

Development and Study on New Constructional Steel for Mechanical Engineering

Assoc. Prof. Ph.D. Christo Argirov, Assoc. Prof. Ph.D. Kamelia
Kalchevska*

*Institute of metal science, equipment and technologies, „Akad. A. Balevski” with hydroaerodynamics centre,
Bulgarian Academy of Sciences*

*Institute of metal science, equipment and technologies „Akad. A. Balevski” with hydroaerodynamics centre,
Bulgarian Academy of Sciences*

Submitted: 05-04-2022

Revised: 14-04-2022

Accepted: 17-04-2022

ABSTRACT: New high nitrogen steel used in mechanical engineering is developed. The new steel and technology of its production are developed on the basis of the metallurgy under pressure. Stress relaxation stability of the steel is investigated. The alloying by super equilibrium nitrogen concentration in quantities up to 0, 11wt.% causes increase of the stress relaxation stability of steel 30Cr2Ni2MoN2V, especially at temperature 400°C. By capillary non-destructive testing dense structure without defects it was established.

KEYWORDS: high nitrogen special constructional steel, stress relaxation stability, capillary non-destructive testing

I. INTRODUCTION

The vigorous scientific and technical progress calls for the necessity of new, high mechanical and service properties of the materials requiring lower energy, material and other expenses for an unit of product. It is well known that the conventional metallurgical technologies and equipment have practically exhausted their potential to solve these complex problems. The analysis of the results from the theoretical and applied projects in the steel industry shows the incomplete use of the thermodynamic factors. Out of the three thermodynamic factors – chemical composition, temperature and pressure, in fact use is only made of the first two. The potential of vacuum as a negative pressure is reduced theoretically only to the maximum one negative atmosphere (-0,1 MPa), whereas the potential of the positive pressure is practically unlimited. Metallurgy under pressure is of quite universal nature. It can be performed as a metallurgical

process both at atmospheric conditions and as a vacuum metallurgy process. The metallurgy under pressure as the most promising process which will become a basic trend in the progress of metallurgy in the XXI century. Gas pressure has positive physical and chemical influence on the process of ingot (product) formation and on the efficient control of the whole complex of technological operations during the pouring process. This has been evaluated by casting, and in particular, by development of method for Counter-pressure casting. The production of high nitrogen steels is highly effective from a technical and economic point of view, but it is also ecologically safe, because the production cannot be carried out if the plant is not closed. Metallurgy under pressure is principally new metallurgy. Out of the three metallurgy types – conventional, vacuum and under pressure, in fact, the metallurgy under pressure is the only one that occurs to be versatile, because the metal could be melt both at normal conditions and in vacuum. The metallurgy under pressure is characterized by great versatility of steel grades, since it enables realization of three possible trends as stated hereunder: development of principally new steel grades; improvement of the properties and potential of the existing grades; revival of the old grades production having good technical and economic characteristics, however, had been abandoned because of ecological, and safety reason. For example: the conventional wear resistant Mn13 steel (Hatfield steel) is well known for the separation of hazardous manganese vapours in the atmosphere and loss of up to 30 % of the alloying manganese [5].

Institute of metal science, technologies and equipment "Akad. A. Balevski" with hydroaerodynamics centre to Bulgarian academy of sciences (IMSTCH-BAS) has created theoretical grounds in the field of alloying with super equilibrium nitrogen concentration and development of new steel grade-high nitrogen steels and technologies for their production by the methods of the metallurgy under pressure. The Institute has capabilities and years of experience gained in the field of this method. Using the available laboratory facilities in combination with the scientific and technologic potential of the researchers, various new steel brands and technologies for their production are developed. In the basis of the our technological concepts the original Bulgarian methods of Counter pressure casting (CPC) and Electroslag remelting under pressure (ESRP) are incorporated, and also the our knowledge of the processes of nitrogen alloyed. A number of steel brands with increased nitrogen concentration have been developed in IMSTCH-BAS: high-speed steels, hot-die, cold-die, constructional, etc. It was proven that the high-nitrogen steels obtained 30% to 150% higher mechanical parameters in comparison with nitrogen free steels. Thus the cutter instruments made of the high-nitrogen steel type W6N2Mo5 (analog to W6Mo5, according to DIN S 6-5-2) were characterized by 38% to 100% higher exploitation parameters [5].

