PROGRAM OF QUALITY MANAGEMENT WHEN FABRICATING FAST REACTOR VIBROPACK OXIDE FUEL PINS

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Abstract

There are presented main principles of creation and operation of Quality Management Program in fabricating vibropack oxide fuel pins for BOR-60 and BN-600 being in force in SSC RF RIAR. There is given structure of documentation for QS principal elements. Under Quality System there are defined all the procedures, assuring that fuel pin meets the normative requirements. The system model is complied with the standard model IS 9001. There are shown technologic flowchart and check operation, statistic results of pin critical parameter check as well as main results of in-pile tests.

Introduction

For the last few years SSC RF RIAR has developed design and manufacture technology of fast reactor vibropac oxide fuel pins. Results of in-pile tests and postirradiation examinations make it possible to recommend fuel pins of this type for large-scale tests in power reactors. Requirements of supervision body to reactor operation safety being currently in use justify the necessity of creating Quality management system. In order to fulfill the requirements SSC RF RIAR is developing the Quality System, which provides that all the necessary procedures of Quality Management in fabricating vibropac oxide fuel pins and SA for BOR-60 and BN-600 reactor should be implemented.

1.Structure of QS principal elements

In order to assure quality of vibropack oxide fuel pin fabrication in accordance with the requirements of IS (International Standard) 9000 series SSC RF RIAR is developing and introducing Quality System, which is a system of organization, procedures, processes and resources [1]. One of Quality system elements is the Quality guidelines and Quality management programs being developed for every fabricated product. Quality System being currently in use accompanies the product for all the stages of its life-time, beginning with development, through manufacture, in-pile tests and PIE followed by utilization. Under Quality System there are defined all the procedures, assuring that fuel pin meets the normative requirements. The system model is complied with the standard model [2].

Quality system application is limited by required documentation, structure of which is given in Fig.1.

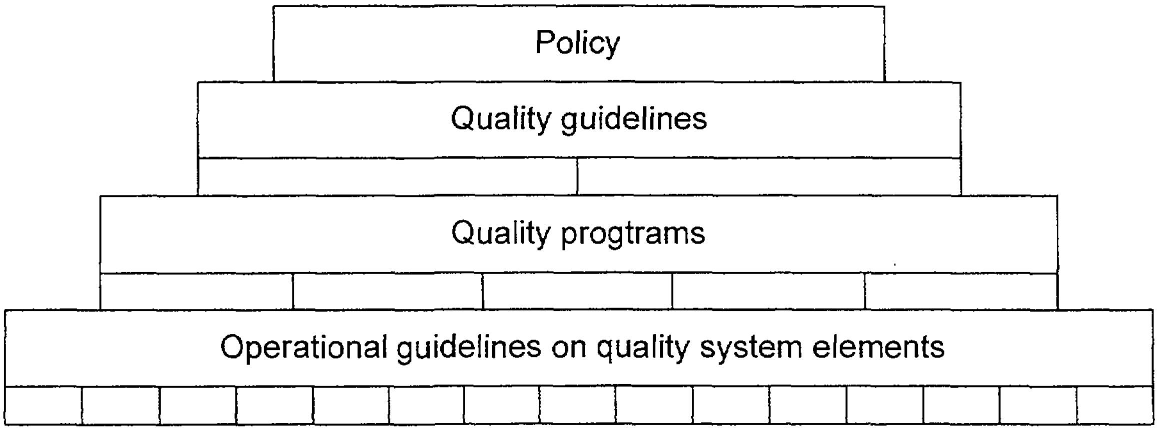


Fig.1. Structure of Quality System documentation

Three upper levels represent organizational-administrative documentation of the system and include:

- policy in quality area, governed by Institute administration;
- quality guidelines, outlining descriptions both of Institute QS and the one when fabricating fuel pin and SA. Guidelines meet the standard requirements [3];
- programs of quality management, incorporating specified steps to assure the quality of each fuel pin and SA kind and flowsheet of their design and manufacture. The programs fulfilled the requirements of International Standard [4].

At present there are in force five QA programs in manufacture, including the ones for different kinds of granulated oxide fuel as well as for BOR-60/BN-600 fuel pin and SA fabrication.

