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HARMONIC RESPONSE ANALYSIS of CHERY 100 HP TRACTOR TRANSFER CASE USING ANSYS

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Abstract: The study aims to make the Harmonic response analysis of Chery 100 Hp tractor transfer case using ANSYS 17.2 software. Taking the manually measured transfer case specification and designed by Auto CAD 2013. The transfer case material composition was analyzed using a spectrometer at Akaki Basic Metals Industry, revealing the transfer case material to be AISI Alloy Steel 4140 with typical mechanical properties such as a tensile strength of 655 MPa and a density of 7.85 g/cm³.

The Auto CAD 3D design is imported to ANSYS 17.2 for the sake of harmonic analysis. Both inner and outer surface of geometry were meshed with nodes 20343 elements. Based on the material properties of the transfer case have an Elastic modulus of 2.0ePa, Poisson ratio- 0.30, density 7850 kg/m³. These mechanical properties are taken for the analysis by taking boundary conditions of fixed-fixed boundary condition.

The result revealed that with the evaluated responses of 10 modal points. As a result the first three modes are 541.46Hz, 547, 65Hz and 557.73Hz respectively shows relatively closer vibration and with slight different deformation, while mode 4 to 10 has shown a complex deformations and high resonance 866.36Hz, 912.18Hz, 1067.9Hz, 1210.1Hz, 1273. 8Hz, 1373Hz, and 1390.9Hz respectively.

Keywords:-Cherry 100HP, Forced Vibration, ANSYS, Harmonic Response

I. INTRODUCTION

Tractor designated to pull and power variety of different agricultural machines and implements applied in complex technological operations of agricultural production. {CITATION Wra16\1033}. Transfer case is located on four-wheel drive vehicles like tractors it connects the transmission to the front axle {CITATION Hom211\1033}. It provide the fluid tight casing to hold the lubricants and provides support to moving components {CITATION Wal16\1033 }

Vibration analysis in tractors are used to determine the operating and mechanical condition of the tractor {CITATION Jaa12 \1033}. Based on the standard of ISO 10816 assessment of machine condition for different types of machines bases on two criteria.{CITATION Tho07\1033}.

Heavy vehicle transmission systems are subjected to noise and vibration. Noise and vibration reduction in heavy vehicle transmission system is a constant development, because noise and vibration are the two reasons for transmission failure. {CITATION Kum14\1033 }

If a system is subjected to an external force, the resulting vibration is known as forced vibration. If no energy is lost or dissipated in friction or other resistance during oscillation, the vibration is known as undamped vibration. If any energy is lost in this way, however, it is called damped vibration.{ CITATION Sin04 \1 1033 } Harmonic excitation refers to a sinusoidal external force of a certain frequency applied to a system. The response of a system to harmonic excitation covers the concept of resonance. Resonance occurs when the external excitation has the same frequency as the natural frequency of the system. It leads to large displacements and can cause a system to exceed its elastic range and fail structurally.{ CITATION Sin04 \1 1033 }.Cherry 100hp designed to overcome 100hp but when it exceeds 95hp the transfer case failed due to vibration. The study attempt to make harmonic response analysis of tractor transfer case by using ANSYS software.

II. METHODOLOGY

2.1. Transfer Case

Cherry 100 Hp tractor transfer case is the examined transfer case which is damaged part of the tractor due to vibration. The main purpose of this transfer case is to distribute engine power and transfer it in to all the four wheel by the rear and front axle. During field operation the traction force need to be increased while the speed will be diminished for this purpose the two wheel drive should be changed in to four wheel drive to perform field operation. In

this kind of situation this transfer case obtains power from the transmission and transfer it in to four wheel of the tractor this helps the operator to change the tractor from two wheel drive in to four wheel drive by moving the gear selector fork by moving slide. Tractor remains at four wheel drive at the entire field task to increase traction force and with stand off-road condition and it will be turned in to two wheel drive whenever the field operation finished and the tractor leave the field and is driven on asphalt or smooth surface. The transfer case works by using gear driven mechanism these gears are spur gears which are meshed by using constant mesh. The examined transfer case has totally 36 components including every micro elements. Shown on figure 1.



