Global Journal of Researches in Engineering: A
Mechanical and Mechanics Engineering
Volume 17 Issue 3 Version 1.0 Year 2017
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN:2249-4596 Print ISSN:0975-5861

The Influence of the Initial Technological Residual Stresses on the Bearing Capacity of Crankshafts Boosted Diesels When Plastic Deformation

By Nadezhda Marina
National Research Nuclear University

Abstract- The exact manufacturing techniques of cranked shaft from stamped preparations at size provide indemnification of influence of the layer not strengthened without carbon from the differentiated water stream of processing, that, in turn, demand research of influence of initial technological residual pressure on the basic loading of the strengthened cranked shaft.

Keywords: the analysis of fatigue failures, revealing of concentrators of pressure, initial technological residual pressure, superficial hardening.

GJRE-A Classification: FOR Code: 091399p

The Influence of the Initial Technological Residual Stresses on the Bearing Capacity of Crankshafts Boosted Diesels When Plastic Deformation

Nadezhda Marina

Abstract- The exact manufacturing techniques of cranked shaft from stamped preparations at size provide indemnification of influence of the layer not strengthened without carbon from the differentiated water stream of processing, that, in turn, demand research of influence of initial technological residual pressure on the basic loading of the strengthened cranked shaft.

Keywords: the analysis of fatigue failures, revealing of concentrators of pressure, initial technological residual pressure, superficial hardening.

I. Introduction

Fatigue strength of modern crankshafts of combined boosted diesel engines with alternating dynamic loading is provided mainly by the reduction of existing dynamic stresses by increasing the size of the cross sections, the neutralization of the stress concentration and the use of high-strength materials. The problem of increasing of the utilization ratio of the material in the manufacturing of crankshafts by applying blanks with high accuracy of production is of great importance. Under these conditions, other ways of increasing fatigue resistance, which are connected with the progressive and highly effective methods of strengthening only in those parts of a construction where fatigue failure is possible is of much greater importance.

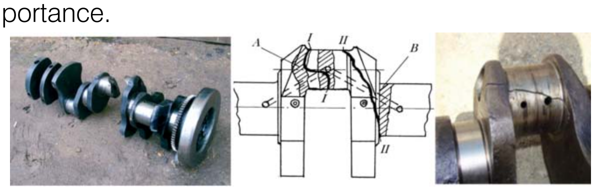

Figure 1: Most Common Crankshaft Damages in Stress Concentration Areas: A) on crank pin; B) on the cheek

Analysis of fatigue failures of crankshafts in the area of the oil hole in the crank pin and on the cheek from the action of the bending moment in the plane of the knee shows that the nucleation of fatigue cracks in the fillet radius of the transition of the crank pin into the cheek and on the oblique section of the connecting space pairing cheeks with crank pin is observed. A similar pattern of fracture developing indicates a high level of working stresses from the bending loads and their presence in a high concentration. To reduce the stress concentration and increase the carrying capacity of the crankshaft fillet zone it would be advantageous the use of surface plastic deformation - hardening of the transitional radius of the indigenous and crankpins of the crankshaft into the cheek with hydro crusher treatment (HCT), which allows to control the properties of the surface layer formation of an initial processing of residual stresses (IPRS) compression. Under the alternating loads the arrangement of the distribution of last in depth of the surface layer of the crankshaft elements is not the main thing in comparison with the magnitude and sign of the stresses on the surface [1]. Therefore, the properties of the hardened differentiated HCT of crankshaft are influenced by IPRS axial compression directed along the cheeks and counterweight, as axial compression coincides with the developing dynamic working stresses. In addition, low-waste technology in the manufacturing of crankshafts by applying blanks with high accuracy of production provides for compensation for softening the impact of the decarburized layer of differentiated HCT, which, in turn, requires a study of the effect on the carrying capacity IPRS of hardened crankshafts. In the technical literature there are no publications on generalizing the problem of increasing the fatigue resistance of crankshafts with differentiated HCT and this fact retards the development of research and the practical use of the results in this field.

