www.ijemr.net ISSN (ONLINE): 2250-0758, ISSN (PRINT): 2394-6962

Vandana Publications
IJEMR

Volume-7, Issue-3, May-June 2017
International Journal of Engineering and Management Research
Page Number: 117-120

Effect of Manufacturing Process on Reliability of Bogie Frame

Subhankar Haldar[1], Ravikant Verma[2]
[1]Research Scholar, GD-Rungta College of Engineering & Technology, Bhilai, Chhattisgarh, INDIA
[2]Assistant Professor, Department of Mechanical Engineering, GD-Rungta College of Engineering & Technology, Bhilai, Chhattisgarh, INDIA

ABSTRACT

The objective of this study is to analyse the effect of manufacturing process on the reliability of bogie frame. This reliability analysis is made through evaluating the fatigue life of casting and fabricated bogie frame of locomotive through finite element method. The casting bogie frame is made with the material Cast Steel whereas the fabricated bogie frame is made with the material E 350C and HFW tube. The results show that bogie frame made through the fabrication process is more reliable with comparison to the bogie frame manufactured through casting process.

Keywords-- Bogie Frame, Fatigue, Manufacturing Process, Reliability

I. INTRODUCTION

HTSC (High Tensile Steel Cast) Bogies are three-axle bolster-less bogie with two-stage suspension with helical coil springs in primary stage and rubber compression springs in secondary stage of suspension. The weight of WDP – 4 locomotive car body in which the HTSC bogie fitted is transferred directly to the bogie frame through four rubber "Compression" spring assemblies. The bogie frame is supported on axles through "soft primary" suspension consisting of twelve single helical coil springs, two springs mounted on each axle box, to provide ride quality and equalization of wheel-set loads.

Reliability of Bogie frame is its ability to perform the required function, under given environmental and operational conditions and for a stated period of time [1]. For the development of bogie, the fatigue strength of a bogie frame is an important design criterion [2]. Fatigue life analysis requires various factors that can be evaluated numerically [3].

As simulation is a powerful tool for analysing process performance; its ability is limited by the availability of accurate input information [4]. Therefore, Reliability Analysis of Bogie frame manufactured through casting and fabrication processes by fatigue life through finite element method is carried out.

Researches have been made in reliability and its importance in the product development. In the same context Simon Minderhoud exercises for improving the quality of product by focusing more on the process management aspects as the product creation process can be improved to better adjust to the market requirements [5].

R. Jianga and D.N.P. Murthyb analyzes that the reliability of manufactured products can differ from the desired design reliability due to variations in manufacturing quality. [6]

Amandeep Singh, Zissimos P. Mourelatos and Jing Li discover that Reliability is an important engineering requirement for consistently delivering acceptable product performance through time and also explains that all costs depend on quality and/or reliability [7].

F. Kimura tells it is important to achieve appropriate product reliability with minimum resource consumption. In the total product lifecycle there exist various kinds of disturbances which may deteriorate product quality and functionality [8].

II. ANALYSIS SETTINGS FOR CASTING AND FABRICATED BOGIE FRAME

2.1 Material specification

HTSC bogie can be manufactured either through Casting and or through Fabrication Process. The material in both the processes is different. In Casting the material selected is Cast steel whereas the material for fabricated bogie is E 350 C and HFW tube. The chemical compositions of materials are specified in Table 1.

Element	% Composition (max.)		
	Casting Bogie	Fabricated Bogie	
	Cast Steel	E 350 C	HFW Tube
C	0.25	0.20	0.25
Mn	0.85	1.55	1.3
P	0.05	0.04	0.005
S	0.06	0.04	0.005
Si	-	0.45	-

Table 1: Description of Chemical Composition of materials

Analysis requires mechanical properties of the material hence the required mechanical properties of the materials used in casting process of bogie frame are specified in Table 2.

Mechanical Properties	
Tensile Strength, MPA, min	435
Yield Point, MPA, min	248
Elongation at 50mm gauge length, %, min	24
Reduction of Area, %, min	36
Hardness, Brinell	137 -170

Table 2: Mechanical Properties of Cast Steel for Casting Bogie

All the above properties were obtained through the specification EMS 22 [9].