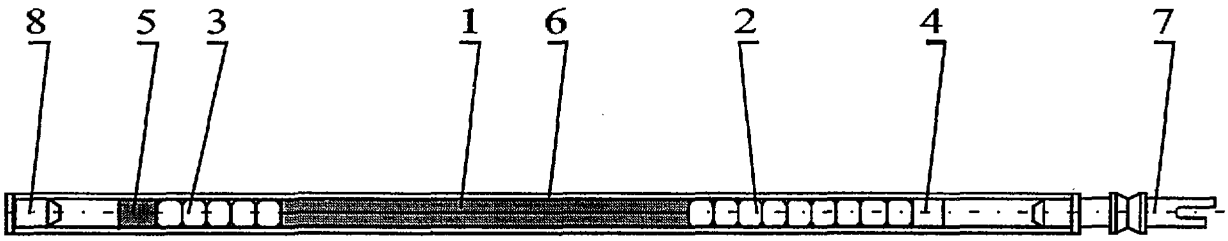
Operational guidelines of bottom level contain design plans and specifications, technologic and technical documentation, which are developed and complied with the requirements of State, Branch and Institute Standards.

2.Quality system operation

There is a special service of quality to check the QS operation efficiency. It is the service that develops the steps of correcting effects if there are found signs of differences.

Management of fabrication process and technical quality administration of initial materials, spare parts and final products (ready fuel pins and SA) are carried out by Inspection subdivision. Quality service and Inspection subdivision analyze deviations of initial materials and final products from the set requirements and together with production manufacturer work out measures to correct deviations. Final acceptance of products is implemented by Branch management-acceptance inspection.

For the last 25 years SSC RF RIAR has carried out the integrated investigations to validate the possibility of using vibropack oxide fuel (Fig.2) in fast reactors.



1- Fuel column
2- Bottom blanket zone
3- Upper blanket zone
4- Can
5- Fixing element
6- Cladding
7- Bottom endplug
8- Upper endplug

Fig.2 Design of fast reactor fuel pin

These investigations were aimed at developing reactor advanced fuel cycle, based on a pyroelectrochemical way of irradiated fuel reprocessing, which resulted in high-dense granulate appropriate for vibropack fuel pin fabrication. Particle density was 10,7 - 10,9 g/cm^3 and particle size was in the range of ~10 mcm-1 mm. In the progress of activities a study was made of granulate physical-mechanical and technologic performance, there were carried out radiation tests of experimental and pilot fuel pins in BOR-60, BN-350 and BN-600 reactors and pin material science investigations. Total quantity of fabricated fuel pins amounts to about 30 000 pieces [5].

In BOR-60 reactor maximum burn up attained 30 % h.a. for standard SA and burnup was of 32,3% h.a. for experimental fuel pins of the dismantled SA. In testing $UPuO_2$ vibropack fuel pins in BN-600 reactor there was attained maximum burn up of ~10.8%h.a. Mass tests of $UPuO_2$ vibropack fuel pins in BOR-60 reactor since 1981, irradiation of large-scale experimental SA in BN-350 and BN-600 made it possible to specify and validate statistically initial technologic parameters of fuel column, to confirm concepts underlying fuel pin design as well as to identify a number of critical design and technology parameters, which are characteristic of vibropack oxide fuel pins and to govern their serviceability. The parameters like these are as follows:

- fuel column smear density;
- uniformity of smear density and FPs distribution along the fuel column length;
- concentration of the major technologic impurities in granulated fuel;
- O/M ratio;
- helium content in fuel.

It is support and check of the parameters that are paid a great attention in fuel pin fabrication and acceptance (Fig 3,4). Besides, while carrying out technologic process of fuel pin fabrication there are checked:

- fuel column and its components mass(Fig.5, Table 1);
- composition of under cladding gas (Fig.6);
- fuel pin integrity and welding seam quality (Fig.7);
- other parameters.

Table 1.