II. Results and Discussion

For a comprehensive evaluation of changes in physical and mechanical condition of the surface layer in the zone of stress concentration at the fillet radius of the zone of the crank pin of crankshaft with differentiated HCT testing plate are used at Volgo Diesel - MAMINS as samples witnesses made of hardenable material items, while believing that the static deflection is a measure of the intensity and stability of the process with differentiated HCT of a hardenable structure. However,

Author: assistant professor, Balakovo Engineering and Technological Institute, a branch of the National Research Nuclear University MEPI, Russia, 413800, Balakovo. e-mail: rdan64@mail.ru

vibro-impact loading of the crankshaft and the testing plates - witnesses with differentiated HCT is different from static one that requires to take into account the comprehensive criterion - the coefficient of dynamic load CD. The research conducted on the flat sample witness of rectangular cross section have determined that the HCT parts K_D is= 1.2 [2]. Since IPRS compression distort the shape of fillet radius transition new approach for assessing IPRS under vibro-impact dynamic loading. Approximate analytical assessment of this form of distortion can be done by considering the state of stress separate strips fillet area of the sample-witness in the form of radius element the width of which is b (φ = 45 °) going perpendicular to the axis of the fillet area and determining the change of sag deflection Y_0 under the influence of the induced residual stresses (Fig. 2).

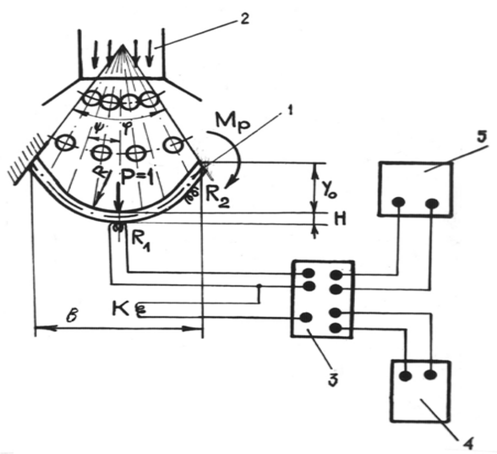

Figure 2: Research diagram of the initial processing of the residual stresses in the sample-witness (fillet area) of crankpin and radical pin of crankshaft with differentiated HCT.

Moment M_R formed as a result differentiated HC treatment deforms the element in question in the direction of reducing the sag deflection. Since the ratio of the sample thickness H to the radius R is small, the internal force factors Q and N are not taken into account, and based on the known dependence Mora for crooked timber for linear static change Δip deflection has the form

$$\Delta_{ip} = \int_0^{\varphi/2} \frac{M_p \bar{M}_i R d\varphi}{EI} + \int_{\varphi/2}^{\varphi} \frac{M_p \bar{M}_i R d\varphi}{EI} \qquad (1)$$

where $\bar{M}_i = PR\sin\psi = R\sin\psi$ the bending moment from a unit force P = 1 applied in determining the deflection.

Whereas $\int_0^{\varphi/2} \frac{M_p \bar{M}_i R d\varphi}{EI} = 0$ after the transformation $\Delta_{ip} = \frac{0.2 M_P^0 R^2}{EJ}$, and the moment $M_P = bh\sigma_x^0 \frac{H}{2}$, where h - depth of plastically deformed layer, calculated according to well - known technique [1].

Thus,

$$\Delta_{iP} = \frac{0{,}1bHR^2\sigma_x^0 h}{EJ} \qquad (2)$$

where σ_x^0 - initial residual stresses in the- radius zone of the sample –witness at technological static loading.

