

Modeling of Stressed State Crankshaft of Boosted Diesels

Nadezhda Marina¹

¹ National Research Nuclear University

Received: 11 December 2016 Accepted: 2 January 2017 Published: 15 January 2017

Abstract

The high alternating dynamic loads on the crank mechanism set for diesels challenge improve operational reliability connecting rods and crankshafts, which can not be solved without a large complex of scientific research. As the experience of JSC «Volzhsky diesel them. Mama's» study the stress state of the connecting rods in a factory bench tests are expensive, require additional time and cost deadlines constrain the development of serial production of diesel engines. Solve the problem can be analytically using numerical methods of strength of materials, theory of elasticity, finite element. However, this approach is real only if the disposal of researchers of modern computer technology and software, corresponding to the level of complexity of tasks. But even then it prompt decision possible under the condition that the design of the new part of the crank mechanism is not very different from what a mathematical model which is already there. Otherwise, the time and labor costs increase appreciably. So often cheaper and faster to determine the stresses arising in the details, experimental methods - on physical models.

Index terms— the high alternating dynamic loads on the crank mechanism; increase operational reliability; the polarization optical method.

1 Introduction

he problem of increasing of operational reliability of crankshafts boosted diesel engines is especially important due to the impact of variables dynamic loads, causing metal fatigue cracks. One of the main means of solving of the research problems of crankshafts or their models with high gradients of stress to determine stress points and obtain a picture of the whole area of the structures are the following physical methods: brittle lacquer method, moiré fringe method and polarization-optical method.

2 II.

3 Methods

A prospective way to study the stress-strain state of the structures of the engine is the modeling on planar and three-dimensional photo elastic models. The solution of the problems in terms of stresses and isostatic model of the connecting rod [1] is known, and it resulted in qualitative pictures and diagrams of isochors and quantitative distribution of stresses in fringe arrangement. In comparison with other methods this polarization-optical method eliminates the full-scale research designs that require bulky and expensive equipment for loading, register the stress pattern along the crankshaft continuously, which is its main advantage. The accuracy of the polarization-optical method increases in locations with high stress gradient and does not depend on the environment. In comparison with the non-contact physical methods such as a method of brittle lacquer and method of moiré fringes the polarization-optical method makes it possible to get results the directly with high accuracy and with little expenditure of funds.

Polariscope with diffuser is taken as an instrument for the study of stress-strain state of crankshafts with polarization-optical method [1]. It should be noted that such polariscopes were not used in our country, and

43 significant research effort was applied to optical systems for the creation of parallel light beams. There is no
 44 information on the study of model of the crankshaft engine with polarization-optical method in the technical
 45 literature.

46 4 III.

47 5 Main Part

48 At JSC «Volgo Diesel -Mamins» the reduced scale models of the crankshaft were made of optically active material
 49 based on epoxy resin EH-5 of hot curing. Manufacturing technology of material includes the development and
 50 forms making, blending of components, pouring the mixture into molds, polymerization, forms disassembling and
 51 annealing the workpiece.

52 Plasticizer (dibutyl phthalate) is added into preheated to 80°C epoxy, and then the polymerization accelerator
 53 (dimetilalanin) and at last hardener (methyltetrahydrophthalic anhydride) in an amount of up to 40% are
 54 introduced. After the addition of each component, the mixture is thoroughly stirred at a constant temperature
 55 of 80°C. The prepared mixture is poured into preheated to 50-60°C forms. Polymerization of the material takes
 56 place in an oven under the condition of a slow rise in temperature. The main property of the elastic model
 57 of crankshafts used in the study of stress-polarization optical method is their optical sensitivity, which is an
 58 indicator of the stress ratio or the price of a strip of material [2]. High optical sensitivity of the used material
 59 gives the simplicity and accuracy of measurement. To determine the stress optical ratio flat calibration pattern
 60 in the form of a disk, which was tested for compression by diametrically applied forces (Figure ??) was produced.