Masses of fuel components in BN-600 SA

SA number	Fuel mass in SA, g	Plutonium dioxide mass in SA, g
1	28695,90	4967,73
2	28630,01	4953,64
3	28651,05	4995,38
4	28616,46	4998,17
5	28590,99	4993,17
6	28563,99	5003,40
7	28622,84	5041,36
Average value	28649,49	4993,26

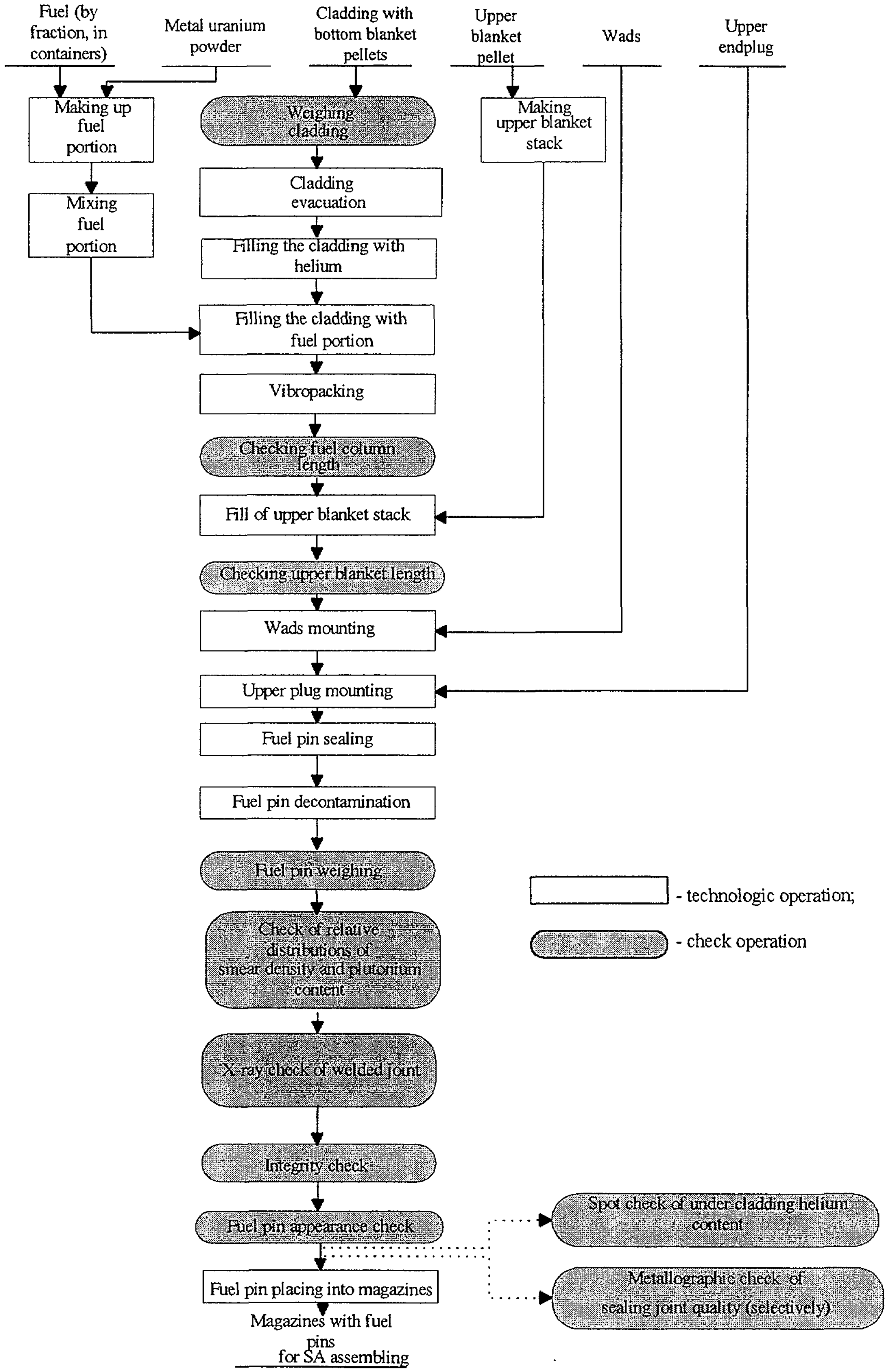


Fig.3 Main technologic and check operations of vibropack oxide fuel pin fabrication