Similarly the mechanical properties of E 350 C which are used as the material for plates and HFW tubes are specified in Table 3.

Mechanical Properties		
Description	E 350 C	HFW Tube
Tensile Strength, MPA, min	490	430
Yield Point, MPA, min	350	275
Elongation at gauge length $5.65\sqrt{s_0}$, %, min	22	20
Internal Bend Diameter	2t	3t
Hardness, Brinell	170	170

Table 3: Mechanical Properties of E 350 C and HFW Tube for fabricated Bogie

These properties are obtained from IS: 2062 [10] and IS: 3601[11]

2.2 Determination of parameters for the Fatigue Life

For the fatigue analysis S – N curve has to be made. This curve is generated by the fatigue test of Cast Steel and E 350 C applied to Casting and fabricated bogie frame was performed under tension-compression loading condition using dynamic test machine according to ASTM E739 – 10 [12].The five specimens were used for one stress level. The endurance limit was selected as 10^6 cycles, which is common for the fatigue test. The tensile and compressive failure strength for fatigue test was obtained by materials property test. Fig 1(a) shows the S – N Curve for Cast Steel and Fig. 1 (b) shows the S – N Curve for E 350 C

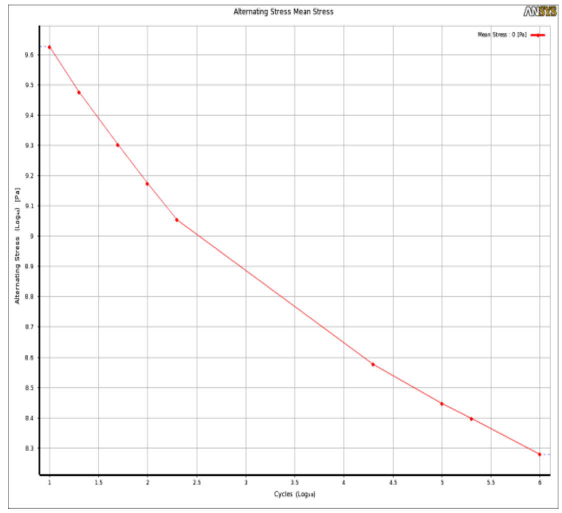

Fig 1(a): S – N Curve for Cast Steel

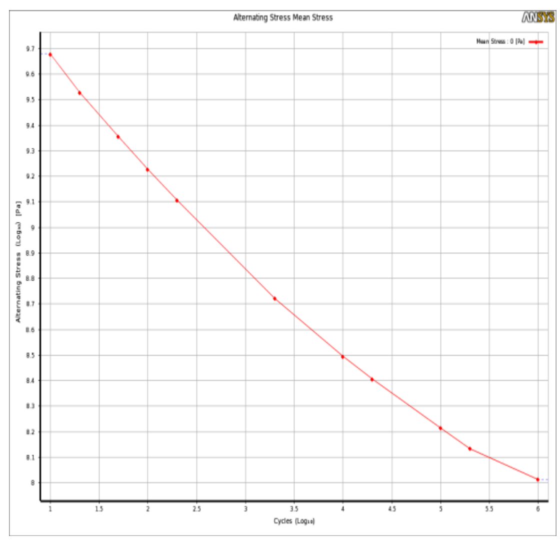

Fig 1(b): S – N Curve for E 350 C

III. EVALUATION OF FATIGUE LIFE

3.1 Loading Details.

Finite Element Modelling of Bogie frame made through Casting and fabricated process requires solid modelling and are shown in Fig. 2(a) and Fig. 2(b). Solid modelling of both the bogie frames is slightly different.

