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Development of System for Centralized Supply of Release Agent to Molds of Casting Facilities of CJSC RIFAR

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Abstract—The Rifar company is a Russian manufacturer of a new series of high-quality bimetallic and aluminum sector radiators. Bimetallic heating radiators are made using a hydraulic press. The weakest adhesion of the alloy to the mold walls (especially during aluminum casting) and the reduction in the mold wear and number of scratches on the blanks are ensured using a release agent to lubricate the molds. This lubricant is taken from an individual intermediate tank standing near each casting facility. In this case, the tanks are filled with the lubricant once. It is used throughout the shift, and after that the tanks are handled with the help of forklifts and sent for refueling. To improve the operational reliability and ease of maintenance of the casting facilities, it is proposed to use a centralized supply system for replacing the individual supply of release agent to the casting facility molds. A hydraulic diagram is developed, and the volume and structure of the hydraulic tank for the concentrate are determined. The tank is welded from steel sheets. As a result of developing the system for the centralized supply of release agent to the casting facility molds, it has been possible to simplify the release agent supply scheme, cut the fuel costs, and reduce the complexity of maintaining the equipment. The replacement of the individual supply to the casting facility molds with the centralized supply system improves the reliability of supplying the release agent to these molds. Estimates suggest that the design solution does not require large capital expenditures for implementation and the proposed measures will cut the production prime cost by 0.02%. The payback period of the proposed investment project does not exceed 1 month.

Keywords: injection molding press, release agent, individual lubricant supply

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A lot of attention in metallurgical enterprises is currently paid to upgrading their existing equipment, adopting new cutting-edge technologies, fully automating the control of metallurgical processes using high-performance computer systems, and improving job management processes and qualification of employed personnel [1–4]. That being said, much attention is paid to identifying bottlenecks [5–8] in the operation of main process equipment and accumulating data for developing managerial and operational arrangements to cut unscheduled equipment downtimes [9–13].

One of the important issues in metallurgy is equipment reliability improvement [14–17]. This issue is resolved by upgrading or replacing outdated equipment [17–21]. This work considers the manufacturing adoption of the device for the centralized supply of release agent to the molds of the casting facilities of CJSC RIFAR.

The Rifar company is a Russian producer of a new series of high-quality bimetallic and aluminum sector radiators. In Russia and other members of the CIS, they are efficiently used in both, autonomous heating systems of detached houses and shared heating systems of cottage estates and in central heating systems of multistoreyed buildings and structures. Rifar radiators have proven themselves well in various Russian regions and countries of the CIS. The high reliability of the radiators ensures their capability of remaining operable for long periods and allows maintaining

