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Visegrad Fund

STOWARZYSZENIE MENEDŻERÓW JAKOŚCI I PRODUKCJI

ISBN 966150773-2

9 789661 507738

TOYOTARITY

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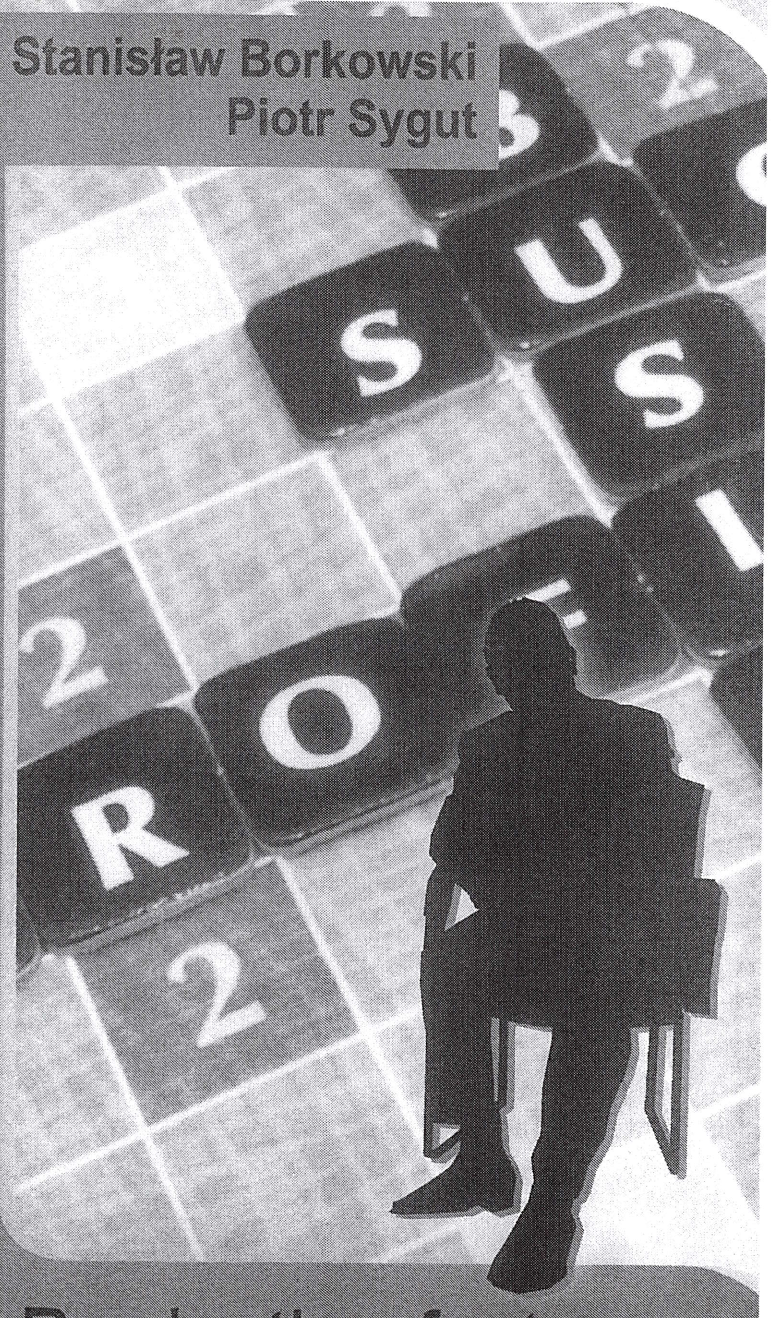

Production factors

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TOYOTARITY.

