. While the vehicle is running, the wheel is affected by different loads and stresses at different temperatures. Generally hubs are made up of ductile iron and aluminum. As we know that the strength and weight of ductile iron is more when compare to aluminum. This research paper describe that Critical parameters such as stress, ultimate tensile stress, % elongation and hardness at different points on the both ductile iron hub and aluminum hub is evaluated by commercial analysis software ANSYS and experimental way with a suitable material for wheel hub. The theoretical critical parameters such as stress, ultimate tensile stress, % elongation and hardness at different points were compared with experimental critical parameters values of each material. Hence the deviation of critical parameters is below 10% so that the analytical values of critical parameters are experimentally proved its correctness.

1. INTRODUCTION

Hub is the main part of the wheel and is mounted on the axle; around the hub the rim and tire are mounted. When the vehicle is on move it exerts several forces and loads on the wheel. The hub is one of major component in the wheel assembly generally affected by the load. Generally the hub gives support to the wheel without failure due to the loads. The hub is the strongest part in the wheel assembly. The hub gives the more strength to the wheel, without hub the wheel cannot withstand to the applied loads[1]. The wheel hub may include spokes at the center of most inline or roller skate wheels. The hub serves as housing for the wheel's bearing and spacers; and is the central support around which the entire wheel revolves on the axle. There are many kinds of wheels, the stability and support of the hub or core is critically important to the performance of any of type of wheel that has one [2]. Usually, inline skates come with wheel hubs designed to fit a standard 1008 sized bearing. But, now some speed and fitness skates uses 1088 sized micro bearings. Bearing sizes can be switched on an inline skate, if the wheel hub matches the bearing size.

2. METHODOLOGY:

2.1 Need of Hub:

Generally automobiles like Lorries, buses, cars, Tractors, trucks, vans, jeeps, etc., having wheels which are mounted on the rim and the rim is mounted on the hub and the hub is mounted on the axle. Whenever the axle rotates these whole setup rotates along with the wheel. Hub is the main and essential part of the wheel which prevents the wheel from failures [3]. Mainly automobiles having 4 hubs. If we add extra wheels then the number of hubs increases as per the wheels. The weight of ductile iron hub is around 30 to 40 kg. The cost of hub is around Rs2500.

- Hub gives support to front, rear and dummy wheels.
- Hub increases the strength of the wheel.
- Hub increases wait of the wheel and balances it with the total automobile wait.
- The total automobile wait is on the hubs itself.

2.2 Hub Failures

Generally there are four primary causes of hub failures. They are lack of lubrication, overloading the vehicle, installing the axle nut too tight, or installing the axle nut too loose. Usually, hub failures are progressive and will produce some evidence of the impending failure. A hub that is adjusted too loose will allow the hub and wheel assembly to oscillate laterally. This will cause bearing wear and will cause a further increase in hub looseness. The loose hub allows excessive movement of the bearing rollers resulting in roller cage wear and uneven race wear or "scalloping [4]". If not repaired, the bearing play will increase progressively to the point where the hub fails. Overloading a hub creates similar conditions as over-tightening the hub. The excessive weight forces the lubricant from between the bearing rollers and bearing races on the loaded side of the bearing causing localized heat and fatigue. In hubs with large outer bearings, separation of the hub occurs when the oscillating hub causes the axle nut to be pulled off the axle like a bottle cap[5]. In other cases, the axle nut is pulled off the axle, ripping the threads out of the axle nut and leaving the threads on the hardened axle relatively undamaged.

- It should have high damping capacity
- The hub should not posses' high thermal conductivity.
- It possesses 450 MPa tensile strength and 10% elongation
- Properties of material is given by 2.1

3. DESIGN AND ANALYSIS:

Among these software's Pro/E is selected since it is having high accuracy in design. The wheel hub design is as shown below Figure 3.1, Figure 3.2 and Figure 3.3. To analyze the hub in ANSYS we have to follow 3 steps

A. Ductile Iron Hub:

For analyzing the hub using ANSYS import the pro/E design of hub. Then for analyzing the hub, divide the whole component into number of small components of known geometrical shapes. This process is known as meshing. Mesh the component in any regular geometry like which is shown in Figure 3.1.After meshing is done then apply the constraints and loads up to the component fails and damages. The constraints are like at where its degree of freedom is made to constraint and the loads are applied on the different nodes of the elements at where there will be possibilities of load affected. After applying all the constraints to the hub, components seem to be like Figure 3.2.