At present in mechanical engineering steel 32 NiCrMo 14 5 of type (DIN 1.6745) is widely applied. In IMSTCH-BAS was carried out investigations to develop original nitrogen constructional steel 30Cr2Ni2MoN2V [4] of the class of conventional steel 32 NiCrMo 14 5. The new steel and technology of its production are developed on the basis of the metallurgy under pressure. Steel 30Cr2Ni2MoN2V is alloyed with super equilibrium nitrogen quantity while the established by us nitrogen equilibrium concentration is 0,0465 %.

Purpose of the present work is carried out of some specific investigations of new nitrogen constructional steel 30Cr2Ni2MoN2V to prove the consumer qualities and to determine the production potentialities of steel products.

II. EXPERIMENTAL

For the purpose of the our experiment on industrial units induction furnace IFP05 and installation for Electroslag remelting under pressure ESRP-2 steel ingots are produced of 30Cr2Ni2MoN2V mark and of nitrogen free analogue steel 32 NiCrMo 14 5 for comparative

investigations. According to developed by us new technology for production of nitrogen steel follows plastic deformation-forging on radial-forge machine SHL 55 up to a diameter 120 mm and length 2000 mm.

The tensile strength tests (R_m , MPa) are carried out according to BS EN 10002-1:2000 on standard samples by a diameter 102 mm and length 50 mm (A5-specific elongation, %; Z-reduction of area, %; HB-Rockwell hardness). The notch-impact strength tests to Sharpie (KCV, MJ/m²) – on standard samples by section 10x10 mm to BDS EN 10045-1:2001. On metal of nitride ingots №№ ESRP3 and ESRP4, produced on units IFP05-ESRP the influence of long thermal loadings at temperature 350°C on the short-term mechanical properties of steel 30Cr2Ni2MoN2V is investigated.

Non-destructive investigations were carried out in the Laboratory of non-destructive testing in IMS-BAS, License I-1193 registration number 04328 for using of ionizing ray sources for scientific and economic purposes. Non-destructive control with radiation methods and with roentgen defectoscope of type 200/5 model MXR-200. Technical parameters: spot focus 2,45x2,80 mm; anode current 5 mA; tension 180 kV at measured equivalent dose 0,210 mSv with tapping \pm 0,8 %. Work conditions and reading of the roentgenograms are conformity with Standards BS EN ISO [2].

Point of the non-destructive testing: Roentgen (X-ray) or Gamma rays are using in the radiation control methods. They penetrate across optical untransparent bodies and operate over photographer's films similar to light rays. Under their operation some substances like for example Zink sulphide, shining (luminescence).

In the roentgen graphic control the radiation source (Roentgen pipe) is placing at a certain distance from object so as the rays to be direct perpendicularly on the axis. On the contrary side Roentgen film is settings. In the irradiation time (X-ray treatment) the film is situated under action of rays in the course of determinate time named exposition. Follows removal of the film in dark from the cassette, development and fixing in order to obtaining a steady photographer's picture. As a result on the section of the investigated object on separate places the picture is with irregular degree of tarnish. Rays who fall into film after passing through a defect are absorbing to a smaller degree in comparison with the rays passed through dense metal. First rays cause stronger darkening of determinate section of film [6,3].

III. RESULTS AND DISCUSSION

The stress relaxation stability test represents slow and gradual downturn of the stresses in trial sample which has obtained one initial constant elastic deformation. Here the elastic deformations slow and gradually pass in plastics. According to [1] at increased temperatures the stresses can almost will disappear (can obtain values, close to zero), however at lowered temperatures the relaxation continues up to achievement of certain stress, which is not lowered further. When the elastic deformation passes in plastic, the stresses disappear. The stress relaxation stability tests are carried out at temperatures 350°C and 400°C after the following heat treatment: hardening at 900°C and tempering at 550°C, duration of tempering is 6 hours. Metal from two ingots is investigated, produced on the units IFP05-ESRP with № ESRP3 ($C_N=0,11\%$) and № ESRP1 ($C_N=0,012\%$) –