PRODUCTION FACTORS

DNIPROPETROVSK 2011

UDC 629.33:658.8
B 25
ISBN 978-966-1507-73-8
Publisher Yurii V. Makovetsky
Dnipropetrovsk, 2011

Reviewers:

Prof. dr hab. inż. Tomasz Lipiński - chapters 1÷5
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TOYOTARITY. PRODUCTION FACTORS

B 25 BORKOWSKI STANISŁAW , SYGUT PIOTR: TOYOTARITY. PRODUCTION FACTORS: Monography/ Stanisław Borkowski, Piotr Sygut – Dnipropetrovsk: Makovetsky, 2011 – 176p. — ISBN 978-966-1507-73-8

UDC 629.33:658.8

TOYOTARITY. PRODUCTION FACTORS

MONOGRAPHY

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Print of monography was financed in the frame of International Visegrad Found (1130004)

Visegrad Fund

Published by: Yurii V. Makovetsky, Dnipropetrovsk 2011

ISBN 978-966-1507-73-8

Cover design: dr inż. Monika Górska

Printing: AWR Edytor, Katowice, Polska, tel. + 48322033719

gender, age, education, work experience, number of jobs in the career and employment mode. From the responses and their analysis showed that most workers are young educated people, for whom the current work is one of the first in their careers. They are supported in their efforts by some staff that can boast of a practical skill learned by years of experience in the industry. This characteristic is extremely beneficial for businesses because of the enthusiasm of young people and their knowledge, which is supplemented by the experience of older colleagues. This structure may result from the financial turmoil and the car, which upset them in recent years. Exemptions from this period are carefully and professionally conducted supplemented by the recruitment process. During the test, respondents were asked to evaluate the factors involved in the production process. The most important factor was considered CP (continuous disclosure issues, 21.3%) followed by PE (stop the production when it detects a problem of quality, 19%) and ST (the sole use of reliable technology, 18.9%). Evaluated the employees were of the opinion that the reliability of production largely depends on the use of fault-free technology and the immediate cessation of production when producing a defective product.

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Chapter 3

Zorica Kovačević [1], Zoran Karastojković [2], Vujadin Aleksić [3]

ON-SITE METALLOGRAPHY & REPLICA METHOD FOR INSPECTION CONNECTING ROD MATERIAL AND CRACKS DETECTION

Abstract: Testing of materials properties is usually a discipline for the quality assurance during manufacturing processes. In condition monitoring, certification or upgrading of existing plants and in failure analysis similar benefits from non destructive testing of materials properties can be achieved. Another benefit from the Non Destructive Metallography (NDM) is that the test can be made on-site.

NDM is a well established and proven tool to help determine the integrity of generator and hydro turbine components during their life-cycle in power plant environments. On-site metallography of components makes it possible to evaluate a material's microstructure. It allows microstructural analysis of large components that are difficult to move or not permitted to be destructively tested, enabling rapid evaluation of the material.

Here are monitored the microstructural changes and crack detection in St 35 connecting rod steel after approximately 15 years in service.

The paper includes a short description the replica method as a technique for microstructural examination of components by using nondestructive testing method.

Key words: NDM-metallography, replica method, microstructure changes, connecting rod

3.1. About water turbines

Water turbines are machines that convert hydraulic energy into mechanical energy. This conversion is possible in a complex harnessing called hydro power plant (HPP). Usually, the mechanical energy further

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is converted into electrical energy, in the same harnessing, using electrical generators.

There are three basic types of hydro turbines:

- impulse,
- reaction and
- submersible propeller.

All produce clean energy or green energy - power from renewable resources.

There are low-, medium- and high-head turbines. They are also classified as having a vertical or horizontal orientation. Schematic View of a Hydro Power Station are shown in Fig. 3.1.

