International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2013): 6.14 | Impact Factor (2013): 4.438

A Review of Optimized Heat Treatment for Bearing Cup in Drive Shaft Assembly

D. R. Lahore[1], R. A. Kathar[2]

[1, 2] Jawaharlal Nehru Engineering College, N-6 Cidco, Aurangabad, India

Abstract: ***Power transmission system has different constructive features according to the vehicle's driving type which can be front wheel drive, rear wheel drive or four wheel drive. In rear wheel drive system, elements of the system include clutch, transmission system, propeller shaft, joints, differential, drive shafts and wheels. Each element has many different designs and construction properties depending on the brands of vehicles. The carden shaft also called drive shaft is used to transmit motion from gear box to differential. The problem identified after critical analysis of the drive shaft assembly. In that bearing cup assembly was getting cracked during assembly operation in universal joint assembly. This was highest rejection, hence it was decided to eliminate bearing cup failure in drive shaft assembly with cost effective solution. It will highlight the methodology adopted for finalizing the solution to this problem by means of the FEA analysis supported by logical reasoning. Various Heat Treatment processes are compared and it was found that the optimum solution which will reduce the failure of bearing cup as well as reduce the overall manufacturing cost.***

Keywords: FEA, Carden shaft.

1. Introduction

The automobile is a typical industrial product that involves a variety of materials and technologies. The present societal needs necessitate that metallic materials are ideally suited for applications in heavily stressed components that require high durability. The degree of functionality and component performance is strongly tied to the effectiveness of the processing technology deployed for a given application.

A propeller shaft or carden shaft is a mechanical component for transmitting torque and rotation usually used to connect other components of a drive train that cannot be connected directly because of distance or the need to allow for relative movement between them. The universal joint is used to transfer drive (power) from one shaft to another when they are inclined (non collinear) to each other.

1.2 Elements of Power Transmission System

The movement of vehicles can be provided by transferring the torque produced by engines to wheels after some modification. The transfer and modification system of vehicles is called as power transmission system and has different constructive features according to the vehicle's driving type which can be front wheel drive, rear wheel drive or four wheel drive. Fig. 1.1 gives elements of a front wheel and a rear wheel drive power transmission system. The elements of the system include clutch, transmission system, propeller shaft, joints, differential, drive shafts and wheels. Each element has many different designs and construction properties depending on the brands of vehicles. The carden shaft also called drive shaft is used to transmit motion from gear box to differential. The universal joint consists of two forged-steel yokes or forks joined to the two shafts being coupled and situated at an angle to each other. Friction due to rubbing between the journal and the yoke bores is minimized by incorporating needle-roller bearings between the hardened journals and hardened bearing caps pressed into the yoke bores