61 6 Figure1: Flat Calibration Sample

62 Simultaneously with the optical constant measurements longitudinal and transverse strains disk to determine the
 63 elastic modulus and Poisson's ratio for the formulas of the theory of elasticity () () [] (4 4 4 1 2 1 1 2 t t D t
 64 D D ? ? ? ? ? ? ? ? = ? ? ? , ? ? μ ? ? ? ? ? = 1 2 1 1 1 2 4 4 t t t D D D

65 where P -force disk compression; D 1 and D 2 -length of horizontal diameter of the disc before and after
 66 loading; t 1 and t 2 -center thickness of the disc were carried out. In the given case??? ? 8 10 34 ? = , 37 , 0 =
 67 μ .

68 To investigate the polarization-optical method models of the crankshaft were placed between the polarizer and
 69 analyzer, and their loading was carried out in the load frame via a hard disk with a bolt.

70 By modeling the loaded state of the crankshaft qualitative pictures and diagrams of quantitative isochors
 71 expressed in distribution of fringes arrangement of quasi-static stresses on the loaded circuit model (Figure 2)
 72 have been obtained.

73 7 Conclusion

74 By modeling the stress state of the crankshaft by polarization optical method qualitative pictures of the isochors
 75 for different models of the tribe of the crankshaft and diagrams of the quantitative distribution of stresses in
 76 fringes arrangements. On the basis of fringe patterns processing theoretical stress concentration factors in the
 77 fillets of the crankshaft are defined. Realized and studied according to the proposed method fillet crankshaft
 78 optimum profile for the engine 6??21/21 provide reduced theoretical stress concentration factor from 2.4 to 1.7,
 79 i.e. 30%, as confirmed by studies on flat models of crankshafts. It allows optimizing and reducing the value
 80 of the maximum stress at a minimal structural changes and increase service life and operational reliability of
 81 crankshafts boosted diesels. Considerable optimization of the distribution of stresses in the fillets of crankshafts
 82 can be achieved by a set of structural measures to reduce both the total related to the form of knee-shaft, and
 83 the local stress concentrations, depending on the relative curvature and shape of the profile of the fillet.

84 When determining the causes of the accident of crankshafts according to the nature of the fracture it is
 85 necessary to find out its root cause that led to the stress concentration and the place where the sequential
 86 formation of a fatigue crack started. In this case the main problem is to retard cracking, to remove and disperse
 87 crack stress concentrators from the tops. In this connection the selection of process of a method of surface
 88 plastic deformation by the artificial creation of the initial processing of the residual compressive stresses [2] on
 89 the elements of the crankshaft is required.

90 The work is executed at financial support of the Ministry of education and science of Russia -UIN FTP
 91 RFMEFI57414X0015, and government job of the Ministry of education of Russia ? 9.896.2014/K. ¹