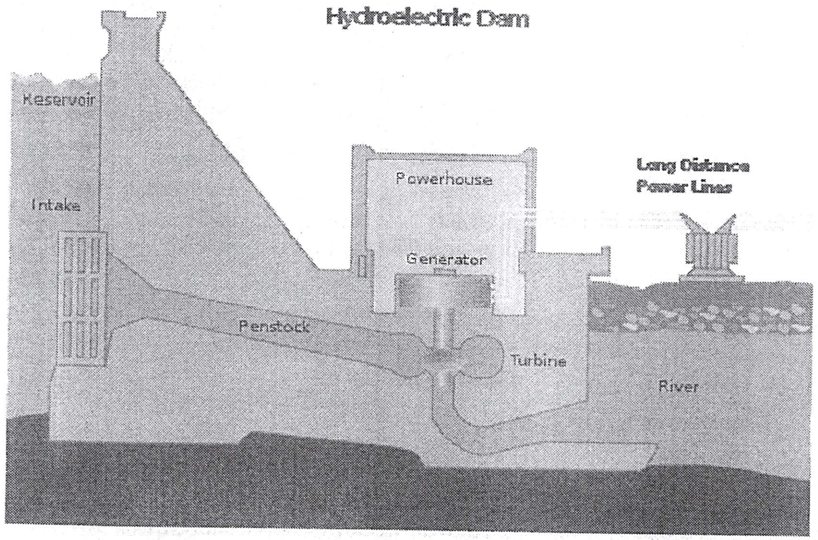

Fig.3.1. Schematic View of a Hydro Power Station, vertical orientated turbine. The connecting rod is between turbine and generator.
Source: http://en.wikiversity.org/wiki/File:Hydroelectric_dam.svg

Such equipment is of the crucial importance for all consumers of electricity in the state.

3.2. Forgings Connecting Rods

For certain purposes, the machine components should be forged. The hammer exerts compressive pressure on a relatively small area. During forging a high degree of crystal grains refinement is obtained. The importance of finishing temperature at hot-forging as in other hot-working deformation processes is well known. The lower finishing temperature at hot forgings is sometimes affected by the presence of brittle ranges in a material. A low finishing temperature may lead to cold-working effect(s), which is indicated as a high value of the ration of yield stress to ultimate stress, either at static or alternate loads.

The sketch of a hydraulic piston which will be a subject in this investigation is shown in Fig. 3.2.

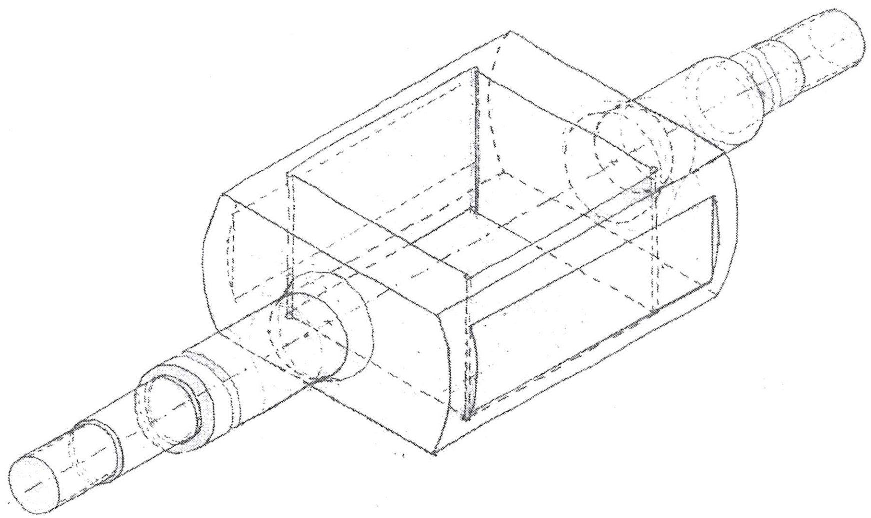

Fig.3.2. Sketch of finished hydraulic piston rod.
Source: own study

For producing a long forged piece, the hot-working deformation is obvious. At forging of a large piece, the deformation is localised. The high rate of forging permittings also great deformations, while the temperature drop must be kept in close limits. Hammering between flat dies may have lead to the causing the compression stresses. At the cold edge, an additional (even tensional) stresses may be introduced by fast&irregular cooling or similar technological factors.