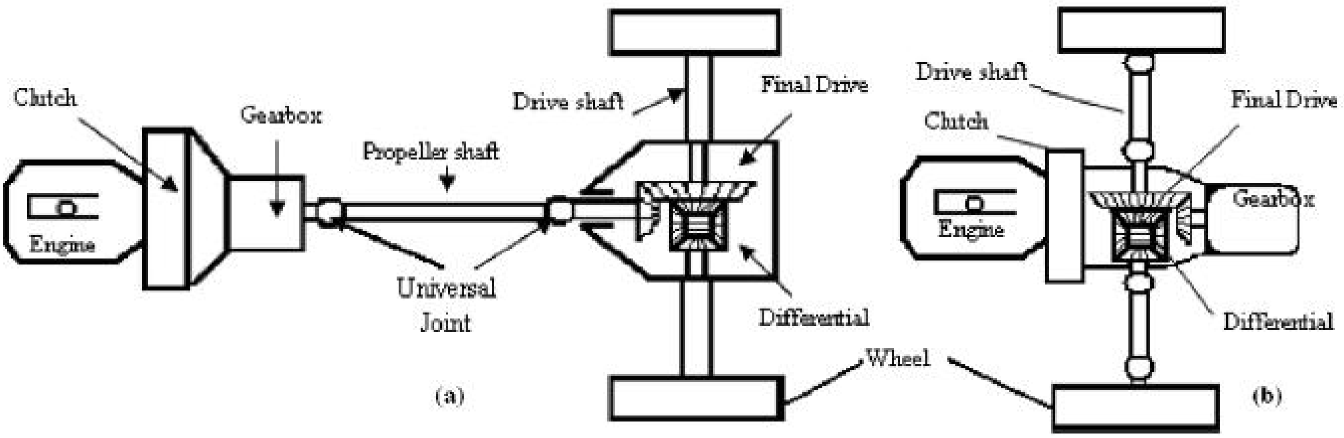

Figure 1.1: Elements of Power Transmission System (a) Rear Wheel Drive (b) Front Wheel Drive.

1.3 History of Propeller Shaft

The main concept of the universal joint is based on the design of gimbals, which has been in use since antiquity. One anticipation of the universal joint was its use by the ancient Greeks on ballistae. The first person known to have suggested its use for transmitting motive power was GerolamoCardano, an Italian mathematician, in 1545, although it's unclear whether he produced a working model. Christopher Polhemlater reinvented it and it was called "Polhem knot". In Europe, the device is often called the carden joint or carden shaft. Robert Hooke produced a working universal joint in 1676, giving rise to an alternative name, the Hooke's joint.

1.4 Types of Propeller Shaft

There are different types of propeller shaft or driveshaft in automotive industry

1) Inboard
    i) Single piece shaft
    ii) Two piece shaft
2) Outboard
    i) Single piece shaft
    ii) Two piece shaft.

The slip in tube driveshaft is the new type which also helps in crash energy management. It can be compressed in case of crash. It is also known as a collapsible driveshaft.

2. Literature Survey

Funatani et. al. [2004] presented various heat treatments and surface technology which satisfy customer needs and environmental norms. Heat treatment and surface modification are the key technologies available today to enhance the effective use of materials, to achieve the desired properties of the components used in the automotive industries, to save energy and conserve natural and surface modification technologies including future technological possibilities of relevance to the automotive industry are also reviewed [7].Ulutan et. al [2010] studied effect of different surface treatment methods on the friction and wear behaviour of AISI 4140 steel in this study sample surfaces of AISI 4140 steel were treated by quenching, carburizing, boronizing and plasma transferred arc (PTA) modification. The microstructural characteristics of surface treated steel samples were examined by optical microscopy and scanning electron microscopy (SEM). The mechanical properties of the samples including the surface roughness, micro hardness, and abrasive and adhesive wear characteristics were also evaluated. Wear tests were applied by using a block-on-disc configuration under dry sliding conditions. The wear behavior and friction characteristics of the samples were determined as a function of sliding distance. Each sample group was compared with the other sample groups. It was observed that the carburized samples demonstrated the lowest weight losses; however, PTA-treated samples demonstrated the lowest coefficient of friction in comparison to the other sample groups at the same sliding distance [8].

Izciler, et. al.[2004] studied abrasive wear behaviour of different case depth gas carburized AISI 8620 gear steel they studied the effect of different case depth on wear behavior of 8620 steel. Experimental study carried out using pin on disc apparatus. Finding of study are (1) Evaluations concerning the SEM photography indicate that austenite particles become smaller and narrower with the increase in gas carburizing period. This is due to the small and narrow structure of AISI 8620 carburized steels. After the heat treatments, austenite particle sizes remain relatively small. (2) In respect with microstructures, samples subjected to longer periods of gas carburizing exhibit greater case depth. (3) The samples having greater case depth and surface hardness are more wear resistant than that with low case depth and low surface hardness [9].

2.1 Methodology for Analysis

Following are different steps are used
Step1: Select the Theme.
Step 2: Justify the choice.
Step 3: Understand the current situation.
Step 4: Select Targets.
Step 5: Analysis.
Step 6: Implement corrective measures.
Step 7: Confirm the Effects.
Step 8: Standardize.
Step 9: Summarize & Plan future actions.