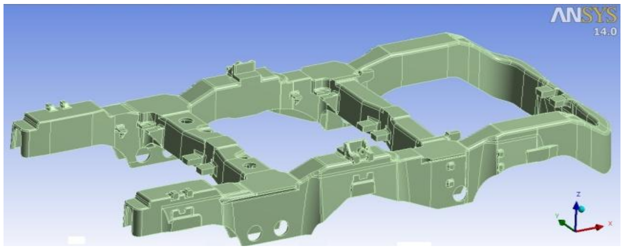

Fig. 2(a) Geometric Modelling of Bogie Frame (Casting Model)

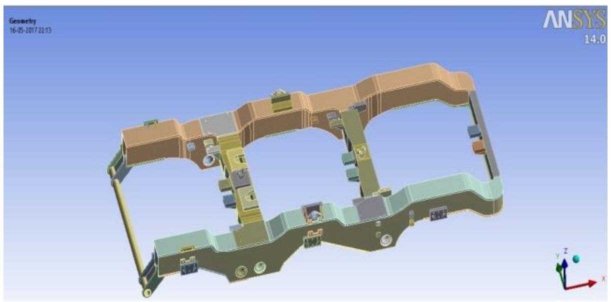

Fig. 2(b) Geometric Modelling of Bogie Frame (Fabrication Model)

Both the type of Bogie Should with stand the load of 125 T as per the assembly details of Locomotive WDP 4. Hence analyses have been made considering this load over the frame.

3.2 Pre-processing of Model

The static structural analysis of the bogie frame was done using Ansys v14.0 Work Bench, a finite element analysis program.

FEA meshes the geometric model to finite element model converting the solid model to elements and nodes to perform the analysis. Therefore, in this case too meshing of the models has been done.

The nodes and elements in the Casting model are 186318 and 50203 respectively whereas the nodes and elements in the fabricated model are 189356 and 50568 respectively.

3.3 Fatigue Analysis

The fatigue analysis of bogie frames can be performed by using S – N curves obtained in above process. For analysis, different criterions are proposed i.e

a. Gerber line: A parabolic curve joining Endurance limit on the ordinate to ultimate stress on the abscissa.

b. Soderberg line: A straight line joining Endurance limit on the ordinate to yield stress on the abscissa

c. Goodman line: A straight line joining Endurance limit on the ordinate to ultimate stress on the abscissa

Now since the Goodman line is safe from design considerations hence it is preferred for the fatigue life analysis.

Fig. 3(a) and fig. 3(b) shows the good man diagram for Cast steel and E 350 C.

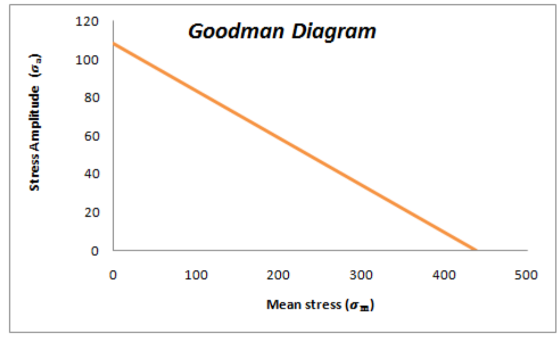

Fig. 3(a) Goodman Diagram of Cast steel

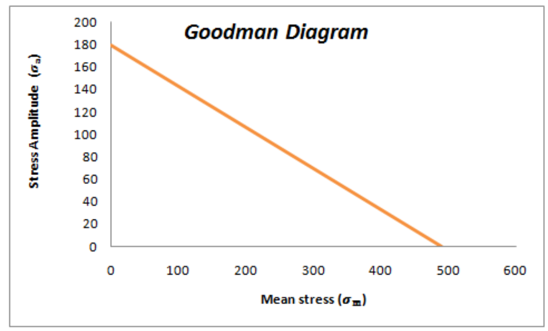

Fig. 3(b) Goodman Diagram of E 350C

Using the Good man diagram fig. 3(a) the fatigue analysis for Casting Bogie frame is shown in fig. 4(a) and 4(b).

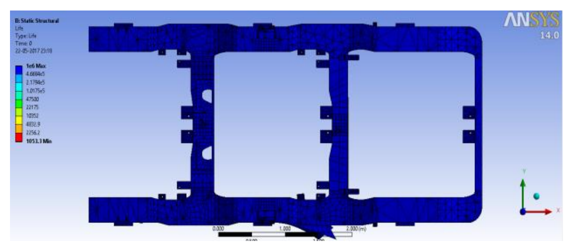

Fig. 4(a) Fatigue life analysis of Casting Bogie Frame

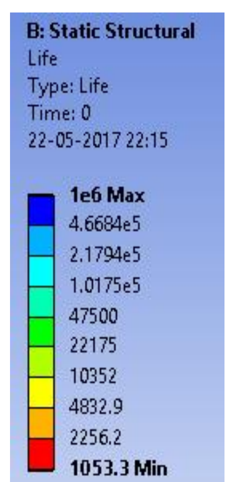

Fig. 4(b) Fatigue life data of Casting Bogie Frame

Similarly the fatigue analysis carried out using Good man diagram fig. 3(b) for fabricated bogie frame is shown in fig. 5(a) and Fig. 5(b)