Medium carbon steels are available for forgings for general engineering purposes as like: turbo-electric rotors, die blocks, gears, large hydraulic pistons, etc. In order to work those products the large ingots are necessary, and the large press must be used.

3.3. Monitoring of turbine components

Monitoring is performed either as stationary and rotating components on the turbine.

Components that are typically inspected for monitoring may include: bearings, bearing housings, pedestals, gears, blades, LP rotor, bolts, etc. Monitoring of power plant components (KOVACEVIĆ Z., KARASTOJKOVIĆ Z., et al. October 2009), (KOVACEVIĆ Z., KARASTOJKOVIĆ Z., et al. September 2010) involves a variety of approaches to obtain comprehensive knowledge of the service component condition.

3.4. Macrostructural Analysis

Macroanalysis is the examination of the structure usually by the naked eye or magnifying glass, up to 60X. This way enables an inspection at once a large area of a product. From that reason, the macroanalysis is more often used for a preliminary than final examination of metal product(s). But, after taking the results of macroanalysis, for certain details the microanalysis must be selected.

The macroanalysis can detect the number of different defects such as: gas blow-holes, shrinkage porosity, eventually improper conditions of melting/casting, cracks formed during forging or heat treatment, etc. By

using a surface-etching reagent it is possible to reveal the nature of segregation(s) and flow lines of deformed metal during forging just at the surface of investigated pattern. It is clear that surface-etching reagent cannot, however, replace the deep-etching reagent(s) or other non-destructive testing methods for discovering the internal faults.

3.5. Microstructural Analysis

The microstructural study of a material can provide information regarding the morphology and distribution of constituent phases as well as the nature and pattern of certain crystal imperfections. Optical metallography is a basic tool of material scientists, since the equipment is relatively inexpensive and the images can be obtained and interpreted easily. Distribution and morphology of the phases can be studied and, if their properties are known, a quantitative analysis of the micrographs provides some information about the bulk properties of the specimen.

The specimen surface is polished and subsequently etched with appropriate reagents before microscopic examination. Etching results in preferential attack or preferential colouring of the surface.

Failure analysis depends a great deal on metallographic examination. Crack determination is important to help establish the root cause of a potential failure in a component. After a preliminary evaluation of the crack to assess crack shape and length by using magnetic flux or dye penetrant, the replica method is then used on unetched specimens to assist in the crack evaluation (KARASTOJKOVIĆ Z., KOVACEVIĆ Z., et al. Belgrade 2010), (KOVACEVIĆ Z., KARASTOJKOVIĆ Z., et al. May 2011).

Fig.3.3. schematically shows the possible propagation of profiles different types of cracks in a steel structure. Each crack has its own characteristics, and it is often possible to make a correct determination of crack type. It is important to determine whether the crack is the original defect or has been caused by service conditions or damage. Once the crack type is identified, the proper corrective action, such as eliminating a corrosive environment or reducing stress levels, can be attempted

(KOVACEVIĆ Z., KARASTOJKOVIĆ Z., et al. June 2011), (KOVACEVIĆ Z., KARASTOJKOVIĆ Z., et al. October 2011).