2.2 Performance Requirement of Material

Owing to the nature of performance of UJ kit in propeller shaft, following properties are
needed in UJ cross and bearing cup.

i) Wear resistance.
ii) Impact toughness.
iii) Fatigue life.

Wear resistance – As the parts are moving in tandem with each other the surface needs to wear resistant. The wear resistance property is directly proportional to hardness and hence high hardness is a requisite (58 to 64 HRC). Impact toughness- The bearing is subjected to impact loads due to movement of propeller shaft and hence the core needs to be tough and not brittle (Hardness – 25 to 40 HRC). To achieve these dual properties with single material is not possible and hence surface treatment is necessary to achieve wear resistant surface and tough core.

3. Heat Treatment

2.3 Carburization

Carburization is simply defined as the addition of carbon to the surface of low carbon steel at temperature generally between 850-950 degree Celsius. Carburization is the most widely used method of surface hardening. It consist of enrichment of surface layers of low carbon / mild steel (c less than equal to 0.30%) with carbon up to 0.8 % to1% by this way the good wear and fatigue resistance is superimposed on a tough low carbon steel core. usually have base-carbon contents of about 0.2%, with the carbon content of the carburized layer generally being controlled at between 0.8 and 1% C. However, surface carbon is often limited to 0.9% because too high a carbon content can result in retained austenite and brittle martensite.

2.4 Nitriding

Nitriding is a surface-hardening heat treatment that introduces nitrogen into the surface of steel at a temperature range (500 to 600°C) while it is in the ferrite condition. Thus, nitriding is similar to carburizing in that surface composition is altered, but different in that nitrogen is added into ferrite instead of austenite. Because nitriding does not involve heating into the austenite phase field and a subsequent quench to form martensite, nitriding can be accomplished with a minimum of distortion and with excellent dimensional control. In this process pure ammonia dissociates by the reaction

$NH3 = 3H + N$

The atomic nitrogen thus formed diffuses into the steel. In addition to providing outstanding wear resistance , the nitride layer increases the corrosion resistance of steel in moist atmosphere. Practically only alloy steels are subjected to nitriding.

2.5 Carbonitriding and cyaniding

Carbonitriding is a modified form of gas carburizing, at a temperature range between 750 – 9000C.The modification consists of introducing ammonia into the gas carburizing atmosphere to add nitrogen to the carburized case as it is being produced. Nascent nitrogen forms at the work surface by the dissociation of ammonia in the furnace atmosphere; the nitrogen diffuses into the steel simultaneously with carbon. Typically, carbonitriding is carried out at a lower temperature and for a shorter time than is gas carburizing, producing a shallower case than is usual in production carburizing. In its effects on steel, carbonitriding is similar to liquid cyaniding. Because of problems in disposing of cyanide-bearing wastes, carbonitriding is often preferred over liquid cyaniding. In terms of case characteristics, carbonitriding differs from carburizing and nitriding in that carburized cases normally do not contain nitrogen, and nitrided cases contain nitrogen primarily, whereas carbonitrided cases contain both.

4. Experimentation Plan

It is decided to evaluate carbonitriding, nitriding and existing heat treatment process carburising.

For this following tests were planned

1) Hardness gradient study of selected processes
2) Wear test of selected processes.
3) Push out force of selected processes.
4) Endurance test of selected processes.

4.1 Tools and Test Rigs

Following tools and test rigs were used during experimentations.

1) Vickers Hardness Testing machine.
2) Optical Microscope.
3) Wear test rig.
4) Endurance Test Rig for Universal Joint.
5) Load test rig.

5. Conclusions

In this study failure analysis of bearing cup was carried out. Bearing cup assembly was produced from low carbon carburising steel and was surface treated by carburising, hardening and tempering processes. Cause and effect diagram was made to find out root cause of the failure. Analysis revealed that bearing cup was failing due to through hardening at groove, as wall thickness was less in this area which results into brittle failure during assembling process. Alternate heat treatment processes like carbonitriding and nitriding were tested on various tests like chemical analysis, microstructure study, hardness measurement, endurance test & push out load tests.

