XXIV International Conference on Chemical Reactors CHEMREACTOR-24
September 12 - 17, 2021

METHOD FOR PREPARATION OF THE DEFECTIVE SURFACE OF PRODUCTS MADE OF HEAT-RESISTANT NICKEL ALLOYS FOR BRAZING

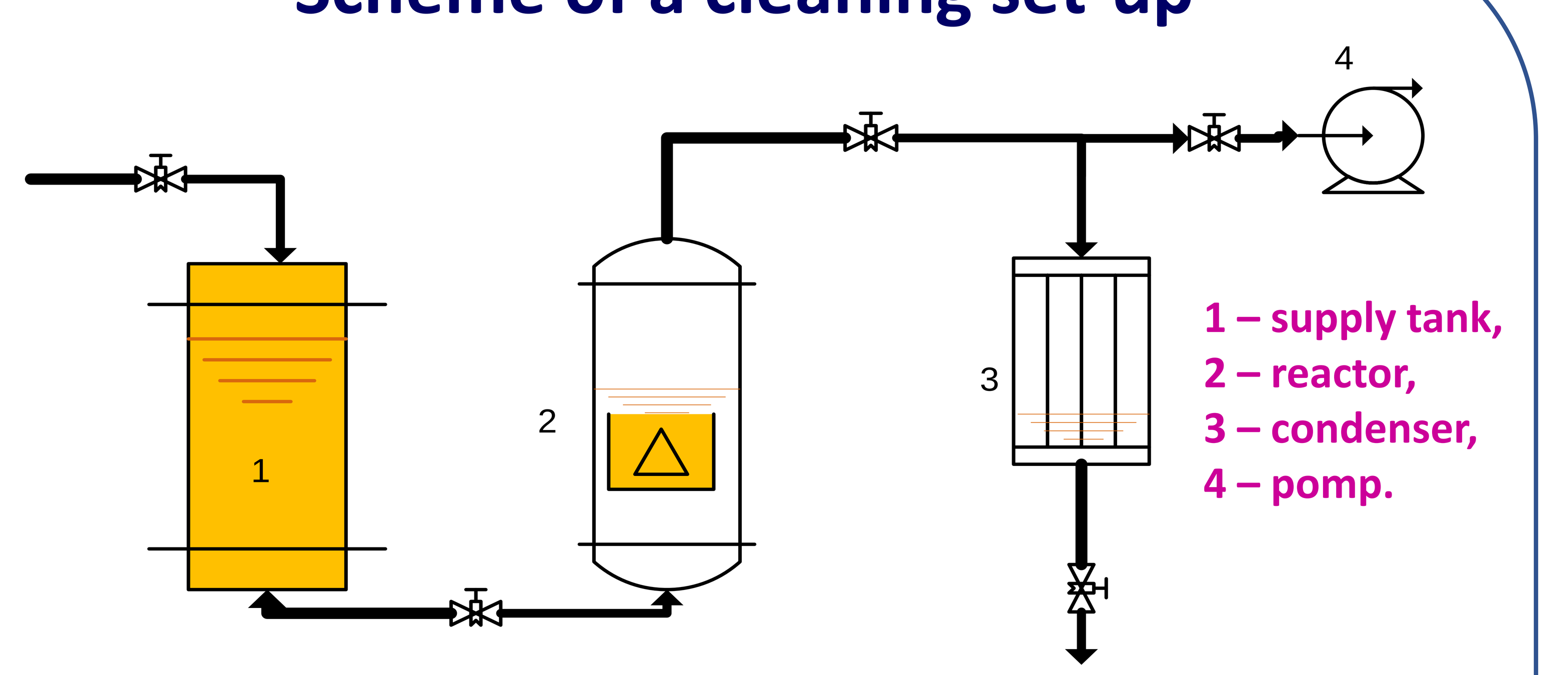
Pai Z.P.[1], Pai V.V.[2], Luk'yanov Ya.L.[2], Shangina A.B.[1], Fedotenko M.A.[2], Parmon V.N.[1], Bukhtiyarov V.I.[1]

[1] Boreskov Institute of Catalysis SB RAS, Novosibirsk, Russia
[2] Lavrentyev Institute of Hydrodynamics SB RAS, Novosibirsk, Russia
E-mail: zpai@catalysis.ru

There are large number of ways for cleaning the surfaces of various components made from metals or their alloys. These methods are based on the use of organic liquids, aqueous solutions of detergents and etchants in combination with mechanical cleaning technique like, for example, pneumatic and hydroabrasive jets. Most of these procedures are applicable to easily accessible surfaces of metal components. A special case is the high-quality cleaning of the hard-to-reach surface of the cracks from metal oxides and fuel combustion products, formed on the turbine blades during the operation of aircraft engines and power plants.