B. Analysis of Aluminium Hub:

Here aluminum metal is used as the material to manufacture the hub. The aluminum is taken because it is economy in cost and less in weight. Then main requirement of the hub is to with stand to the applied load by the wheel and to the tensional stress due to rotation of wheel. So Aluminum hub should be tested whether it could with stand to the requirements or not. For testing the aluminum hub 2 steps, may proceeded,

1. By using ANSYS software. and
2. By using testing machines.

The following are the inputs required to find the stress values in the hub using Ansys.

Material properties:

- Young's modulus of the aluminum -70 GP
- Poisons ratio of the aluminum -0.35

3.1 Meshing of the hub

After importing the design the meshing should be done. In ANSYS mesh200 as the meshing command we divide the components into small component using the quad 4-nodes This is the analyzed component shown in Figure 3.3 ANS 3.4 variation of stress at different positions are differently colored as shown.

4. MANUFACTURING WHEEL HUB

4.1 Manufacturing Procedure:

Manufacturing procedure shows the figure 4.1 Cores are mould parts used to shape internal holes and cavities. They are also fortification parts of moulds where wearing occurs. These parts are made of sand and organic-inorganic bonders such as cereal meals, dextrin, sodium silicate, cement etc. While the hub is in action it is undergoing to so many forces, mainly torsional forces, because the hub is a rotating component along with wheel, Self weight due to gravity, Weight of the truck etc., by the acting of these forces so many stresses induced in the hub like ultimate tensile stress, yield stress, tensile stress,. We are finding these parameters by using testing machines like universal testing machine to find ultimate tensile stress, % elongation, yield stress and by using Rockwell hardness test we get the hardness.

5. RESULTS AND ANALYSIS:

The critical parameters of ductile iron hub are identified and listed in table 5.1 as ductile iron hub and 5.2 as aluminum hub.

1. On comparing both ductile iron hub and aluminum hub we came to know that %elongation of aluminum hub is more than ductile iron hub. If the hub elongates then it will easily breaks. Hardness of aluminum hub is also less compare to ductile iron hub. The hub should have max hardness to withstand.
2. Permissible stress and ultimate tensile stress of aluminum hub is more compare to ductile iron hub. For a good hub it should posses less stresses. If stresses induced are more than the hub may easily fail. Based on all these values we conclude that aluminum metal not feasible as a hub. Ductile iron material is best selected as a hub.
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6. CONCLUSION:

- Analytical (Ansys) parameters are close to experimental parameters with 9% deviation. So the Analytical (Ansys) parameters proven its exactness with experimental parameters.
- Critical parameters of aluminum hub are in lower end as compared to ductile iron hub, so aluminum is not feasible to use as a hub material. However, aluminum alloys may be considered for the hub.
- Critical properties of ductile iron hub is ultimate tensile stress - 532.6 MPa, %elongation - 14.1, hardness - 185.65 BHN, permissible stress - 404.06 MPa. The analytical and experimental properties of the ductile iron are achieved higher than the required properties. Hence, ductile iron is more suitable and feasible as hub material.

8. SUGGESTIONS:

In some cases like aero planes where weight is main phenomenon, there one cannot go for such a weightier material like ductile iron. In that case aluminum plays major role, but aluminum is itself not feasible as a metal for hub, by adding some metals to form an aluminum alloy. The alloy is Aluminum 6 vanadium. In aero planes heavy forces act on the hub while takeoff and landing. The Aluminum 6 vanadium withstands that heavy impact forces and loads. But it is very expensive. Approximately Rs150/Kg. So aluminum alloy is not feasible for normal automobiles like Lorries, trucks, etc.

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9. FUTURE SCOPE:

Generally in Ashok Leyland lorry company manufacturing 3 hubs per a mold. By increase the hubs per mold the productivity increases. They are producing 100 hubs per hour. By doing like this one can produce 150 hubs per hour.

