Open Joint Stock Company
Scientific-Research Institute of Metallurgical Heat Engineering
OJSC VNIIMT

16 Studencheskaya St., Yekaterinburg, Russia, 620137 Tel: +7 (343) 374-03-80, fax: +7 (343) 374-29-23
E-mail: aup@vniimt.ru, website: www.vniimt.ru

A/c 40702810902400230701 in Yekaterinburg affiliate of NOMOS-BANK (JSC) Yekaterinburg
Correspondent account No.30101810800000000918, BIK 046577918, INN 6660011779, KPP 667001001, OKVED 73.10 OKPO 00190259

OJSC Scientific-Research Institute of Metallurgical Heat Engineering (VNIIMT) established in 1930 as Ural Division of All-Union Heat Engineering Institute is widely known in Russia and the CIS. The Institute focuses on development of high-technology heat engineering units, energy efficient and ecologically friendly technologies in ferrous and non-ferrous metallurgy, machine-building and other fuel-consuming branches of industry.

Highly-qualified academic researchers, unique experimental and production facilities and own research and design centre enable efficient scientific-and-research, design-and-experimental, engineering and project works, delivery of equipment, designer's supervision and commissioning works including execution of turnkey contracts in the following areas:

Sintering:
- development of techniques and modes of metal raw material heat treatment;
- design of energy-efficient agglomeration hearths and agglomeration gas heat recovery circuits allowing to reduce energy consumption and dust and gas emissions.

Pellet production:
- optimal traveling grate pelletizing furnaces for heat treatment of iron-ore pellets from various concentrates (hematite, magnetite, etc.) with optimal automatic process control system.

Preparation of metallic and nonmetallic raw materials:
- technique of iron-ore raw material dephosphorization by roasting and leaching;
- installations for drying high-moisture dispersive materials of various designs;
- efficient techniques of magnetizing roasting and subsequent dressing;
- technique of rare-earth element extraction (for example, germanium from germanium iron ores).

Blast-furnace ironmaking:
- explosion-proof near-furnace systems of blast furnace slag granulation giving a high-quality product for cement production;
- optimal control system for hot blast stoves;
- an innovative bench for drying hot metal and steel-smelting ladles;
- copper coolers and tuyeres of blast furnaces.

DRI (direct reduction of iron)
- improvement of the reduction technique in shaft furnaces for radical improvement of technical and economic indicators of their operation (productivity is increased twice);
- technique of raw material reduction in rotary furnaces using coal as the reductant.

Lime production: development of the technique and increase of lime production process efficiency:
- in shaft furnaces;
- in double-shaft furnaces;
- in rotary furnaces;
- in "stacked-tower preheater - rotary furnace" installations;
- in "shaft calciner - rotary furnace" installations (VNIIMT innovative technology).

Granulation of metal melts:
- development of technologies and designs of explosion-proof plants for near-furnace granulation of metallurgical slag, molten metal, etc., including heat recovery;

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Reheating furnaces:

- development of new and update of the existing designs of furnaces for stock heating;
- high-performance systems of reheating furnace firing with recovery and regeneration firing systems based on the innovative burner units designed by VNIIMT;
- switching the furnace firing systems to cheaper fuel types;
- development and implementation of optimal furnace operating parameters.

Heat-treatment furnaces development of techniques and equipment for heat treatment of roll stock and metal products including those with protective atmospheres:

- thermochemical treatment conditions ensuring retention or directional change in chemical composition of metal surface;
- gas dampers for heat-treatment furnaces;
- spray quenching units and other elements of convective cooling systems;

Furnaces with protective atmosphere and gas treatment units:

- development of the furnace structure, design, manufacture, delivery and commissioning works;
- development of a technology for treatment of articles and devices for protective gas generation;
- calculation, development and manufacture of endogas and exogas atmosphere generators for metal product thermochemical treatment units;
- gas analysis systems for monitoring and control of physico-chemical properties of protective process atmospheres.