Figure { SEQ Figure * ARABIC } Cherry 100HP components of the transfer casing

2.1.1. Description of the Examined Transfer Case

The transfer case has 36 components including shift fork shaft, intermediate gear shaft, transfer case gear shaft, bearings, gears both driven and driving gear, sleeve, spacer bush and others figure. The gears are spur gears meshed in a constant mesh. The dimension of the transfer case is length 145mm, Width 122mm and height 185mm.



Figure { SEQ Figure * ARABIC } Cherry 100HP tractor transfer case

2. Field visit

The total day spent for industry visit is 10 days starting from September 20 up to march 28 the most industry visit is taken place in the research area AAMI the company provided essential and very significant information and data in line with the objective of the thesis. At the beginning different problems projects were visited in order to find the specific problems that are expected to be solved and to start MSc thesis. After discussion of the available problems needed to be solved or studied with an advisors the study was started on the failed Chery 100 hp tractor model transfer case analysis due to frequent damage and repair of this transfer case as per evidence from the operators, chief mechanics and marketing sectors. Once the analysis was started serious measurements and vibration recording was taken on this particular area.

The other industry visit was taken place at is at Akaki basic metals industry this visit was taken three days starting from letter of acceptance for spectrometer testing which is on Tuesday March 21, 2018. The sample spectrometer sample measurement of the failed transfer case in order to identify the material type and material composition.

2.3. Technical specification

Technical specification was taken for the sake 3D modeling on Catia software each component of the tractor model transfer case disassembled and measured using caliper and meter in order to get proper design.



Figure {SEQ Figure * ARABIC} Manual Technical Measurement of Cherry 100Hp transfer case

2.2. Spectrometer test

Knowing the material type is mandatory to study vibration. the sample of transfer case was taken from AAMI for the purpose test on spectrometer .the spectrometer test were performed at Akaki Basic Metal Industry .The result indicated that the material type was unable to identify from the industry available resource of the company but the composition are identified.



Table {SEQ Table * ARABIC} Spectrometer test result of Cherry 100HP tractor transfer case

Ets	C	Si	N	P	S	Cr	Mo	Ni	Al
%	1. 53	1. 35	0.75	0. 04	>0.096	>0.071	3E-04	0.0 1	0. 003
Ets	Cu	Ti	V	W	Sn	As	Fe		
%	0. 07 follows	>0 .03	0.0 3{	<0.04	0.013 The transfer case material type is found that ADDIN	0.02	95.9 steel 4140 which has the physical properties are as CSL_CITATION	AISI Alloy	

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Table {SEQ Table * ARABIC}. Physical property of AISI Alloy steel 4140

Physical Property of AISI Alloy steel 4140	
Density	7.85g/cm ³
Melting point	1416°C
Tensile strength	655Mpa
Yield strength	415Mpa
Bulk modulus	140Mpa
Shear modulus	80Gpa
Elastic modulus	190-210Gpa
Poisson ratio	0.27-0.30
Elongation	25-75%

2.3. CAD Modeling and Meshing

The CAD Model of transfer case has specification of length 145mm, Width 122mm and height 185mm is taken from measurement. The CAD model is imported with IGS format to the FEM design software ANSYS 17.2.

Mesh model is prepared by using ANSYS 17.2 software meshing is carried out on all the outer and inner surfaces of the geometry. The transfer case is meshed with about 41046 nodes 20343 elements.