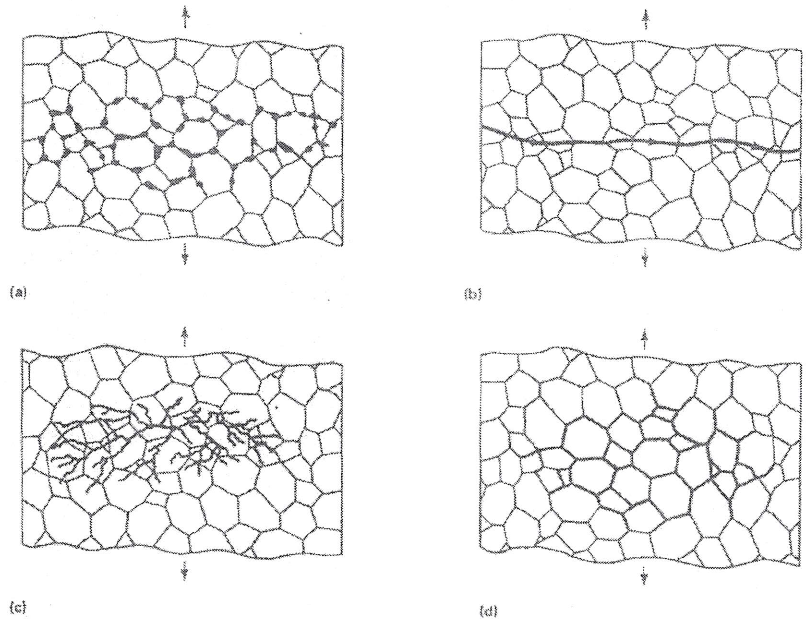

Fig.3.3. Propagation of different crack types caused by: (a) Creep, (b) Fatigue, (c) Stress corrosion, (d) Intergranular corrosion.

Source: ASM Handbook, Volume 17, p54

3.5.1. Nondestructive Metallography

Testing of materials properties is usually a discipline for the quality assurance during manufacturing processes. Tests on finished or almost-finished components may preferably be non destructive. In condition monitoring, certification or upgrading of existing plants and in failure analysis similar benefits from non destructive testing of materials properties can be achieved. Another benefit from the Non Destructive Metallography is that the test can be made on-site.

Nondestructive Evaluation (NDE) Methods is a well established and proven tool to help determine the integrity of turbine in power plant environments.

The most known conventional NDE methods are: visual testing (VT), penetrant testing (PT), magnetic particle testing (MT), ultrasonic testing (UT), radiography testing (RT) and eddy current testing (ET).

Materials Properties to be tested by NDM frequently obviously include one or more of the following methods:

- Replication technique,
- Hardness test,
- Chemical composition.

Replication technique

Replication techniques can be classified as either surface or extraction replication. Surface replicas provide an image of the surface topography of a specimen, while extraction replicas lift particles from the specimen.

Replication of a surface can involve either direct or indirect methods. In the direct, or single-stage, method, a replica is made of the specimen surface and subsequently examined in the microscope, while in the indirect method, the final replica is taken from an earlier primary replica of the specimen surface. Only the direct method will be considered in this article. The most extensively used direct methods involve plastic, carbon, or oxide replica material.

As illustrated in Fig. 3.4., the plastic replica technique involves softening a plastic film in a solvent, applying it to the surface, and then allowing it to harden as the solvent evaporates. After careful removal from the surface, the plastic film contains a negative image, or replica, of the microstructure that can be directly examined in the light microscope or, after some preparation, in the electron microscope.

Several materials, including acetate, acrylic resin, and rubber, can be used in the surface replica technique.

Plastic replicas lend themselves to in-plant nondestructive examination because of their relative simplicity and short preparation time. Plastic replicas can be examined with the light optical microscope, the scanning electron microscope, and the transmission electron microscope, depending on the resolution required.