In the Boreskov Institute of Catalysis SB RAS, together with the Lavrent'yev Institute of Hydrodynamics SB RAS, interdisciplinary research was carried out to develop the new method for cleaning microcracks in metallic materials, taking into account the aspects of chemical, thermophysical and hydrodynamic processes in capillary structures of micron and submicron sizes [2, 3]. Concept and the new approach based on the use of a contact solution in the liquid phase have been developed. Compositions of contact solutions have been developed and setup-stand for experimental justification of the new method was created. The experiments were carried out on simulator samples made of nickel-base alloy (see Table) and pre-treated under operating conditions. In the experiments, the state of the cracks surface of the samples-simulators was controlled by an INCA Energy (X-ray energy dispersion) spectrometer, installed on the LEO-420 focused beam electron microscope. The process of cleaning the dirty surface of alloys from metal oxides is carried out without the use of high temperatures (about 100 °C versus 500 - 1100 °C for DAYTON FCP technology) and pressures (≤ 1 atm).

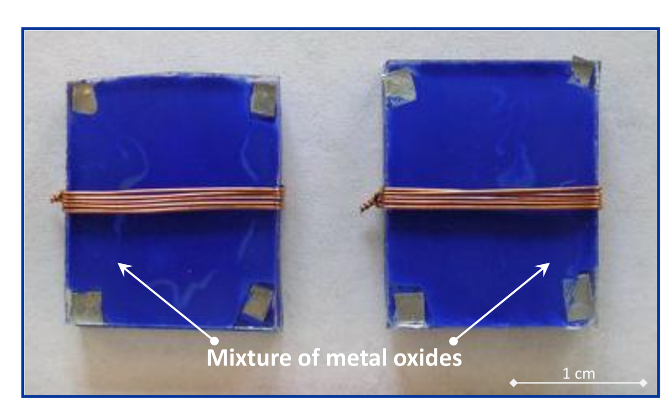
Scheme of a cleaning set-up



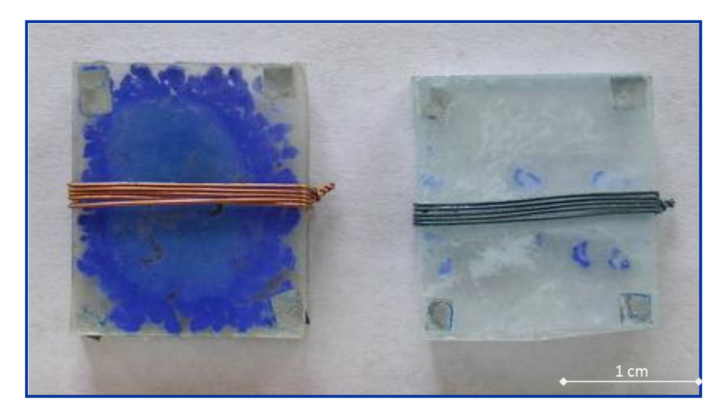
The process is carried out at T - *100 – 120 °C*, P ≤ *1 atm*.

Stage I: **washing of the system by water vapour;**
Stage II: **filling the reactor with a contact solution from 1;**
Stage III: **heating the solution in the reactor 2;**
Stage IV: **evaporation of the solution and its condensation in 3.**