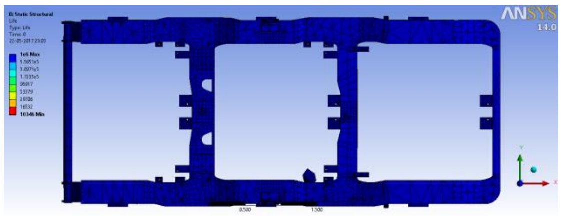

Fig. 5(a) Fatigue life analysis of Fabricated Bogie Frame

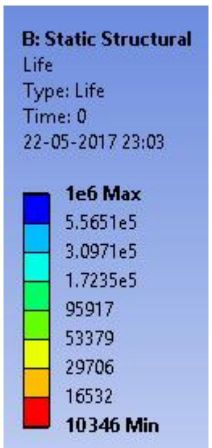

Fig. 5(b) Fatigue life data of Fabricated Bogie Frame

IV. RESULTS AND DISCUSSIONS

Analysis of casting and fabricated bogie frame produces the result that minimum life at which the model will start deforming will be 1053.3 cycles where as for fabricated bogie it is 10346 cycles.

Despite of these results there are some more facts that are to be considered:

- Weight of fabricated Bogie is lesser than the weight of casting bogie.
- Lesser weight of fabricated bogie also contributes to life of bogie frame and which leads to greater life of locomotive.
- Manufacturing Cost of a Casting Bogie is higher than Fabricated Bogie.

V. CONCLUSION

Manufacturing process of the product has the great impact on its Reliability. As it is seen the performance and life cycle of product changes when the manufacturing process changes. Therefore, the fabricated bogie frame is more reliable than the casting bogie frame in all respects.

REFERENCES

[1] Marvin Rausand and Arnljot Hoyland, System Reliability Theory, A John Wiley & Sons, Inc., Publication, New Jersey, 2nd Edition.

[2] B H Park, K Y Lee , "Bogie frame design in consideration of fatigue strength and weight reduction" Published May 1, 2006

[3] P.H. Wirsching (1991), "Advanced fatigue reliability analysis", International Journal of Fatigue, Volume 13, Issue 5, Pages 389-394.

[4] Ali A. Yassine, "Investigating product development process reliability and robustness using simulation." Journal of engineering design (2008), Pages 545-561.

[5] Simon Minderhoud, "Quality and reliability in product creation—extending the traditional approach", Quality and Reliability Engineering, November 1999.

[6] R. Jianga, , D.N.P. Murthyb, "Impact of quality variations on product reliability", Division of Mechanical Engineering, The University of Queensland, Brisbane, Qld. 4072, Australia, 21 May 2008.

[7] Amandeep Singh, Zissimos P. Mourelatos and Jing Li, "Design for Lifecycle Cost Using Time-Dependent Reliability", J. Mech. Des 132(9), 091008 (Sep 16, 2010) (11 pages).

[8] F. Kimura, "Designing Product Reliability based on Total Product Lifecycle Modelling", Journal: CIRP Annuals: Manufacturing Technology, Department of Precision Machinery Engineering, The University of Tokyo, Japan, volume 56, Issue 1 , 2007, Pages 163 – 166.

[9] EMS 22: Truck Frame and Bolster Cast steel Material Specification by RDSO.

[10] IS 2062 (2011): Hot Rolled Medium and High Tensile Structural Steel. [MTD 4: Wrought Steel Products].

[11] IS 3601 (2006): Steel tubes for mechanical and general engineering purposes [MTD 19: Steel Tubes, Pipes and Fittings].

[12] ASTM E739 – 10: Standard Practice for statistical analysis of linear or linearized stress life (S - N) and strain life (ε- N) Fatigue data