Reheating, heat-treatment and drying furnaces with convection heat transfer:

- development, design and manufacture using industrial heat-resistant (up to 900 ^{o}C) furnace fans designed by VNIIMT.

Rolled products:

- techniques and units for controlled high-speed air-to-water cooling (quenching) of rolled ferrous and non-ferrous metal products including thick plate on mill 5000;
- replacement of oil quenching technology with VNIIMT's eco-friendly air-to-water technique;
- innovative technique of oily mill scale processing;
- line of wire rod accelerated air cooling with process improvement.

Manufacturing manufacture and delivery of:

- high-performance burner units;
- heat-resistant (furnace) fans (up to 900 ^{o}C);
- copper coolers for blast furnaces and nonferrous furnaces based on VNIIMT technology;
- Pitot tubes for measuring flow rates and pressures.

OJSC VNIIMT developments are widely used in metallurgical enterprises of Russia, Ukraine, Kazakhstan, China, India and others.

For detailed information on institute developments, please visit OJSC VNIIMT site at www.vniimt.ru

Contact details:
CEO: Lik Zajnullin
Scientific Research Institute of Metallurgical Heat Engineering OJSC VNIIMT
Tel: +7 (343) 374-03-80, fax: +7 (343) 374-29-23
16 Studencheskaya St., Yekaterinburg, Russia**,** 620137,
e-mail: aup@vniimt.ru,
website: www.vniimt.ru

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Using Centrifugal Fans in the Cooling of Convective Furnaces

L. A. Zainullin[a], N. A. Spirin[b], M. V. Kalganov[a], and D. V. Kalganov[a]

[a]*OAO VNIIMT, Yekaterinburg, Russia*
e-mail: aup@vniimt.ru
[b]*Yeltsin Ural Federal University, Yekaterinburg, Russia*

Abstract—A circulatory convective furnace is developed for the heat treatment of long parts. This furnace, which has a complete heat-transfer cycle (heating, holding, and cooling), is characterized by periodic reversal of gas motion. Experimental control characteristics are presented for reversible devices based on centrifugal fans. The results may be used in the development of circulatory convective furnaces with a complete heat-transfer cycle.

Keywords: convective furnace, reversible device, centrifugal fan, aerodynamic closure

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At OAO VNIIMT, circulatory convective furnaces with a complete heat-transfer cycle (heating, holding, and cooling) have been developed for the heating and cooling of heat-insulated pumping pipe [1]. To improve the heat treatment of such components, the direction of gas motion is periodically reversed, so as to ensure a uniform temperature distribution over the pipe length [2].

In Fig. 1, we show a furnace for the heat treatment of long parts, with a complete heat-transfer cycle. The use of a reversible device with two centrifugal fans connected in opposite directions permits periodic reversal of gas motion, by alternate fan operation. In heating and holding, the input and output valves are closed, and the gas moves over a circulatory loop, transferring heat from the heater to the long part, with periodic reversal of its direction.

The parts are cooled in a controllable air flux within the furnace through alternately opening supply valves. To maintain the required cooling rate, especially in the final stage, increasing air fluxes are required. To that end, the fan responsible for the reverse flow of air must steadily increase the hydraulic drag, so that the flow rate of the hot air returned to the furnace is smoothly reduced to zero and complete removal of spent coolant (air) through the open output is promoted. The proposed method of regulating the circulating air flow permits the elimination of traditional control valves, which are inclined to jam after sustained high-temperature operation.

In Fig. 2, we show the test bench for simulation of the reversible device. In the experiments, fans of very different types are considered: the Ts14-46 fan with blades that are bent forward and the Ts3-81 fan with blades that are bend backward [3].