REFERENCES:

1. Todd, Robert H.; Allen, Dell K.; Alting, Leo, *Manufacturing Processes Reference Guide*, Industrial Press Inc., ISBN 0-8311-3049-0, 1994
2. Bishop, N.W.M and Serrate, F, Fatigue life prediction from power spectral density data. Part 1- traditional approaches and part 2-recent development, *Environmental Engineering*, (2) 1989.
3. Degarmo, E. Paul; Black, J T; Kohser, Ronald A. *Materials and Processes in Manufacturing*, (9th ed.), Wiley publishers, 2003
4. Howard E. B., Timothy L. G., *Metal Handbook*, Desk edition, America Society for Metal (ASM) USA, 1992.
5. Mikhailow A. M., *Metal Casting*, 1st edition, Mir Publishers, 1989
6. L. Edwards, M. Endean, *Manufacturing with Materials*, The Open University, U.K., 1990
7. Rao, T. V, *Metal Casting: Principles and Practice*, New Age International publishers,2003
8. Schey, A. J., *Introduction to Manufacturing Processes*, TATA McGraw Hill, Singapore, 1987

Table 2.1: Material Properties

S. No	properties	Hhh Hub properties	Carbon steel	Malleable cast iron	Ductile iron	Al
1	Density (kg/m³)	0.4×10^3	7.8×10^3	7.4×10^3	0.3×10^3	7.9×10^3
2	Modulus of elasticity (GPa)	240	200	172	230	70
3	Thermal Conductivity (W/mk)	850	64.9	125	825	237
4	Hardness (BHN)	150	49	269	143-187	125
5	% Elongation	10	30	3	18	40
6	Tensile strength (MPa)	450	330	586	414	600
7	Yield strength (MPa)	270	285	483	276	480
8	Damping capacity	High	Low	Low	High	Low

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Table 5.1 Ductile iron hub values

S. No	EXPERIMENTAL VALUES				ANALYTICAL VALUES(Ansys)			
	U.T.S (MPa)	P.S (MPa)	%ELONG ATION	HARDNESS (BHN)	U.T.S (MPa)	P.S (MPa)	%ELONG ATION	HARDNESS (BHN)
1	377.4	459	14.3	179	370.3	455	12.3	180
2	417.1	510	12.9	182	410	510	12.9	181
3	410	565.9	13.9	184	414	564.9	12.9	183
4	403.9	516.1	15.7	183	403.9	515.1	14.7	181
5	390.6	555.9	12.1	190	390.6	553.9	11.1	189
6	410	595.6	15.0	191	409.3	594.6	14.0	189
7	377.4	510	15.7	193	376.4	511	13.7	190
8	390.6	522.2	14.3	183	389.9	527.2	15.3	181
9	423.3	595.6	12.1	189	421.3	594.6	11.1	186
10	377.4	502.8	12.9	193	370.3	507.8	14.9	192
Avg	**403.09**	**532.6**	**14.1**	**182.05**	**402.9**	**532.75**	**13.92**	**183.01**

Table 5.2 Aluminum hub values

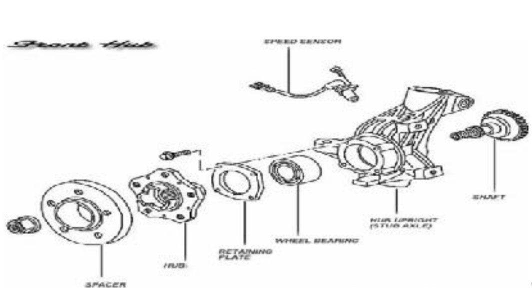
S. No	EXPERIMENTAL VALUES				ANALYTICAL VALUES(Ansys)			
	U.T.S (MPa)	P.S (MPa)	%ELONG ATION	HARDNESS (BHN)	U.T.S (MPa)	P.S (MPa)	%ELONG ATION	HARDNESS (BHN)
1	600	475	120	29	590	465	124	30
2	625	480	122	24	623	479	121	25
3	610	456	125	34	609	453	123	35
4	580	482	126	30	579	480	129	32
5	534	480	125	39	524	478	124	35
6	590	481	125	32	580	478	123	35
7	603	479	127	41	598	482	126	40
8	615	483	125	34	608	473	135	38
9	623	412	125	30	620	409	125	32
10	600	475	127	36	590	450	121	35
Avg	**595.15**	**472.6**	**124.2**	**32.9**	**594.97**	**470.7**	**123.9**	**33.7**

6.1 Ductile Iron Hub: The averages of experimental values, analytical values and their % deviations are shown in below table 6.3

PARAMETERS	Experimental values	Analytical values (Ansys)	Deviation
U.T.S(MPa)	403.09	402.9	0.09
%ELONGATION	532.6	532.75	0.075
HARDNESS(BHN)	14.1	13.92	0.09
PERMISSIBLE STRESS(MPa)	182.05	183.01	0.48

