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Studies on Creep Rupture Strength of Nitrogen Constructional Steel

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ABSTRACT: Behaviour of nitrogen steel 30Cr2Ni2MoN2V with optimized chemical composition and with super equilibrium nitrogen concentration, in the process creep rupture strength has been investigated. The nitrogen influence on the characteristics of the creep at 480 ^{o}C, 540 ^{o}C and 590 ^{o}C has been determined. With increase of the nitrogen content it has been established increase of the time till tensile fracture and decrease of the elongation of the experimental specimens.

KEYWORDS: high nitrogen constructional steel,creep rupture strength

I. INTRODUCTION

At present in east European countries 32 NiCrMo 14 5 of type (DIN 1.6745, similar to4337+V, AISI) is used for threaded connection element for water cooled nuclear reactor bodies (WWNR-type). The problem is related to the increasing requirements for bolted joint materials intended for water-cooled nuclear reactor [4]. 32 NiCrMo 14 5 of type steel has not the required properties to maintain the tightness for the whole lifetime.

Institute ofmetal science, technologies and equipment with hydroaerodynamicscentre"Akad. A. Balevski" 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 andtechnologies 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 productionare 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-nitrogensteels obtained 30% to 150% higher mechanical parameters in comparison with nitrogen free steels. Thus the cutter instruments made of the high-nitrogen steel typeW6N2Mo5 (analog to W6Mo5, according to DIN S 6-5-2) were characterized by 38% to 100% higher exploitation parameters [2].

30Cr2Ni2MoN2V steel [3], of optimized chemical composition and alloyed with super equilibrium nitrogen concentration,while the established by us nitrogen equilibrium concentration is 0, 0465 %, has been developed in the Institute of metal science, equipment and technologies „Akad. A. Balevski" with hydroaerodynamicscentreat the Bulgarian Academy ofSciences, in order to improve the mechanical properties and the behaviour under different types of loading. This steel has been produced by original Bulgarian methods of Counter pressure casting and Electroslag remelting under pressure. The ingots have been homogenized and then cooled in the furnace after plastic deformation-forging on radial-forge machine SHL 55 with deformation rate of 4. The ingots have been heat treated at 880 ^{o}C for 40 minutes, cooled in the furnace and then annealed. Thus, a bainitic structure has been obtained. The chemical compositions of the newly developed material and nitrogen free analogue steel 32

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NiCrMo 14 5 for comparative investigations, are given in Table.

Chemical compositions of the steels investigated, in wt. %

STEEL	N	C	Cr	Ni	Mo	V	Mn	Si	S
30Cr2Ni2MoN2V	0,086	0,31	1,62	2,21	0,34	0,23	0,19	0,24	0,012
32 NiCrMo 14 5	0,012	0,31	1,24	3,25	0,38	0,15	0,36	0,13	0,011

Purpose of thepresent work is carried outof investigations of creep rupture strength 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 30Cr2Ni2MoN2Vmark 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 (Rm, MPa) are carried out on standard samples 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, %).

Methods for short-time strength testing have been developed in orderto establish the behaviour of metallic structures of high temperatures. From the results thus obtained it is possible the real rupture stresses to be determined accurately; stress, deformation, temperature and deformation rate are basic variables characterizing the creep process. The method of extrapolation using data, obtained from short-time strength tests is the most wide-spreader for parameters estimation and it has proved its reliability in the practice. The test results are plotted using family of curves: long-time loading high-temperature deformation versus time for different values of the applied stress at the same temperature.

Tests were carried out for 30Cr2Ni2MoN2V alloy specimens using E 3/6-1200 creep testing equipment in the temperature range 300 ^{o}C-1200 ^{o}C under20 kN loading. For parallel tests for 3 specimens simultaneously grips were designed for cell № 3. The equipment consists of main body, loading device, 6 tubular furnaces and additional automatic regulation of the loading lever, elongation measuring device, temperature and electric currency regulators. Independent mechanical and electrical loading devices exist.

The testing temperature was set in tubular furnace using 4 thermocouples for each of the six cells. The thermocouple in the middle of the furnace was coupled to registered device in such manner that the furnace temperature is continuously plotted.

The thermocouples of Pt RH/Pt were calibrated using type S standard thermocouple class 1 in horizontal furnace of SUOL-1200 type with temperature gradient in the working place dt/dl = -0,1 ^{o}C/cm.

