ScienceDirect

Materials Today: Proceedings

Volume 69, Part 3, 2022, Pages 901-907

Experimental investigation of high carbon steel MMC for crown pinion gear

R. Charles Godwin, C. Dhanasekaran

Show more

https://doi.org/10.1016/j.matpr.2022.07.367

Get rights and content

Abstract

The implementation of high carbon steel composite is growing continuously in the field of automotive and manufacturing industries because of their superior physical, mechanical and tribological properties as compared to normal steel. In automobiles, the differential plays major role to power transmission from engine to wheel. However, failure of crown pinion observed that the gear teeth have been sheared off by heat failure and edge of pinion gear is worn down caused by lubricant failure. So, this high carbon steel composite (high carbon steel+silicon carbide) could be proposed for crown pinion gear to control material wear and fracture. In this paper, the various proportions of high carbon steel composites were investigated and evaluated the characteristics of material hardness, compressive strength and material wear. The material proportions were 100–0%, 99–1% and 97.5–2.5% of high carbon steel with silicon carbide. By observing experimental results, the high carbon steel with 2% of silicon carbide have better material characteristics than other proportions and this also suggested to crown pinion gear production.

Introduction

Life expectancy of mechanical system is always dependent on the most critical component of the system. The crown wheel and pinion gears are one of the critical components in the transmission system of an automobile. Failure of this components has drastic effect on the vehicular movement. This in turn leads to increased downtime for repairs. The cost of these components adds to the criticality in addition to its function.Gear design is commonly bounded by the requirements that gear should carry high loads at high speeds with minimal size and weight. Gear wear refers to the progressive material loss from contacting tooth surface due to the combined rolling and sliding motion under mixed or boundary lubrication conditions. The direct result of gear wear includes dynamic transmission error [1], [2], [3], [4]. When one gear is mesh with other in that one is bigger than the other in that mechanical advantages achieve, with the torques and rotational speeds, of the two gears differing in part to their diameters.For gear failure mode occurring tooth bending fatigue, surface scoring and wear, contact fatigue.There are two different types of gear teeth devastation occur in gears under several freight due to fatigue known as tooth breakage in a root and teeth damage, teeth breakage of teeth is clearly worst damage case, the gear hampered operating condition or destroyed, because of this, the localized stresses in a tooth should be conceptually studied in all gear application. The crack imitation period commonly accounts for the most service life of gear, particularly in high cycle fatigue [5], [6], [7], [8].The noise and vibrations measured were very low for new set of gears and increased considerably for used gear pairs and there was a very peak rise in noise and vibration level for the damaged gear pair. By studying the sound and vibration spectrum it is possible to know the status of the given spiral bevel gear pair and it is also possible for early detection of failure of given spiral bevel gear pair during operation [9], [10], [11]. During study work, it is also seen that, the Gear failures, can be avoided if designers and operators recognize that the crown wheel is an important component of a differential unit and appreciate that the tribology of gearing requires the attention and control of many related factors [12], [13], [14], [15]. Successful diagnosis, and especially prognosis, of gear damage based on observed accelerometer responses requires that one have the capability to relate accelerometer response characteristics to physical damage on the subject gears.for the case of tooth bending-fatigue damage, precision measurements, made on a gear failed in a four-square power-circulating test apparatus, have provided strong evidence that the detectable damage feature prior to tooth breakage is plastic deformation of failing teeth, rather than reductions in tooth stiffness due to root cracks, as is commonly believed [16], [17], [18], [19].The component failure occurs in crown pinion gear were discussed by Bensely et al. The failure began in the pinion, causing the crown wheel to fail prematurely wherever the failed tooth made contact with it. The failure mode of the pinion is sub case fatigue caused by inadequate case depth. The crown wheel's

failure mode is partial uprooting. As a result, the substitute material must decrease component failure(See Fig. 1).

Section snippets

Material selection

The nature and methodology of the metal matrix composites depicts their performance and characteristics that can be assessed. Some factors for example intrinsic properties, structural arrangement of the reinforcing particles in the matrix system and the relations between the constituents are of great significance. The intrinsic properties of reinforcements and matrix system decide the general order of properties that will play an important role in the composite materials [20], [21], [22], [23], …

Specimen preparation

The test samples of proposed material have been prepared by powder metallurgy method. Powder metallurgy is a relatively common way of producing parts, particularly in the automobile industry, as it enables the high-volume production of small and intricately shaped parts with homogenous structures. In powder metallurgy, mixtures of metal (and sometimes non-metal) powders are compacted and then sintered. The manufacturing process is expensive, but the finished parts have specific advantages over…

Wear test

In this experimentation, only dry sliding wear will be considered Fig. 4 shows the setup. The actual wear mechanism for dry wear depends on a number of variables including surface finish, surface geometry, orientation, sliding speed, relative hardness, material microstructure, and more. From this variable, it can be seen that

wear rate is not pure material property and does not always occur uniformly, this experimental setup is pin on disc machine. During the wear test, loads can be applied at…

Conclusion

This investigation describes about the characteristics of high carbon steel composite material that was proposed to crown pinion gear in differential unit.The implementation of carbon steel material has been raised in field of automobile to avoid component failure due to heat. This present study shows the importance of material selection for heavy duty application by investigating the proposed materials (i.e., high carbon steel with reinforcement of silicon carbide). The thermal analysis of…

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.…

Acknowledgements

All persons who have made substantial contributions to the work reported in the manuscript (e.g., technical help, writing and editing assistance, general support), but who do not meet the criteria for authorship, are named in the Acknowledgements and have given us their written permission to be named. If we have not included an Acknowledgements, then that indicates that we have not received substantial contributions from non-authors.…

Special issue articles Recommended articles

References (27)

A. Bensely *et al.*
Failure investigation of crown wheel and pinion
Eng. Fail. Anal. (2006)

Munde Rahul M andKamble D P, “Experimental investigation and FEA of wear ingear

at torque loading conditions", IJARIIE,...

I. Bhavi *et al.*
Determination of Fatigue life of Spiral bevel gears used in automotive differential gearbox
IJERA (2017)

Prerana U. Jiwane, Prof. (Dr.) Prashant D. Deshmukh and Dhiraj K. More, "Review on Failure Analysis of a Differential...

W.D. Mark *et al.*
Static-transmission-error vibratory-excitation contributions from plastically deformed gear teeth caused bytooth bending-fatigue damage
Mech. Syst. Sig. Process. (2007)

Rohit Sreekumar and Prof. Jeyapoovan T, "Design and Analysis of a Composite Bevel Gear in An Automobile Differential...

J. Kumaraswamy *et al.*
Thermal analysis of nickel alloy/Al2O3/TiO2 hybrid metal matrix composite in automotive engine exhaust valve using FEA method
J. Therm. Eng. (2021)

S.S. Bagewadi *et al.*
Design and analysis of crown pinion of adifferential gear box for reduced numberof teeth to improve torque transmitted
Int. J. Mech. Eng. Robot. Res. (2014)

Jaehoon Kim, Jaebong Jung, Taejoon Park, Daeyong Kim, Young Hoon Moon, FarhangPourboghrat and Ji Hoon Kim,...

G. Kishore *et al.*
Experimental investigation of mechanical and wear properties of AL7075/Al2O3/MICA hybrid composite
J. Inorg. Organomet. Polym Mater. (2021)

View more references

Cited by (0)

View full text