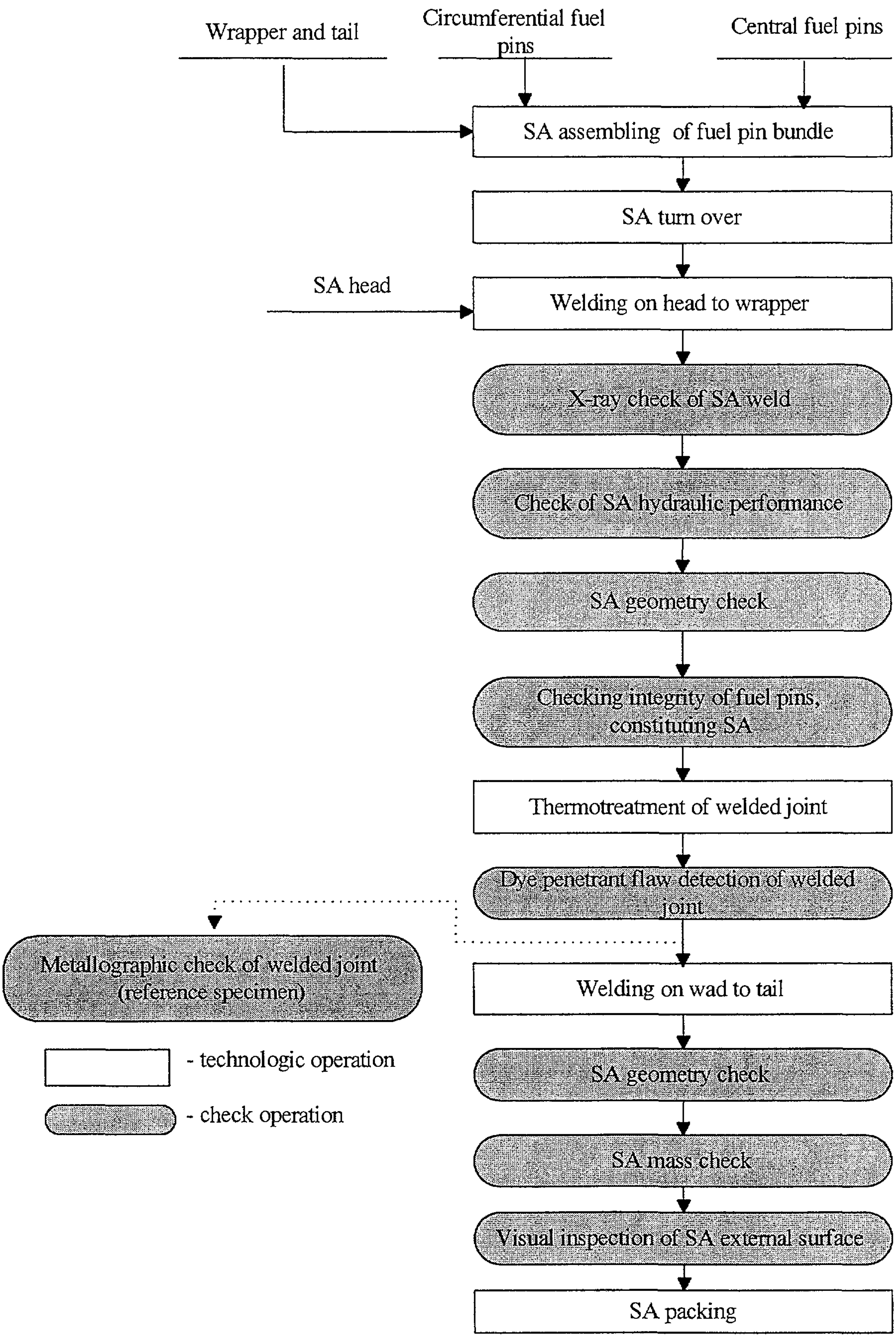


Fig.4 Flowchart of BN-600 SA manufacture

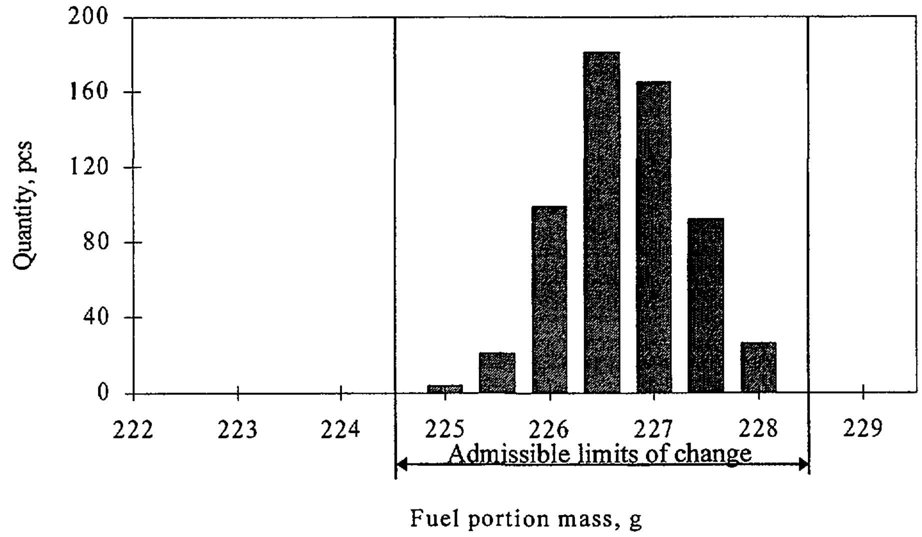


Fig. 5 Histogram of fuel column masses for BN-600 vibropac fuel pins

Both standard and non-standard techniques are used to manage quality.

Standard method of quality management is typical of the plants produced fuel elements. Among