

Manufacturing of Zirconium Products at Chepetsky Mechanical Plant, Stock Company. Prospects of Development and Products Quality Assurance

K. Vergazov, M. Shtuza, S. Lozitsky, A. Kutyaev

CMP, SC, Glazov, Russian Federation

The modern nuclear power engineering is based on reactors with fuel elements which shells, as well as other spacing, sealing, and other details are made of zirconium alloys.

“Chepetsky Mechanical plant”, SC is one of the largest enterprises in the world producing zirconium and its alloys. Powerful scientific and technological capacity, up-to-date manufacturing processes, high-performance monitoring allows the enterprise to manufacture products which meet international standards. Among the products there is the following: fuel element claddings, wire, sheets, end and component parts for TVEL and TVS (*fuel assembly*).

The entire production chain is concentrated at one enterprise: from raw materials up to the finished products. Zircon concentrate supplied to the plant is processed into zirconium powder in chemical production, thereafter on that basis ingots are melted in size of 450 mm in diameter and weight up to 3.5 tons in metallurgical production. During the following operations the ingots are transformed into the billets for rolling of sheets, extrusion of tubes or bars by hot forging or rolling. Further on depending on the purpose the billets are subjected to hot rolling or extrusion, cold rolling cycle, finishing operations and control for compliance with the technical requirements.

1. Development Prospects of Chemical Industry

At present metallic zirconium is produced by fluoride-electrolytic process method of powder production at the plant. Current method shortcomings are complex apparatus structure, high labour-intensiveness, low output and extraction of zirconium. In addition, the process is accompanied by high power inputs, a significant amount of liquid and solid wastes.

For the purpose of reducing the cost of zirconium, improving the quality and fuel effectiveness the transition on chloride-magnesium-thermal pro-

cess of zirconium sponge production is carried out actively at the enterprise. Creation of zirconium sponge production at CMP, SC will also open a window of opportunity to enter the world market with zirconium alloys: there will be the opportunity of fuel licensing in the reactor facilities of foreign customers and advanced fuel cycles taking into account growing safety requirements.

Today 11 main operations from 12 target operations have been developed. The only unresolved challenge is a rectifying separation of zirconium and hafnium chlorides on the production unit. On the laboratory facility acknowledgement of dividing ability is received: decrease of hafnium concentration in the melt more than 10 times to design values < 100 ppm. Construction materials for industrial use at operating temperatures are selected. On industrial scale constructive and operational decisions are tested. At the enterprise preliminary works for the production of industrial facility are initiated according to the developed technical project.

For the nearest period the plant has the following tasks in chemical production:

- to manufacture equipment, to carry out the construction and erection works, and commissioning in 2015;
- to carry out full-scale tests and produce qualification lots of sponge up to 2017;
- to start commercialization of zirconium sponge since 2018.

2. Development Prospects of Rolling Mill Production

Technical re-equipment of rolling mill production has been conducted (recently) in recent years at CMP, SC: a horizontal mill is installed and introduced in the production chain, radial-forging machines, rolling mills, modern heating equipment.

The main purpose of technical re-equipment of production is tube production with characteristics at the level of the best world analogues. In addi-

tion, the new equipment is intended to establish production of rolled metal for foreign customers, and increase engineering-and-economical performance in whole.

Since the second half of 2014 the company has gone over to 100% output of cladding tubes with stricter requirements for the needs of domestic consumers. High technical requirements for tubes provide for the range items with a thinned wall (0.54 mm min in addition to 0.63 mm min) tightened tolerance for outer diameter (± 0.04 mm instead of ± 0.05 mm), thickness variation no more than 0.05 and 0.06 mm for tubes with an internal diameter of 7.93 and 7.73 mm correspondingly (new parameter), outer surface roughness not exceeding $0.6 \mu\text{m}$ (instead of $1 \mu\text{m}$) and roughness of inner surface not more than $0.8 \mu\text{m}$ (instead of $1.5 \mu\text{m}$).

At present, production of flat-rolled products also does not manage without improvements. Process layout and inspection of sheets including a large number of manual operations, such as pickling and cleaning of slimes needs to be improved.

Toughening of operating conditions and improvement of spacer grid leads to the necessity of strengthening the requirements for the construction and properties of spacer grid parts, such as rims.

The main factors defining the characteristics of sheets for spacer grid rims are their structural-phase condition and surface quality. Structural-phase condition of the sheets, in turn, depends on the strain-thermal conditions of manufacturing and surface quality depends on surface finishing conditions at all stages of their manufacture.

Thus, there are two directions of technological advancement of production process of sheets: adjustment of strain-thermal conditions and optimization of surface treatment methods at the stages of their manufacture. The enterprise is trying to implement both directions during the given period of time.

The plugs for claddings of fuel rods are also the significant range of products produced by the plant. For the end parts of fuel rods developers of engineering design documentation assigned strict requirements on the parameters deviation for co-axiality, therefore the plugs are manufactured using bar lathes with CNC.

The plugs must be sealed that is provided by quality of welding with cladding and continuity of plug and cladding material. Material continuity must be ensured, in turn, by manufacturing scheme of products.

Bars of high accuracy are used for the manufacture of plugs. Since 2008 a number of measures have been taken to improve the process of manufacturing of bars and toughening their quality control at the enterprise:

- in 2008 the manufacturing scheme of bars was changed (drawn bars were changed for rolled);
- tolerance for diameter of finished bar was toughened from 0.05 mm up to 0.04 mm;
- metallographic test for detection of discontinuities, inclusions, and phase discontinuities in the body of the bar was introduced;
- for ultrasonic testing of the continuity in the body of the bar a flat-bottomed artificial reflector was changed for cylindrical side reflector;
- in 2012 for the purpose of sensitivity increase of the instrument inspection the parameters of artificial reflector have been changed on standard samples during ultrasonic testing of continuity on the surface of the bars, etc.

In accordance with the measures taken at CMP, SC to improve manufacturing process of bars and toughening their quality control since 2008 the guaranteed manufacturing of products meeting requirements both domestic, and foreign customers is provided.

3. Quality System

The system of quality operating at the enterprise covers all stages of manufacture, since marketing, launching of new products statements, and finishing with its implementation. Modern methods of nondestructive testing, metallography is widely used, mechanical and corrosion testing is carried out for compliance with the quality of the products

Non-destructive testing (NDT) is an integral part of the process for manufacturing tube products of at CMP, SC during intermediate stages of operations (operational control), and the final stage (acceptance control). Now in the shops of the enterprise more than 50 facilities NDT is used mainly self-developed and manufactured at CMP, SC. For example, over the entire length of the tubes eddy-current and ultrasonic testing of continuity is carried out in a single pass with the help of one facility of complex control, as well as ultrasonic inspection of tube sizes: outer diameter, wall thickness, inside diameter, ovality, finish the outer diameter, internal diameter ovality. Hourly testing and periodically (every 3 months) calibration of facilities confirms their metrological suitability. Since

2011 active updating of all major types of facilities has been implementing in order to put the technical condition of monitoring equipment to modern requirements.

Thus, CMP, SC provides a complete service for manufacturing, and supply, as well as scientific and technical support of the zirconium nuclear

fuel components having characteristics of the best world analogues. Currently, the company has the following main tasks:

- development of zirconium sponge production;
- improvement of through yield in cladding tube production;
- improvement of other items quality.