6.2 Aluminum Hub: The averages of experimental values, analytical values and their % deviations are shown in below table 6.4

PARAMETERS	Experimental values	Analytical values (Ansys)	Deviation
U.T.S(MPa)	595.15	594.97	0.09
%ELONGATION	472.6	470.7	0.45
HARDNESS(BHN)	124.2	123.9	0.15
YIELD STRESS(MPa)	32.9	33.7	0.022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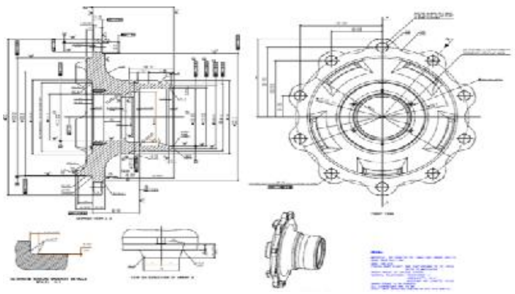

Fig: 3.1 Design of hub using Pro/E

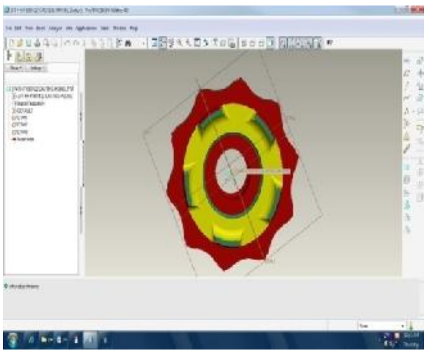

Fig 3.2 Hub Front view

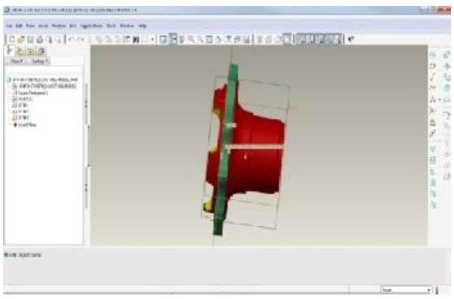

Fig 3.3 Hub side view

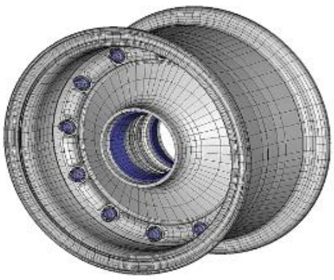

Fig:3.3 Meshed hub

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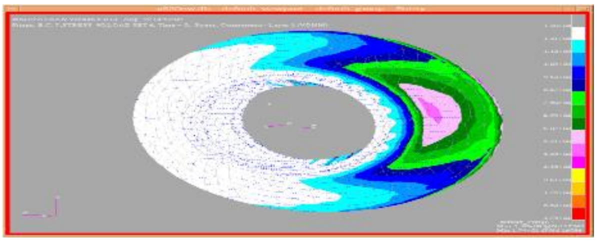

Fig :3.4 Analysed hub component

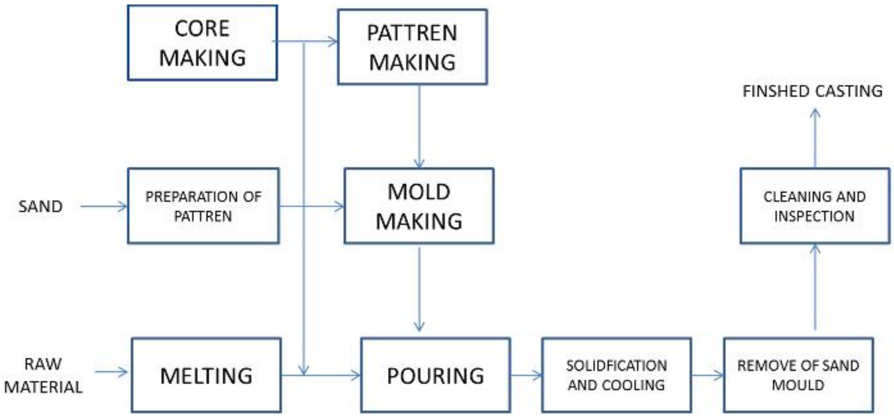

Figure: 4.1 casting process flow line

Figure :5.2 Hubs removing from drag boxFigure : Figure :5.3 Pattern for hub