nitrogen free for comparative tests. The obtained experimental results are submitted graphically on Figure 1a/,b/. It is established that the alloying by super equilibrium nitrogen concentration in quantity up to 0,11 wt.% causes increase of the stress relaxation stability of the steel, especially at temperature 400°C up to 36 %. The residual stress for 1000 hours at temperature 350°C are accordingly 260 MPa and 240 MPa and the difference becomes some greater at temperature 400°C – accordingly 225 MPa and 165 MPa. By the methods of capillary non-destructive testing the density of the new steel 30 Cr2Ni2MoN2V is investigated. Dense structure without defects it is established (Figure2). The dense structure after Electroslag remelting under pressure is one of the advantages of this process. As it is known, this advantage “economizes” the finally technological operation-the plastic deformation.

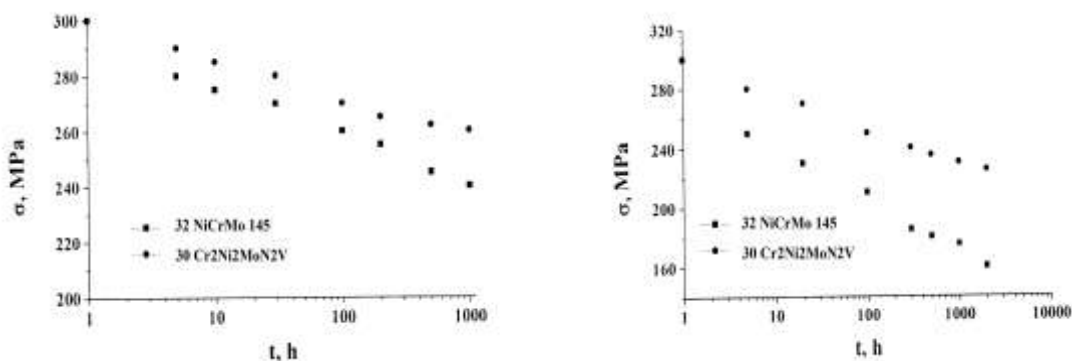


Fig.1. Stress relaxation stability at temperature: a/ 350oC ;b /400oC; initial stress 300 MPa

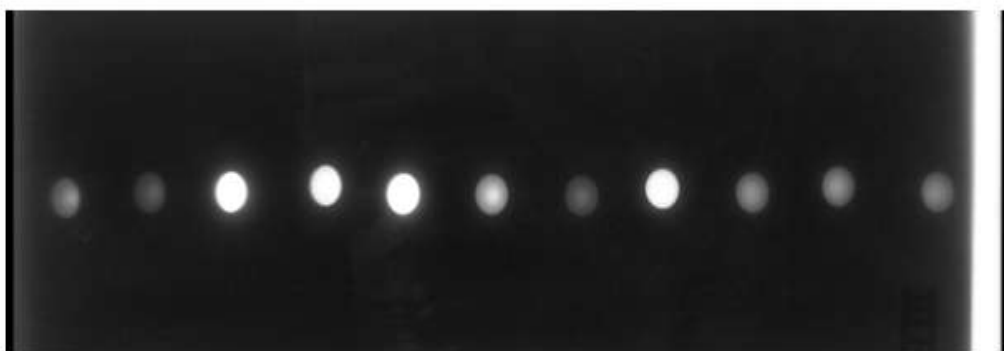


Fig.2.Roentgen graphic image

IV. CONCLUSIONS

New original high nitrogen steel used in mechanical engineering is developed. The new steel and technology of its production are developed on the basis of the metallurgy under pressure.. The investigated ingots from nitrogen

constructional steel 30Cr2Ni2MoN2V satisfy the technical project requirements: $R_{02}>1000$ MPa at room temperature. At the working temperature values of $R_{02}>900$ MPa have the ingots with super equilibrium nitrogen concentration limits from 0,07 - 0,11 wt. %. With respect to the plasticity and

notch-impact strength characteristics the investigated ingots essentially exceed the technical requirements. The alloying by super equilibrium nitrogen concentration in quantities up to 0,11 wt. % causes increase of the stress relaxation stability of steel 30Cr2Ni2MoN2V, especially at temperature 400°C. By capillary non-destructive testing dense structure without defects it was established. It proves that the long use of high nitrogen steel will not cause appreciable softening and embrittlement of the material and subsequent brittleness destruction.

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