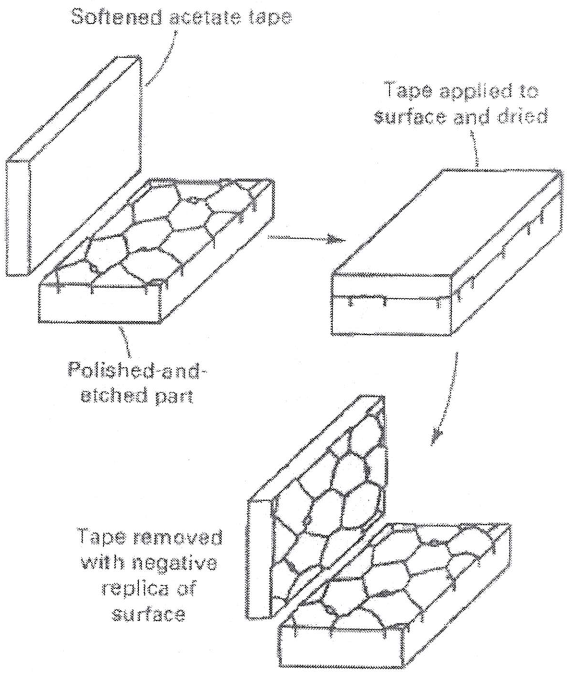

Fig. 3.4. Schematic of the plastic replica technique.
Source: ASM Handbook, Volume 17, p53

One of the great advantages of the replica technique is that efficient preparation and collection of copies can be made on site by skilled personal and the evaluation can be done in the laboratory with the best microscopes by qualified metallurgists. Further the results can be

documented by photos, and the replicas stored for comparison with later retesting.

3.6. Experimental results and discussion

The hydro-power generator plant always is a complex in structure. The connecting rod is just a part in such structure. Hydro-power plant, water turbines and similar parts/components from equipment are available for analysis from many aspects. Here are monitored the micro-structural changes that have took place in connecting rod material, after servicing in a pretty long period, about 15 years.

The using replica method for monitoring the microstructure quality has the sense only by periodically investigation and comparison of obtained with previous results.

In the moment of forging production of a new part, it is clear that all consequences whish would arise from the servicing conditions simply are not predictionable or visible. Here are described some examples of cracking at one hydraulic piston, when all parameters about mechanical or chemical requirements are satisfied in the moment of production, but inspite of this the piston is failured in servicing.

Such discontinuities could not be explained by regular working conditions of a hydraulic component, but the just from the quality of forged&heat treated product.

For obtaining those irregularities at the surface just near the square part of forged connecting rod are responsible the melting and refining regimes, also forging while machining (either turning or milling) operations could not be responsible for detected faults.

Micro- and macro cracks could be successfuly registered by replica method. This method used to detect metallurgical inhomogeneity or discontinuity on the surface of metals.

Scetch of connecting rod and places for replica R1 and R2 monitoring are shown in Fig. 3.5.

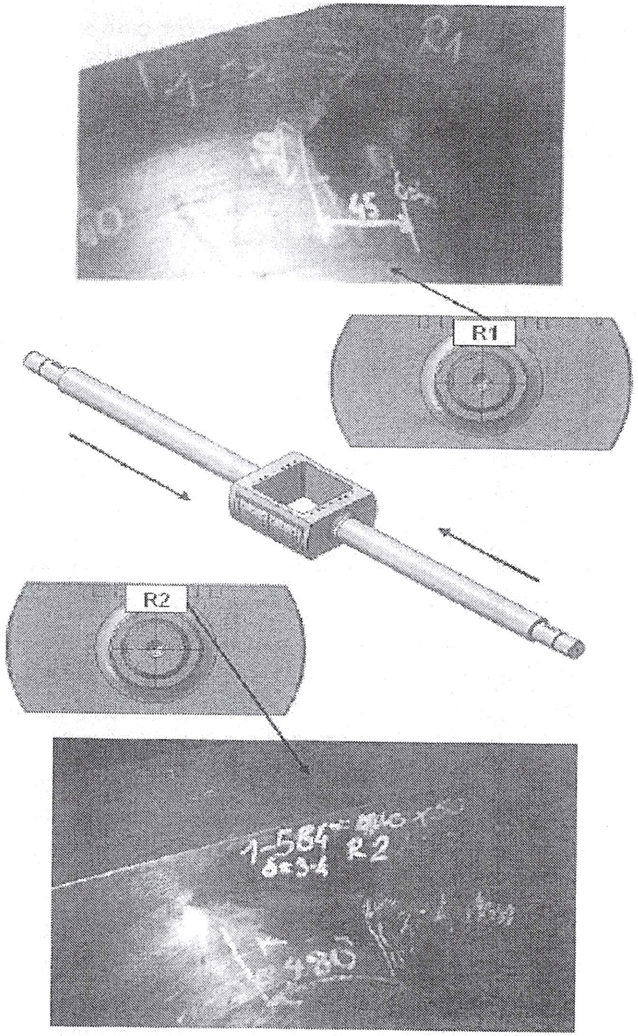

Fig. 3.5. Scetch of connecting rod and places for replica monitoring.
Source: own study

At areas where replicas R1 and R2 were taken, also were determined chemical composition and hardness measurements.