non-standard quality management methods there are those of smear density and FPs distributions (Fig.8) uniformity along the fuel column and under cladding helium content, developed in SSC RF RIAR and occupying a particular place.

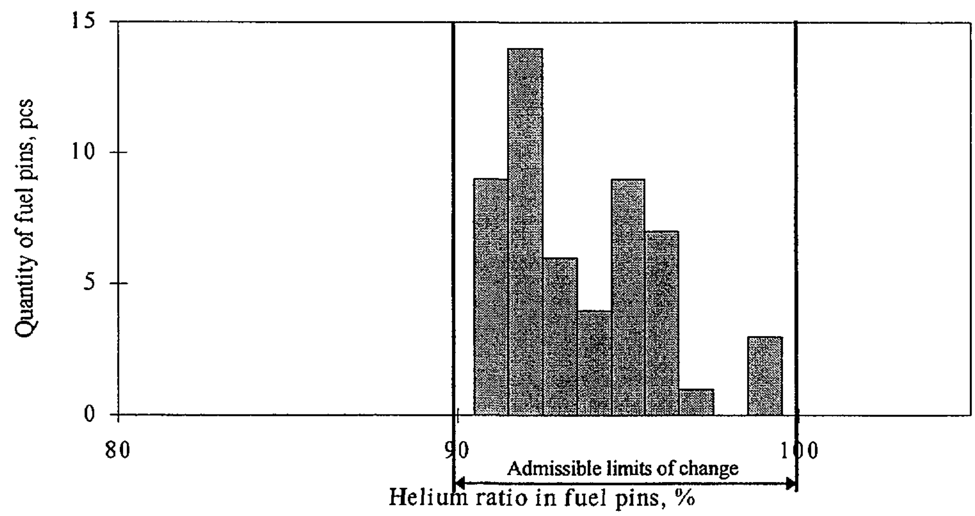
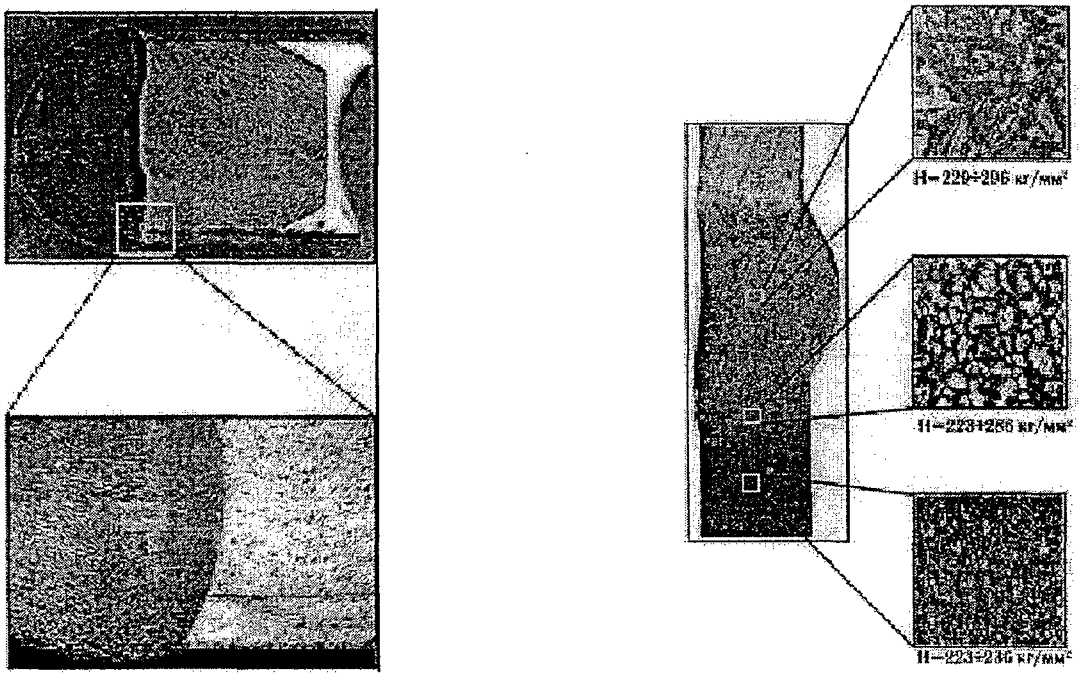
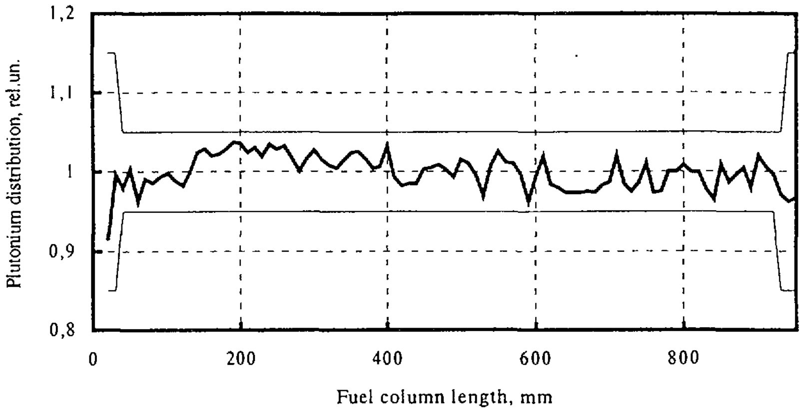