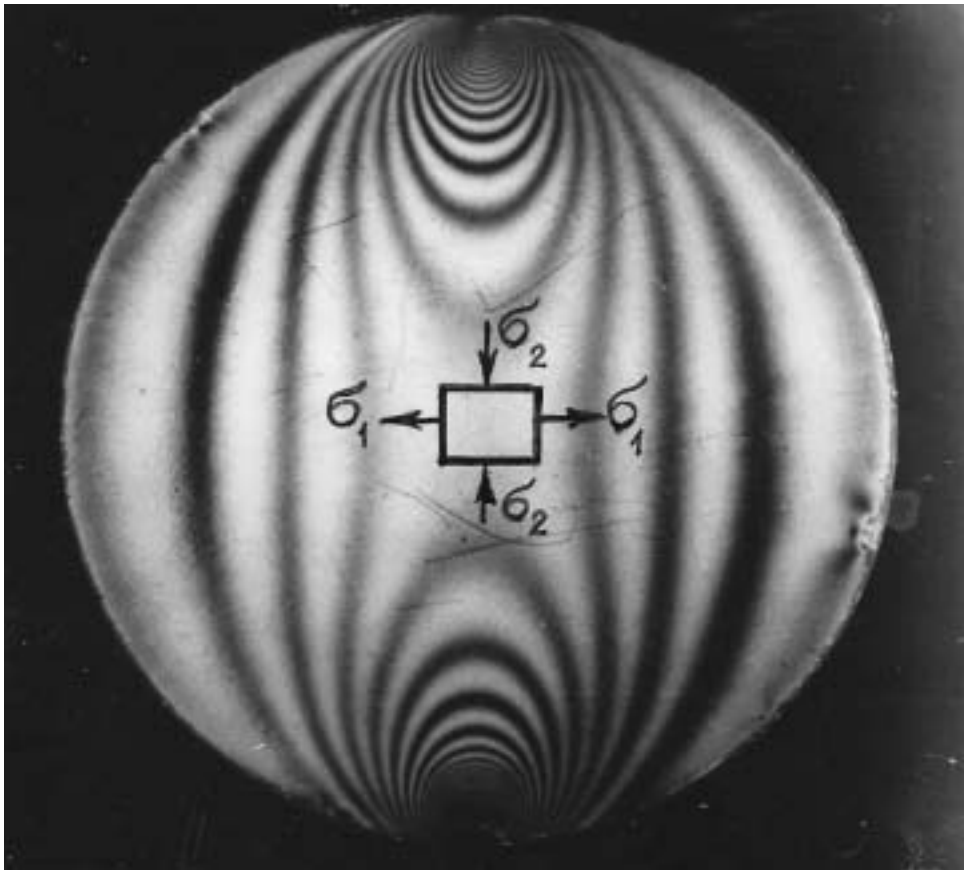


Figure 1: A

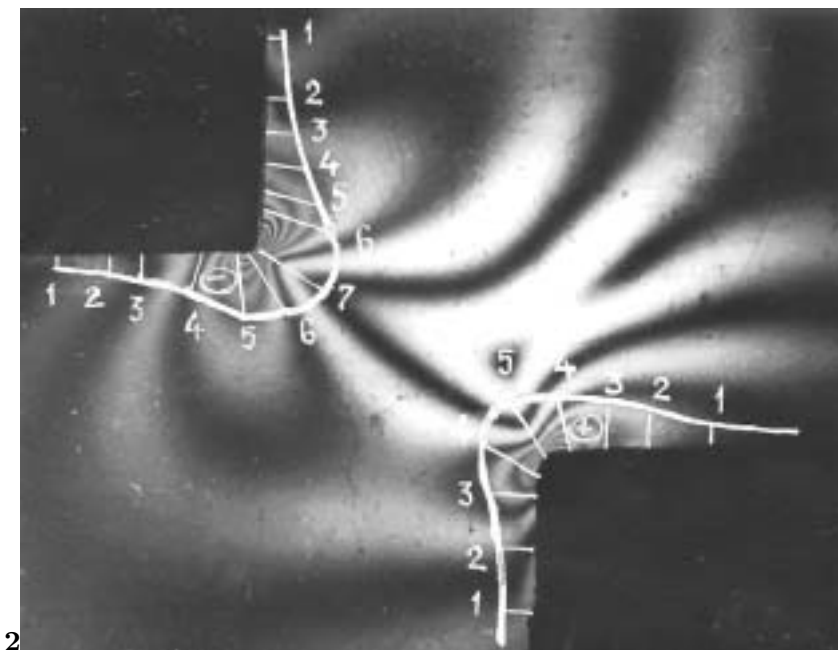


Figure 2: Figure 2 :

1

Options	The maximum order of the bands	Nominal order strips	The theoretical stress concentration factor
crankshaft fillets	n_{\max}	n_{nom}	$k = n_{\max} / n_{\text{nom}}$
1	6	2,5	2,4
2	5	3	1,7
3	10	4,5	2,2

Figure 3: Table 1 :

92 .1 Global

93 [Kosyrev and Marina ()] *Elements of information systems management monitoring of the stressstrain state of*
94 *rods of boosted diesels*” Publisher “Exact high technologies, S Kosyrev , Marina . 2013. Sary Oskol. 190.

95 [Kosyrev and Marina ()] *Fundamentals of the theory and experiment in terms of technological surface plastic*
96 *deformation of crankshafts elements*, S Kosyrev , Marina . 2010. Saratov. 116. Saratov State Technical
97 University