The block scheme of multiple-channel microcomputer system, connected with a equipment for gathering data is shown in Figure 1. Three interface module, two of which are eight-channel twelve bites analogue-to-digital converters, and the third one with eight optronic divided digital entries and outputs are connected to the basic configuration of microcomputer IBM-486DX with HD/hard disk/549 Mb. The first analogue-to-digital convertor registers, and measures the temperatures of the tested specimens, and the second one-relative elongation, as entry signals are standardized by the analogue devices of the testing machine. The abnormal signals from the separate cells of the machine are connected to the digital entries, which received commands for stopping the test by digital outputs.

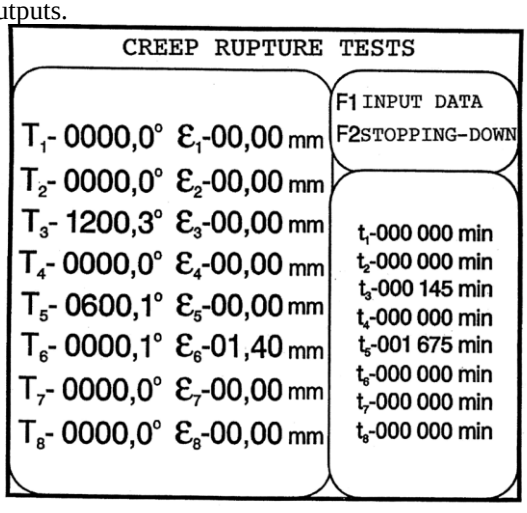

Fig. 1. Block scheme

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After the starting of the main program, through the functional push-button is unloaded the menu for choice of the separate cell of the testing machine, in which is setted the specimens and is starting the subprogram for measuring the parameters – temperature, elongation and time, which from this moment further are visualled in screen. Through the functional push-button F2 it is possible to be individual interruptedthe measuring of the parameters in anyone of cell without exert influence on the rest.

The time for scanning measuring from 5 to 600 s is given of the entry data, where at will it is possible to be recorded additional a data, the type of material and the name of the researcher.

The test is performed after reaching of the temperature 590 ^{o}C with a time establishment 1h, according to the requirements, give in [1].

The results from one exemplary testing are shown graphically in Figure 2 and Figure 3. In Figure 2 is shown a four-hour interval from testing, on the basis of which it is possible to receive a common idea for flowing in the time a macro elastic and macro plastic bucking, while in Figure 3 the showing 15 minute interval is gives a concrete information from advancing changes in the structure of the testing an experimental specimen.

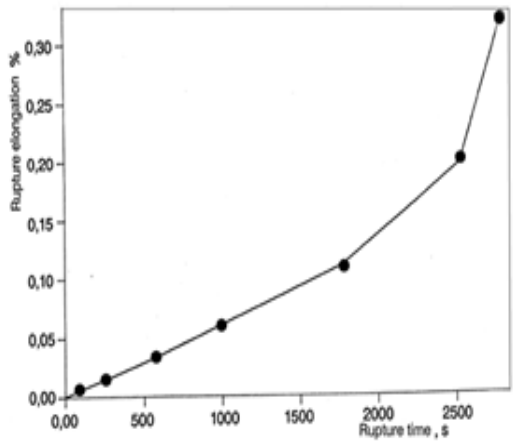

Fig.2. Four-hour interval from testing

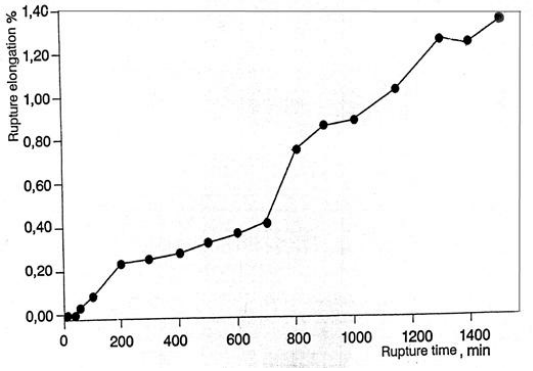

Fig.3. 15 minute interval from testin

III. RESULTS AND DISCUSSION

The dependence of rupture stress versus of the time at testing temperatures of 480 ^{o}C, 540 ^{o}C and 590 ^{o}C for a steel 30Cr2Ni2MoN2V are presented in Figure 4. The specimens were marked with square, triangle and circle symbols depending on the rolling direction, radial and tangential.

An attempt was made for comparison between steels 30Cr2Ni2MoN2V and 32 NiCrMo 145 at temperature 590 ^{o}C (Figures 5 and 6). For a steel 30Cr2Ni2MoN2V is observed increase of the time till destruction, while the elongationis decreased, probably because of the higher nitrogen content.