Fig. 6 Histogram of helium ratio in BN-600 fuel pins

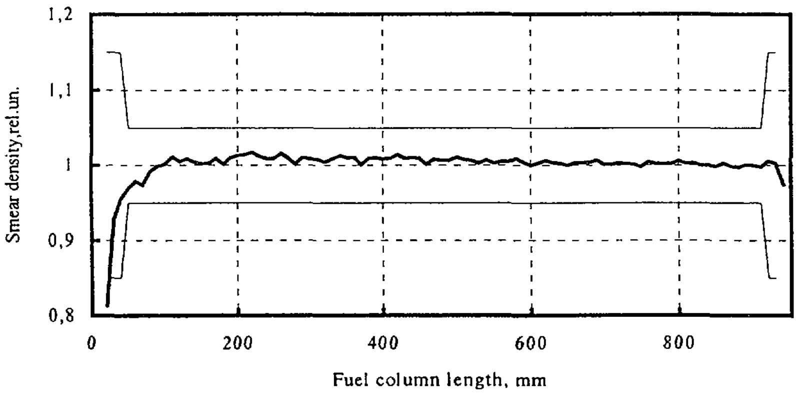


a b

Fig. 7 Multipass weld of fuel pin (a) and SA (b)



a



b

Fig. 8 Distributions of plutonium content (a) and smear density (b) along the fuel column length

The methods developed and their equipment support are realized in technologic lines both for hand- (in glove boxes) and automated (in shield cells) manufacture of vibropack fuel pins. Operation of quality management methods for many years exhibited their high authenticity and reliability.

At present annual capacity is:

- up to 2000 BOR-60 fuel pins;
- up to 6500 BN-600 fuel pins.

At that production yield is not less than 98 %, and there are no rejects in separate operations.

3.Conclusions

Statistical analysis of in-pile test results and material science investigations of vibropack oxide fuel pins provides evidence for their high operational reliability and efficiency of QS elements being in use

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