The amplitude of the dynamic plate deflection with differentiated HCT is $\Delta_{iP Д} = К_Д \Delta_{iP}$. The dynamics of loading from HCT IPRS in radius area of the sample-witness

$$\Delta_{iP} = \frac{0{,}1bHR^2\sigma_x^0 h}{EJ}, \qquad (3)$$

For the experimental evaluation σ_{xx}^0 in a separate strip of fillet zone after differentiated HCT at Volgo Diesel - MAMINS special research a block diagram of which contains cantilevered thin surface element 2 radiuses R (Figure 3), which is a one-sided cavity treated with vibro-impact from the nozzle 1 in the chamber installation GDEU-5 was conducted. Working R_1 and R_2 and the compensating K strain resistor included in the amplifier 3 strain resistor station 8ANCH TM were glued on the opposite side of the unreinforced surface element R_2 was installed on a flat plot of the element in the immediate vicinity of R_1, glued to the curved area. This scheme allowed installation of strain gages to investigate the state of stress of both flat and rounded fillet area, thus eliminating errors associated with changes in the state of stress at the ends of the samples (edge effect). The converted signal of dynamic deformation of the surface element on the loop oscillograph recorded 4 brands H-115. The circuit is powered from the power P-131. Before carrying out research working resistors were statically calibrated on the special device with the task sag deflection micrometer and its monitoring by indicator. Oscillograms of dynamic stresses in the zone of their concentration in the HCT and on the flat part of the surface of the element were received/ (Figure 3a, b).

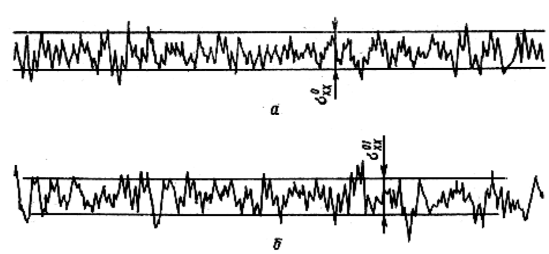

Figure 3: Oscillograms of Dynamic Stresses in Zone of Their Concentration in Sample-Witness with HCT: a) from gage R_1; b) from gage R_2

Initial technological residual stresses on the flat part of the sample at its removal from hydro crusher setting were determined according to the technique for a flat rectangular element

$$\sigma_{xx}^{01} = \frac{8E}{l^2}\left(\frac{H}{2} - h\right) y_c,$$

where y_c - static deflection amplitude of the cantilever plate.

Taking into account the nature of the vibro-impact loading sample witness with differentiated HCT, this expression is replaced by the amplitude of the amplitude y_C y_0 known relation $y_0 = K_D \cdot y_c$.

III. Conclusion

According to the latest formulas for cantilevered plates in a cell radius fillet area of the crank pin and crank engine crankshaft 6CHN21/21 define IPRS in a hollow on a flat plot and concentration factor IPRS at l = 0.04M, H = 2 · 10-4M, h = 2,82 · 10^{-4}M, σ_{xx}^{0} = -110MPa, σ_{xx}^{01} = -75MPa, α_σ = 1,5.

The foregoing leads to the following conclusions. During the study found that IPRS compression in rounding conjugation of the main and connecting rod journals and the crank web at differentiated HCT create the same stress concentration as well as operating stresses by the external loading of the crankshaft. The study of the crankshaft optimal profiles using plain models of the polarization-optical method [3] proves the foregoing: α_σ=1.7. This circumstance must be taken into account when assessing the reserves of the crankshaft fatigue strength. Using the differentiated HCT the adverse development of effective stress concentrators can be neutralized and the effect achieved can be greater than structural changes in the shape of parts, for example by means of the stress deconcentrator. It should be noted here that the effectiveness of stress concentration reducing by differentiated HCT is 40% in comparison with 19% effect from the deconcentrator.

The work is done under the financial support of the Ministry of Education and Science of Russia - UIN FTP RFMEFI57414X0015 and government order of the Ministry of Education of Russia № 9.896.2014 / K
Literature

References Références Referencias

1. Podzeya AV Technological residual stresses - M: Mechanical Engineering, 1973 - P.156.
2. Rykovsky BP, Smirnov VA, Schetinin GM Local hardening machine parts surface hardening. - M: Mechanical Engineering, 1985 - P.14-16.
3. Kosirev SP, NL Marina Vibration aging technology crankshafts boosted diesels // TNT, Stary Oskol. 2012 144p.

This page is intentionally left blank