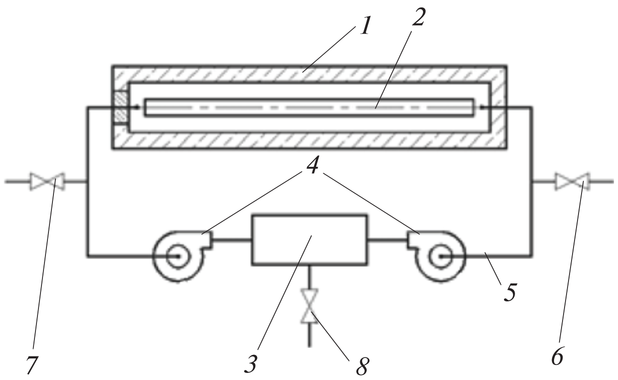

Fig. 1. Convective furnace with a complete heat-transfer cycle and periodic reversal of the gas motion, for the heat treatment of long parts: *1*) furnace housing; *2*) long part; *3*) heater; *4*) reversible device; *5*) connecting channels; *6*, *7*) coolant (air) supply; *8*) coolant extraction.

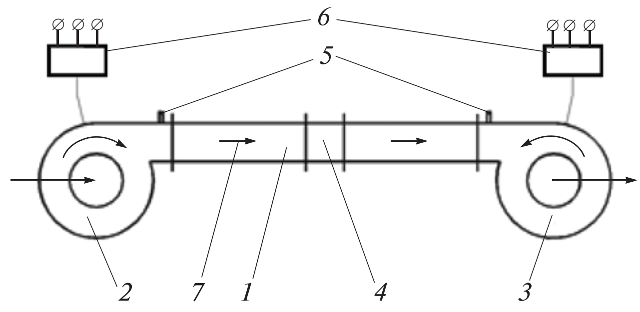

Fig. 2. Test bench for the investigation of centrifugal fans operating with aerodynamic regulation of the air flow: *1*) pipeline; *2*) blast fan; *3*) counterflow fan; *4*) flow meter; *5*) pressure sensors; *6*) frequency converters; *7*) direction of air motion. 1

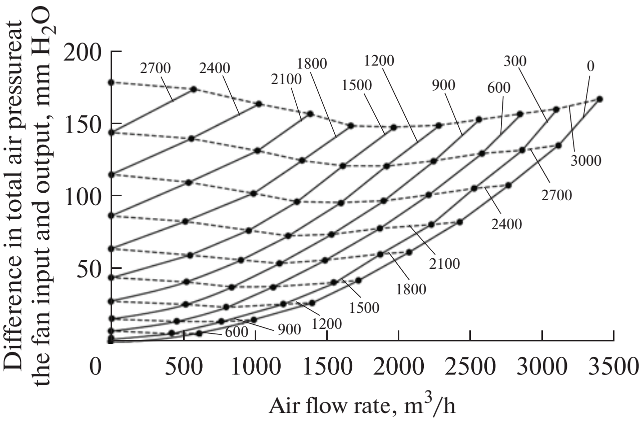

Fig. 3. Experimental aerodynamic characteristics of the reversible device in conditions of aerodynamic closure (air
1 density $\rho = 1.2\ g/dm^3$) for the counterflow fan (continuous curves) and blast fan (dashed curves), in the case of Ts14-46 2.5 fans; the fan speeds (n, rpm) are given on the curves.