References

[1] M. Godec, DJ. Mandrino, M. jenko Investigation of fracture of car‘s drive shaft Institute of Metals and Technology Ljubljana, Slovenia, Elsevier- Engineering failure analysis 2009, pp 1252-1261.

[2] H.Bayrakceken Failure analysis of automobile differential pinion shaft Elsevier Engineering failure analysis 2006, pp 1422-1428.

[3] E. Makevet, I Roman Failure analysis of final drive transmission in off-road vehicle Elsevier -Engineering failure analysis 2002, pp 579-592.

[4] Osman Asi Fatigue failure of rear axle shaft of an automobile Elsevier-Engineering failure analysis 2006, pp 1293-1302.

[5] Dai Gil Lee, Hack sung kim, Jong woonkim, Jin kook kim Design and manufacture of an automotive hybrid aluminum/composite drive shaft Elsevier-Composite structures 2004 pp 87-99.

[6] S.A. Mutasher Prediction of torsional strength of the hybrid aluminum/composite Drive shaft Elsevier-Materials and Design 2009 pp 215-220.

[7] Kiyoshi Funatani Heat treatment of automotive components IMST Institute, Nagoya, Aichi JAPAN Trans Indian Inst. Met. Vol. 57, No.4, Aug 2004, pp 381-396.

[8] Mustafa Ulutan, Osman N. Celik, etal. Effect of Different Surface Treatment Methods on the Friction and Wear Behavior of AISI 4140 Steel‖ Elsevier-J. Mater. Sci. Technol., 2010, pp 251-257.

[9] M .Izciler, et. al. ‖Abrasive wear behavior of different case depth gas carburized AISI 8620 gear steel‖ Elsevier- Wear, 2006, PP 90-98.

[10] H sert, A. can et. al. Wear behavior of different surface treated cam spindles Elsevier- Wear, 2006, pp 1013-1019.

[11] A. Ben CheikhLarbi et al. Improvement of the adhesive wear resistance of steelby nitriding quantified by the energy dissipated in friction Elsevier Wear 2005,PP 712-718

[12] Mohamed Ali et al in Fatigue life evaluation of 42CrMo4 nitrided steel by local approach Equivalent strain-life-time Elsevier- Material and Design 33,2012 PP 444-450.

[13] D. Rodziňák1, R..Zahradníček, et al. Effect of nitridation on contact fatigue and wear damage of AstaloycrL and crM steels ActaMetallurgicaSlovaca, Vol. 16, 2010, No. 1, pp. 12-19.

[14] George Fillari, Thomas Murphy, Igor Gabrielov Effect of case carburizing on Mechanical properties and fatigue endurance limits of p/m steels.
[15] K. palaniradja, N.alagumurthi, et. al. Optimization of process variables in gas carburizing process Turkish J. Eng. Env. Sci.29, 2005, pp 279-284.
[16] C. Kanchanomai and W. Limtrakarn Effect of residual stress on fatigue failure of carbonitrided low-carbon steel ASM international- journal of materials Engineering and performance volume 17 December 2008, pp879-887.
[17] J.P. Wise, G. Krauss, et al. Microstructure and fatigue resistance of carburized steels 20th ASM Heat Treating Society Conference Proceedings, 9-12 October 2000, St. Louis, MO, ASM International.
[18] B.A. Shaw,A.M. Korsunskyet al. surface treatment and residual stress effects onthe fatigue strength of carburised gears
[19] A.C. Batista, A.M.Dias Contact fatigue of carbonitrided gears effect of residualStresses Faculadade de engenharia da universidade do porio June 2003.
[20] Chikaraooki, Kikuo Maeda et al. Improving rolling contact fatigue life of bearing steels through grain refinement NTN technical review 2004.