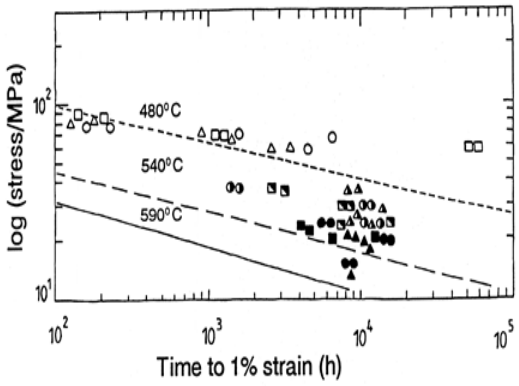

Fig.4. Dependence of rupture stress versus of the time

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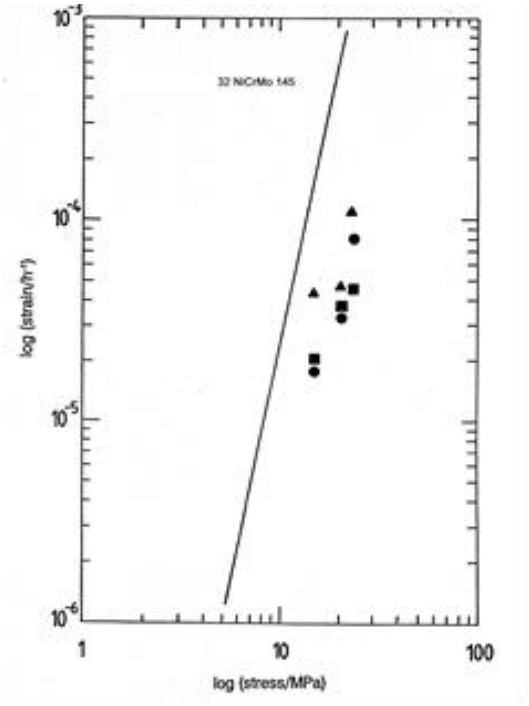

Fig.5. Comparison between steels 32 NiCrMo 145

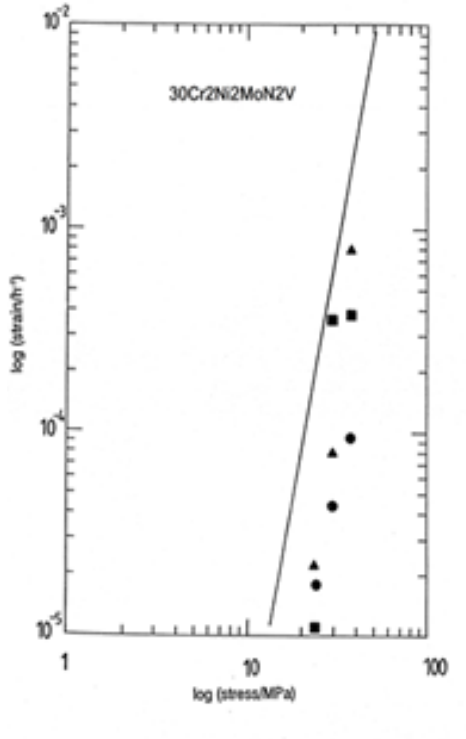

Fig.6. Comparison between steels 30Cr2Ni2MoN2V

IV. CONCLUSIONS

Behaviour of nitrogen steel 30Cr2Ni2MoN2V with optimized chemical composition and with super equilibrium nitrogen concentration, in the process creep rupture strength has been investigated. The nitrogen influence on the characteristics of the creep at 480 ^{o}C, 540 ^{o}C and 590 ^{o}C has been determined. With increase of the nitrogen content it has been established increase of the time till tensile fracture and decrease of the elongation of the experimental specimens.

REFERENCES

[1]. Fedelich B., A. Epishin, T. Link, H. Klingelhöffer, G. Künecke, P.D. Portella Experimental characterization and mechanical modeling of creep induced rafting in super alloys. Computer Material Science, 64 (2012), pp. 2-6.

[2]. Rashev Ts. High nitrogen steels. Metallurgy under pressure. Prof. Marin Drinov Publishing House of BAS. ISBN 954-430-352-9. 1995. Pp. 5-9.

[3]. Patent Russia № 1627584: Steel, Ch. Argirov, 15, 2. 1990.

[4]. Structural materials for generation IV nuclear reactors. Pascal Yvon. Woodhead publishing. 2016. 684 p. ISBN 008 1009 127.