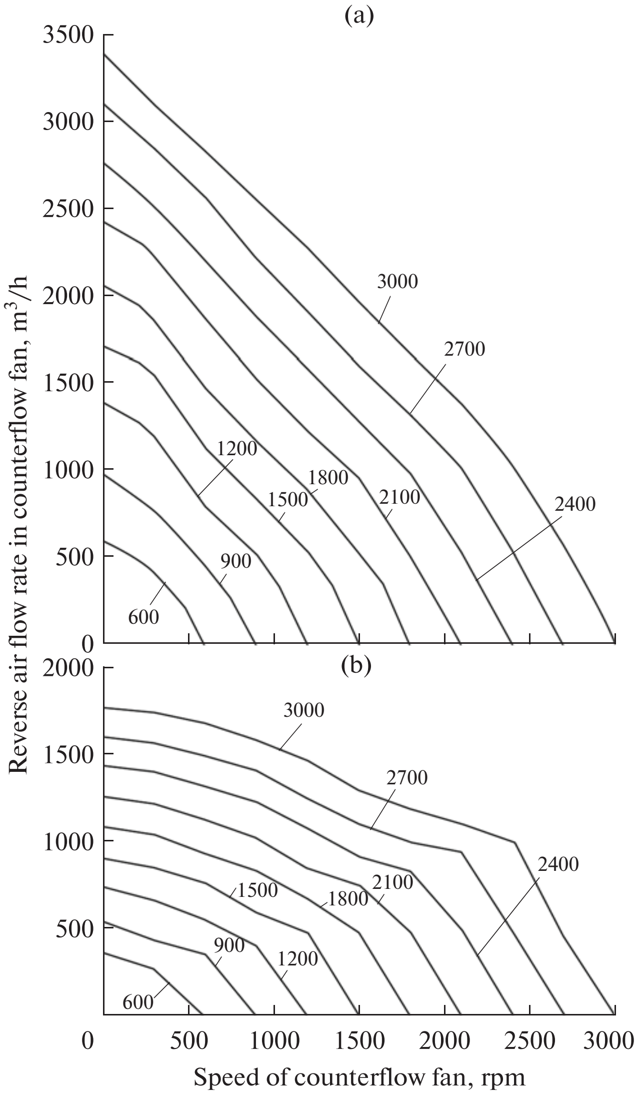

Fig. 4. Experimental control characteristics of the reversible devices based on the Ts14-46 2.5 fan (a) and Ts3-81 2.5 fan (b) in conditions of aerodynamic closure; the fan speeds (n, rpm) are given on the curves.

In Fig. 3, we show the results for the reversible device in conditions of aerodynamic closure. Ts14-46 2.5 fans (with blades that are bent forward) are used in this case. The maximum flow rate in the reversible device corresponds to stopped motion of the counter- 1
flow fan (Fig. 3, $n = 0$). In this case, the fan corresponds to the local minimum hydraulic drag. Increasing the fan speed in opposition to air motion increases the hydraulic drag and correspondingly reduces the reverse air flow through the fan. That corresponds to aerodynamic closure of the reversible device.

The experimental characteristics for the fan transmitting the reverse air flow, with rotation in opposition to this flux, correspond to the counterpressure created by the fan and the hydraulic losses in air motion within the fan.

In Fig. 4a, we show the control characteristics for the reversible device based on the Ts14-46 2.5 fan operating in conditions of aerodynamic closure. If the aerodynamic characteristics of the fan are adjusted by varying the fan speed, we may regulate the air flow rate in the reverse direction, which acts like a traditional mechanical valve. In Fig. 4b, we show the control characteristics for the reversible device based on the Ts3-81 2.5 fan operating in conditions of aerodynamic closure.

It follows from the results that both of the reversible devices considered operate effectively in conditions of aerodynamic closure and may be used in circulatory convective furnaces with a complete heat-transfer cycle in the course of cooling.

CONCLUSIONS

A circulatory convective furnace has been developed for the heat treatment of long parts. This furnace, which has a complete heat-transfer cycle (heating, holding, and cooling), is characterized by periodic reversal of gas motion. A method of increasing the cooling rate by increasing the air flow rate in the furnace chamber is proposed. This method employs reversible devices based on two centrifugal fans, one of which operates in conditions of aerodynamic closure. Experimental aerodynamic characteristics are obtained for reversible devices based on centrifugal fans.

The results may be used in the development of circulatory convective furnaces with a complete heat-transfer cycle.

REFERENCES

1. *STO* (Organizational Standard) *Gazprom 2-3.2-174—2007: Requirements on Heat-Insulated Pumping Pipe*, 2007.
2. Kalganov, V.M., Zainullin, L.A., Mekhryakov, D.V., et al., Russian patent 2 467 077, *Byull. Izobret.*, 2012, no. 32.
3. Solomakhov, T.S. and Chebysheva, K.V., *Tsentrobezhnye ventilatory: spravochnik* (Centrifugal Fans: A Handbook), Moscow: Mashinostroenie, 1980.

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SPELL: 1. counterflow