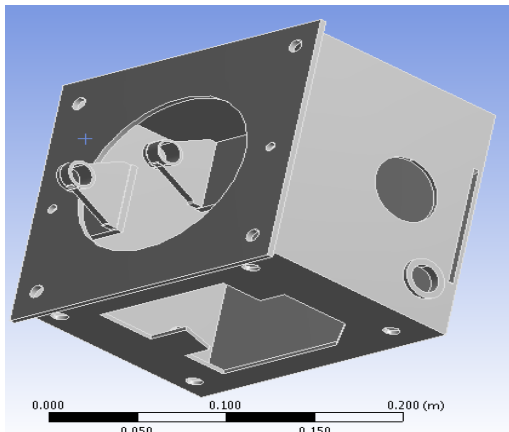


Figure { SEQ Figure * ARABIC } 3D Model of Tractor Transfer Case

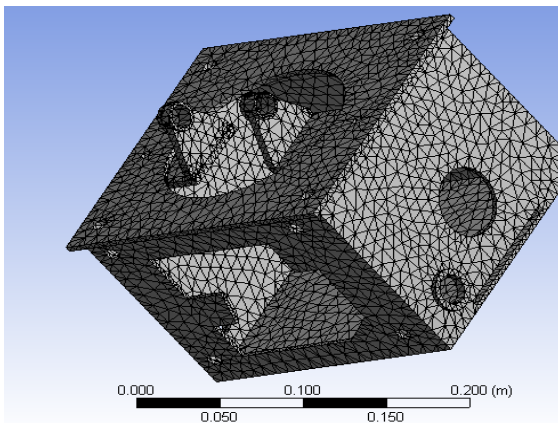


Figure { SEQ Figure * ARABIC } Meshed transfer case

2.5 Boundary condition and material property

Chery 100hp tractor transfer case. It is manufactured by casting process this transfer case is mounted below the differential by using bolts. Based on the laboratory spectrometer test of the sample of the transfer case the material type is identified to be steel alloy. The Mechanical properties (Elastic modulus, Poisson ratio and density) are required for force vibration or harmonic response vibration analysis. The material properties selected for the study of the transfer case are Elastic modulus – 2.0ePa, Poisson ratio- 0.30, density-7850 kg/m³ found from spectrometer test of sample.

After selecting the material the next step is boundary conditions. There are two predefined boundary condition in ANSYS for vibration analysis. These are free-free and fixed-fixed boundary conditions. In free-free boundary conditions all degree of freedom are unconstrained. Fixed fixed boundary condition is suitable for the transfer case analysis because transfer case is constraint by bolts.

III. RESULTS AND DISCUSSION

ANSYS solver is used to calculate the modal and harmonic response evaluate the mode shape of the transfer case the simulation is performed for fixed- fixed boundary conditions. In forced vibration analysis using ANSYS the load calculated from the working power torque and speed of Chery 100hp tractor and Mode Frequency [Hz] 1 541.46 2 547.65 3 557.73 4 866.36 5 912.18 6 1067.9 7 1210.1 8 1273.8 9 1373 10 1390.9 applied. The result revealed that with the evaluated responses of 10 modal points. As a result the first three modes are 541.46Hz,547,65Hz and 557.73Hz respectively shows relatively closer vibration and with slight different deformation, while mode 4 to 10 has shown a complex deformations and high resonance 866.36Hz, 912.18Hz,1067.9Hz,1210.1Hz,1273.8Hz,137 3Hz,and 1390.9 Hz respectively.

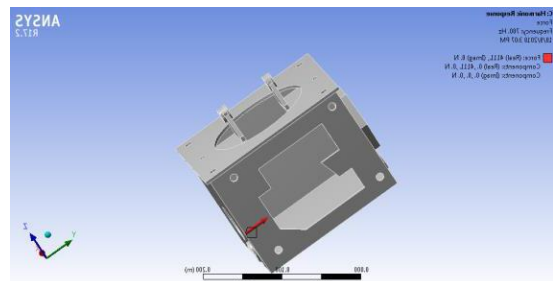


Figure {SEQ Figure * ARABIC} Load application on transfer case

Table {SEQ Table * ARABIC} 10 modal values of transfer case

Mode	Frequency [Hz]
1	541.46
2	547.65
3	557.73
4	866.36
5	912.18
6	1067.9
7	1210.1
8	1273.8
9	1373
10	1390.9

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