3.6.1. Visual Inspection

The classic visual inspection is the simplest test method and can be carried out without great expense. Basically, it is conceived as initial inspection to detect all major visible on-site nonconformances, deterioration, obstruction to strain, etc.

All further measures are substantially influenced by the results obtained from such visual inspections.

3.6.2. Chemical composition

The material from which connecting rod is made corresponding to the quality Ст 35, according to standard ГОСТ 500-58, which chemical composition corresponds to data given in Tab. 3.1.

Table 3.1. Chemical composition of steel St 35 for connecting rod

Chemical composition, wt. %							
C	Si	Mn	Cr	S	P	Cu	Ni
0,38	0,32	0,79	0,16	0,028	0,027	0,14	0,12

Source: own study.

3.6.3. Hardness measurements

One of the cheapest method for inspection the state of the material is the hardness testing. Hardness testing is provided by Brinell method, with ball-identor diameter of 3 mm.

Hardness changes are in good correlation with micro-structural observations. All of these findings are available for further assessment of residual life of such equipment.

The results of hardness measurements obtained from connecting rod, at same positions as replicas were taken, are shown in Tab. 3.2.

Table3.2. Hardness values at the connecting rod

Positions for hardness measurements	R1	R2
Measured values, HB	189 - 237	176 - 228

Source: own study.

3.6.4. Microstructures changes during operation of material connecting rod

The microstructure of investigated material before exploitation consist of ferrite and pearlite with small non-metallic inclusions.

The changes in microstructure of connecting rod material must be also of great importance. Those processes are: decarburization, corrosion, micro- and macro-cracks, etc.

A wide variety of degradation processes are possible to discover by using a replica metallography.

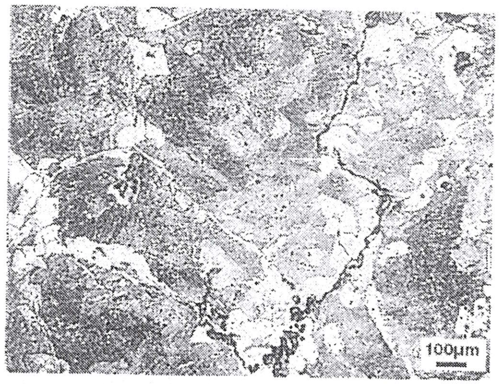

Fig.3.6. The microstructure consists of ferrite, pearlite and some bainite. Micro- and macro cracks observed under optical microscope. 4% natal.
Source: own study

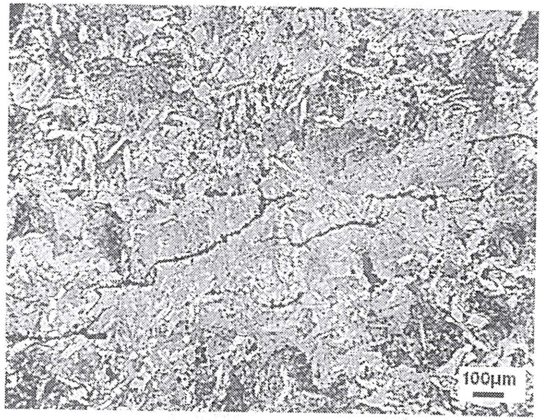

Fig. 3.7.'Macro cracks. Proeutectoid ferrite and probably some upper bainite in a matrix of ferrite and pearlite . 4% natal.
Source: own study

