Analysis of Fatigue Crack Growth Rate in Spur Gear Due To Bending Fatigue

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Abstract- *A computational model for determination of crack propagation rate of spur gears in regard to bending fatigue in a gear tooth root is being presented. The fatigue process leading to tooth breakage is represented as crack propagation period. The crack propagation rate is determine by plotting the graph of cyclic stress versus the crack growth rate da/dn with stress intensity factor ΔK being the controlling factor and crack length versus cycles Np. The functional relationship between the stress intensity factor and crack length K =f(a), which is needed for determination of the required number of loading cycles Np for a crack propagation from the initial to the critical length is obtained using displacement correlation method in the framework of the FEM method. The result is compare with FEM model to determine the crack propagation rate and direction of crack growth due to bending fatigue.*

Keywords- Crack growth rate, stress intensity factor , bending fatigue, FEA Model, crack length, cycle N

I. INTRODUCTION

A gear is a machine element designed to transmit force and motion from one mechanical unit to another. The design and function of gears are usually closely associated, since gears are designed for a specific function. Various types of gears have been developed to perform different functions, the most common of these being spur gears. Gears are commonly used mechanical components in power transmission and are frequently responsible for gearbox failures Like all mechanical components, gears can and do fail in service for a variety of reasons. Two kinds of tooth damage can occur under repeated loadings that cause fatigue; namely, the pitting and spallig of gear teeth flanks and tooth fracture in the tooth root. The most undesirable damage that can occur in gear units is the crack in the tooth foot as it often makes the operation of the gear unit impossible. The aim of the maintenance is to keep a gear-unit or technical system in the most suitable working condition and to discover, diagnose, foresee, prevent, and/or to eliminate damage. Obviously, the purpose of modern maintenance is not only to avoid failures but also to define the stage of gear degradation where there is significant potential for a sudden system operation failure. In most cases, except for an increase in noise level and vibration, total gear failure is often the first and only indication of a problem, out of this failure the most common failure in gear is fatigue failure due to bending fatigue. These fatigue failure is due to pitting, wearing, scoring and bending all these fatigue failure is due to vibration , improper mounting of gear , improper lubrication, hardening of gear. The spur gear test specimen is used to evaluate the fatigue failure by determining the FCPR (fatigue crack propagation rate and examine in a graphical format with stress intensity factor K and number of cycle N.

II. LITERATURE REVIEW

Structural components, such as gears, can be subjected to short–time overloads due to dynamically acting loads on gear teeth during torque transmission and because of the other excitations in gearbox that cause additional loads on teeth and leads to low–cycle fatigue damage in material. The material behaviour in low–cycle fatigue regime is described by complex material model that combines isotropic and kinematic hardening and/or softening with mechanics of material damage to simulate elastic-plastic material behaviour and damage nucleation and accumulation. Numerical modelling of fatigue damage can provide better fatigue life estimation of gears, focusing on the crack initiation period [1]. The crack beginning location and its influence on the crack propagation, theoretically the crack beginning can occur in very narrow area on the tooth root surface where the principal stresses are the highest. It is derived that the crack can appear at very different locations in tooth root and then propagates in their own way. The primary attention is focused into the loading distribution over the tooth flank, the undercutting of the tooth and to the tracks that remain from the cutting tool [2].Tooth bending fatigue is one of the most common modes of fatigue failure in gears. It results in progressive damage to gear teeth and ultimately leads to complete failure of the gear [3]. The fatigue process leading to tooth breakage is divided into crack initiation and crack propagation period. The simple Paris equation is then used for the further simulation of the fatigue crack growth. The functional relationship between the stress intensity factor and crack length K f(a),The total number of stress cycles N for the final failure to occur is then a sum of Ni and Np [4]. The gear considers the conditions required for the surface fatigue crack initiation and then allows for proper

simulation of the fatigue crack propagation that leads to the appearance of small pits on the contact surface. The fatigue process leading to pitting is divided into crack initiation and a crack propagation period. The short crack theory together with the finite element method is then used for simulation of the fatigue crack growth [5]. The failed gear had a number of adjacent teeth and random teeth breakage at one end of teeth. An evaluation of the failed gear was undertaken to assess its integrity that included a visual examination, photo documentation, chemical analysis, micro-hardness measurement, and metallographic examination. Results indicate that teeth of the gear failed by fatigue with a fatigue crack initiation from destructive pitting and spalling region at one end of tooth in the vicinity of the pitch line because of misalignment[6]. A general computational model for the simulation of contact fatigue-damage initiation in the contact area of meshing gears. The model considers the continuum mechanics approach, where the use of homogenous and elastic material is assumed. The stress field in the contact area and the relationship between the cyclic contact loading conditions and observed contact points on the tooth flank are simulated with moving Hertzian contact pressure in the framework of the finite element method analysis. On the basis of geometrical and material parameters, the initiation life of contacting spur gears in regard to contact fatigue damage can be estimated[7].

III. PROBLEM STATEMENT

Bending fatigue is one of the major failure modes of gears. Since the fatigue process is a combination of an initiation stage followed by a propagation stage which eventually leads to failure. gear, overload, inadvertent stress raiser or subsurface defect in critical area, use of incorrect material, heat treatment. Hence to gear due to bending fatigue analysed the crack growth rate during crack propagation in spur

IV. METHODOLOGY

The fatigue analysis will be done both by experimental as well as analytical method. Fatigue testing machine is used to evaluate the FCGR (fatigue crack growth rate) of spur gear. Eight different specimen of spur gear is tested according to their size and material were tested in different loading condition. The test result is evaluated by using NDT(non-destructive testing) to evaluate the crack length due to crack propagation. Test result mathematical evaluated by paris law equation, hence graphical representation of stress intensity factor ΔK v/s da/dn is evaluated . These result will be compared with FEA model and determined the crack growth and direction of crack

B. Use of Simulation software

The anlaysis of spur gear is done on anysys14.0 software to analysis the crack propagation and to evaluated the result.

The result were compare with the analytical experimental result and compared each other.

1) The method of crack in gear or notch on gear is done by standard testing method.
2) The analysis can be done on FRAC2D and 3D will be more accurate.
3) The graph should be Minitab software for accurate and well define.

V. IMPROVEMENTAS PER REVIEWER COMMENTS

1) The tensile testing method is used for crack generation.
2) As Ansys Software is user friendly so it is used for analysis.
3) The graph should be done in Minitab only.

VI. CONCLUSION

The fatigue crack analysis in spur gear is tested experimentally and analytically to determine fatigue crack growth rate and the direction of crack growth and comparing the result of stress intensity factor to determine crack growth rate. The FZG gear test rig was applied to study and analyze the Bending fatigue strength of spur gear by using the theory of mathematical statistics and reliability.. The fatigue process leading to tooth breakage in a tooth root is to determine the number of crack propagation cycles Np. It is assumed that the crack is initiated at the point of the maximum principal stress in a gear tooth root, which is calculated numerically using FEM. The displacement correlation method is then used for the numerical determination of the functional relationship between the stress intensity factor and crack length K=f(a), which is necessary for consequent analysis of fatigue crack growth, i.e. determination of stress cycles Np. Use of stress

intensity factor for predicting crack growth behavior in different loading conditions. Experimentation for determination of fatigue crack growth on spur gears to establish expression for fatigue crack growth rate. Validation of experimental results is done by Finite element method.

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