Model samples with metal oxides

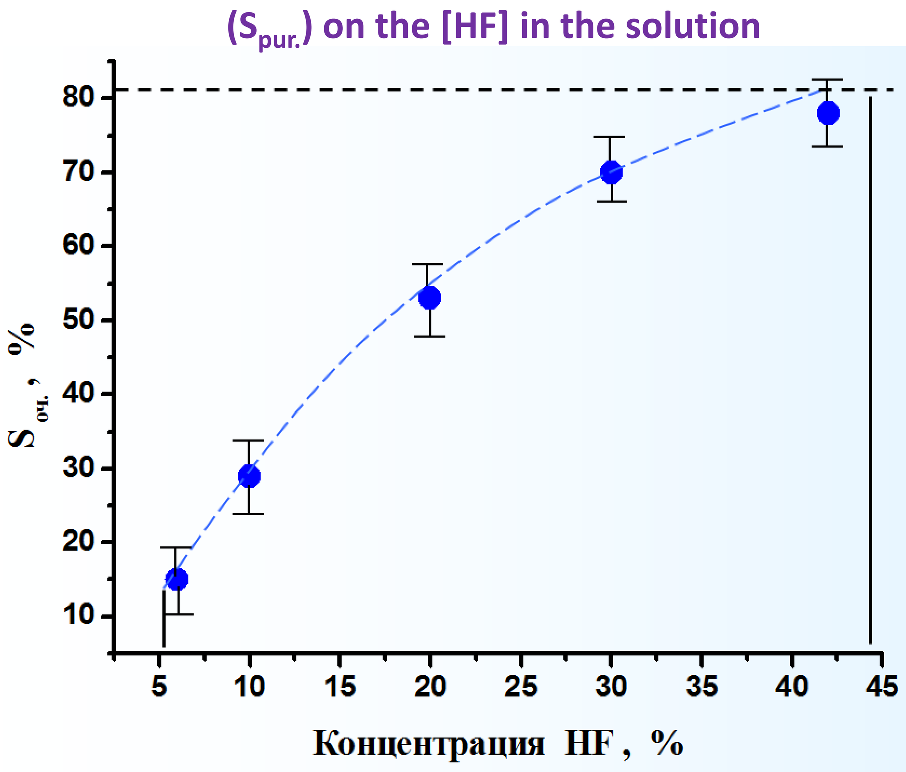


Initial samples 1B and 1A before purification.



Samples after cleaning.
2A - after boiling in solution;
2B - after cleaning set-up.

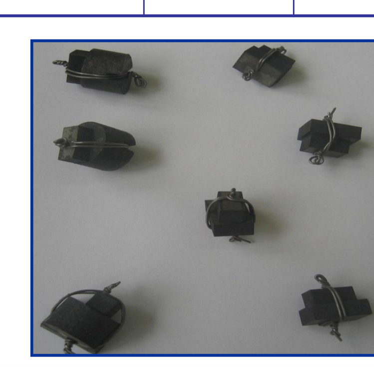
Dependence of the purification area value ($S_{pur.}$) on the [HF] in the solution



Oxides: Al, Ti, Cr, Nb – freely soluble;
W, Co – slightly soluble (20÷35%)