Fig. 3.8. Micro- and macro-cracks formed due to segregation in the material connecting rod. 4% natal.
Source: own study

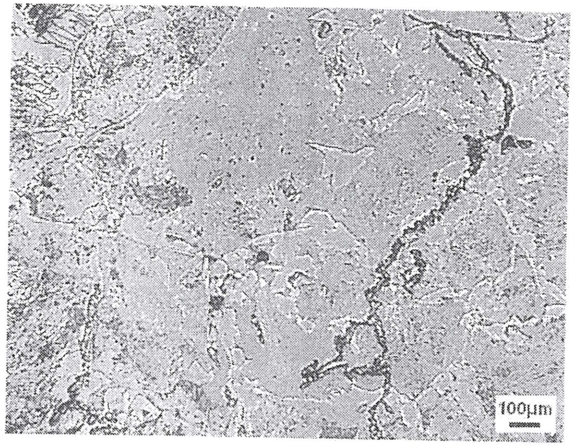

Fig.3.9. Long macro-cracks (>10mm) formed due to segregation in the connecting rod material. 4% natal.
Source: own study

3.7. Summary

The role of connecting rod in hydro-power plant is of very importance.

The NDM techniques offer a possibility to detect materials damage in an early stage and by this prohibit dangerous and costly failures.

Plants that are notoriously exposed to gradual degradation will be safer and live longer if areas of highest degradation rate is located and possible damage repaired at an early stage.

The changes in microstructure of connecting rod material must be also of great importance. A wide variety of degradation processes are possible to discover by using a replica metallography. Those processes are: decarburization, corrosion, micro- and macro-cracks, etc.

Hardness changes are in good correlation with micro-structural observations. All of these findings are available for further assessment of residual life of such equipment.

The above results led to a direct connecting rod recovery water turbines in the area identified macro-cracks, and after repeated tests, it was determined that the same it is not necessary to replace.

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Chapter 4

Martin Novak[1]

THE DEVELOPMENT OF MACHINING FOR DIFFICULT TO CUT MATERIALS

Abstract: Rapid development of engineering materials that use in production area is given by pressure of producer of new products types. This pressure cause also public that want products with higher safety, service life and operation capability. The producers are forced to use of technical materials in your products that corresponded with public requirements. On these materials are placed demands in point of view higher solidity, toughness and chemical compost. All these components decide about materials machinability including production costs (use special types of machine, machining and cutting tools, tips and coolant) and cycle times. The using of new types cutting tools with set a cutting conditions show possible ways in machining of the difficult to cut materials like hardened steels, aluminium alloys, titanium and nickel alloys and many others.

Keywords: Machining, production costs, machining tools, difficult to cut materials

4.1 Introduction

Presently is machining very important area in many states with engineering production. Automotive industry creations base of production and implementation of advanced technology. These technologies are base on the reduction of productions costs and use new methods like materials, geometry and shape of machining tools. Next part in advanced technology is the raising of the cutting speed and speed of feed. Raise of the speeds is important for the time of machining. These advanced methods we can used machining of the difficult to cut materials as hardened steels, stainless steels, aluminium alloys and alloys with titanium, nickel, brass, copper and others. Especially hardened steels for

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suppliers with long-term existence that can offer better quality and production in all the ways.

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TOYOTARİTY. PRODUCTION FACTORS

Publisher Yurii V. Makovetsky
Licence DK № 2665 from 25.10.2006
Plehanov str. 16, office 14,
Dnipropetrovsk, Ukraine, 49000
Tel. + 38056 798-33-64, fax. + 38056 236-79-93
e-mail: europress@gala.net

Printing: drukarnia AWR Edytor, Katowice, Polska,
tel. + 48322033719, fax. + 48322013796
It was signed for the press 30.11.10. Format A5
Offset print 80g. Digital press. Publisher's sheet 11
Edition 200 copies

ISBN 978-966-1507-73-8