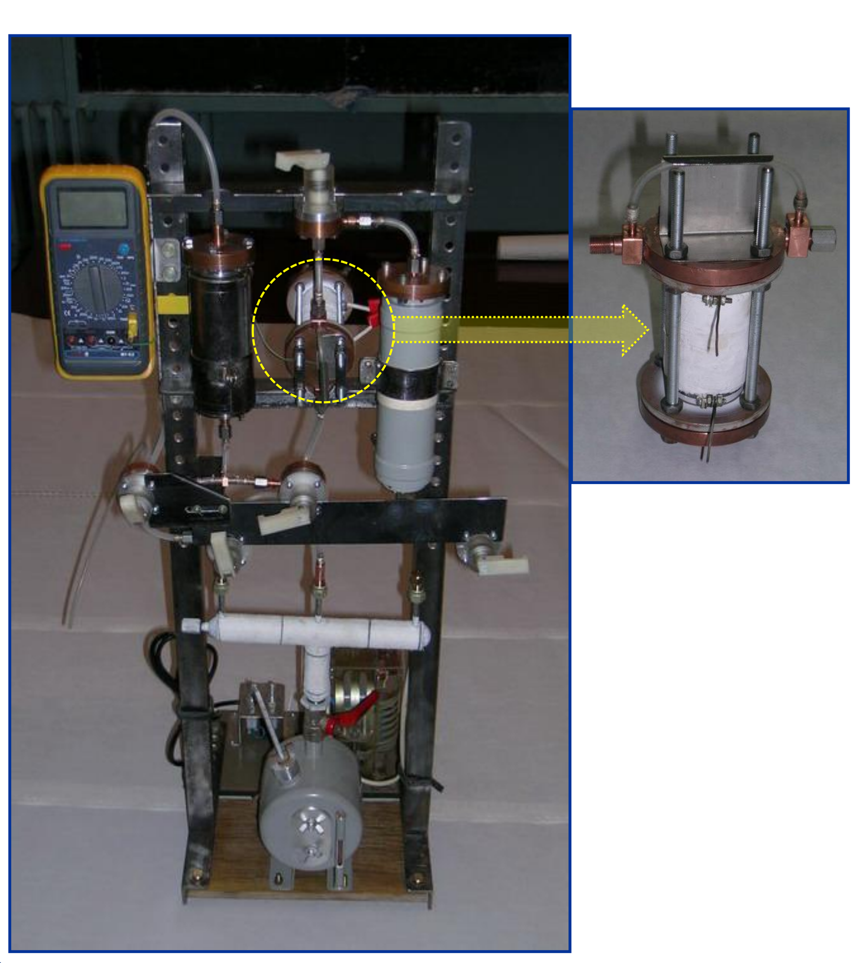
Table. Composition of samples-imitators

Alloy	C	Cr	Al	Ti	Mo	W	Co	Nb	B	Ni
C-1023	0,15	15	4,2	3,6	8,25	-	10	-	-	Base
ЖС6У	0,13-0,2	8-9,5	5,1-6	2-2,9	1,2-2,4	9,5-11	9-10,5	0,8-1,2	< 0,05	Base



Samples-imitators from alloy (ЖС6У)

Laboratory stend

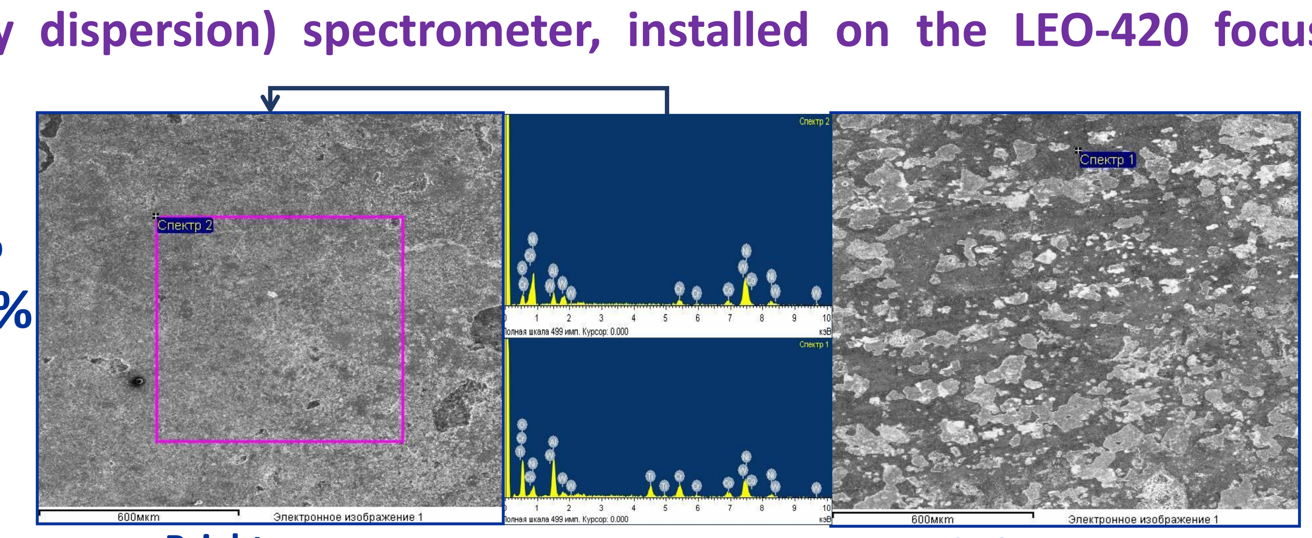


Purpose of the work: Development of scientific foundations of the technology for cleaning the surface of cracks in steels made of ZhS6U alloy.

Tasks:
1. Development of a method for physical delivery of a contact solution into cracks in parts and its subsequent removal;
2. Creation of a laboratory stand to demonstrate of the cleaning method;
3. Development of the composition of the contact solution.

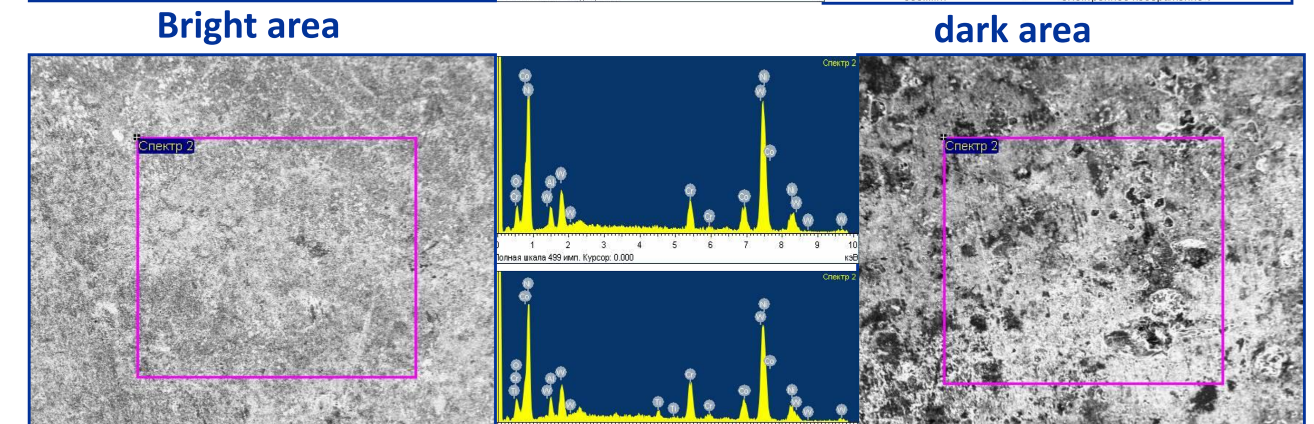
In the experiments, the state of the cracks surface of the samples-simulators was controlled by an INCA Energy (X-ray energy dispersion) spectrometer, installed on the LEO-420 focused beam electron microscope.

Original
O□ = 9-12%
O■ = 29-35%
C□ = 4-6%
C■ = отс.



Bright area — dark area

Processed
C = отс.
O = отс.



It is shown that the selected gas and hydrodynamic parameters of the process with variation of the temperature and composition of the contact solutions provide multi-cycle flushing of narrow gaps in times not exceeding 30 min, achieving complete removal of the metal oxides and of the hydrocarbon fuel combustion products.

This work was performed as a part of the state task for the Boreskov Institute of Catalysis (project no. AAAA-A21-121011390007-7).

References
[1] a) Patent US 4324594 // Chasteen J. W., 1982; b) Patent US 5071486 // Chasteen J. W., 1991.
[2] Patent RU 2419684 // Pai Z.P., Parmon V.N., Pai V.V., Fedotenko M.A., Yakovlev I.V., and Shangina A.B., 2011.
[3] a) Z.P. Pai, V.V. Pai, and V.N. Parmon // Abstracts of the Report on IX International conference "THE IMPROVENT OF THE QUALITY, RELIBILITY AND LONG USAGE OF TECHNICAL SYSTEMS TECHNOLOGICAL PROCESSES" December 12-19, 2010, Sharm el Sheikh, Egypt. C. 61-63.b) L.L. Makarshin, Z.P. Pai, V.N. Parmon. / Microchannel systems for fine organic synthesis // RUSS CHEM REV, 2016, V. 85, No.2, P. 139-155. DOI: 10.1070/RCR4484; c) Z.P. Pai, V.V. Pai, and V.N. Parmon, V.I. Bukhtiyarov, Method for cleaning the surface of cracks formed on turbine blades during operation of engines of gas turbine engines (GTE) «Innovation. Technology. Production» April 4-27, 2017, Russia, Rybinsk.

BORESKOV INSTITUTE OF CATALYSIS