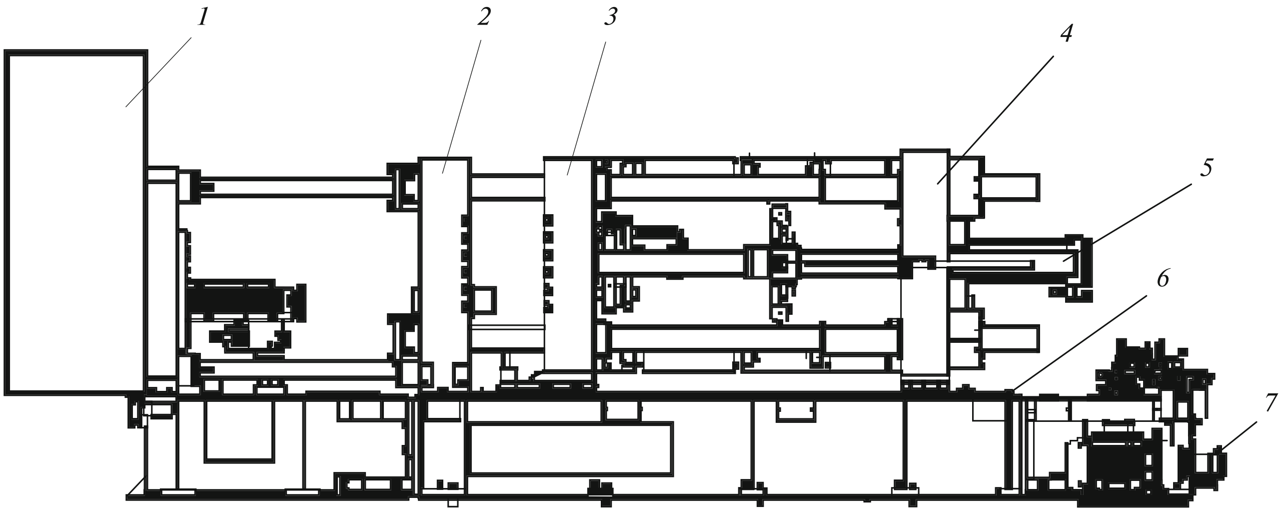

Fig. 1. Injection molding press design: (*1*) the plate; (*2*) the movable plate; (*3*) the fixed plate; (*4*) the hydraulic batteries; (*5*) the frame; (*6*) the hydraulic pumps; (*7*) the hydraulic cylinder.

comfortable heat levels with any functional heating systems [17, 18].

The casting shop is equipped with an Italy-made melting gas furnace MTX-300 used for melting and teeming aluminum. High-quality aluminum alloy of Russian producers, stable maintenance of constant temperature, and strict dosing of metal allow minimizing the expenditures for production residues. To melt the flux, GOST 1583–93 AK12M2 aluminum blanks are necessary. These blanks (ingots) and secondary waste (sprues and burrs) are loaded into the furnace with the help of an automatic skip hoist with a loading cart on its pins. To achieve the maximal furnace productivity, it is necessary to strictly observe the order and schedule of loading charge materials, stipulated by the regulatory documents [19–20].

Bimetallic heating radiators are made using a hydraulic press OL-A 1200. The operating principle of the injection molding press is based on the forced filling of a working mold cavity with melt and preshaping blanks under the pressure of a casting piston moving in a molding chamber filled with melt [21–26]. Unlike the block mold, the working faces of the mold in contact with the cast have no refractory coating. This process leads to the need for the short-term filling of the molds with the melt and generating an overpressure on the crystallizing cast hundreds of times greater than the gravity pressure. Implemented on modern hydraulic machines, this process ensures the production of tens to hundreds of thousands of high-quality low-roughness casts per hour of various purposes, with dimensions and surfaces that correspond or are as close as possible to the finished part.

The design of the Rifar molding press is shown in Fig. 1.

To reduce the adhesion of the alloy to the mold walls (especially in aluminum casting) and the wear of the molds and cut the number of burrs on the blanks, the molds are lubricated with release agent. Parts of the pressing chamber, such as filling cup, piston, and heel, are also lubricated.

The production of high-quality blanks requires applying a thin layer of lubricant. The excessive amount of lubricant flows into the mold, does not allow fully filling the press-mold contour, and favors frosting. In addition, at high amounts of lubricant the generation of bubbles intensifies and generates extra pressure in the mold, which creates burrs on casts (burr is part of the melt that flows into the partings and remains on the cast).

The mold parts, where the melt can stick, and the parts leaving rubmarks or scratch marks on the blank, must be lubricated. The rods and molds must be greased periodically, at working hours, depending on the shape of the cast. Complex molds must be greased more frequently than basic molds. The chamber parts must be greased after several operating cycles. When brass blanks are cast, the first few blanks are discarded after lubrication because they are full of gas and considered rejects.

The best way of applying release agent on all of the working parts is to use a spraying machine that ensures a thin even layer of the agent. Release agents used for lubricating molds must be resistant to high pressures and temperatures, not cause the corrosion of casts and mold parts, be harmless for the operator, and generate a stationary film on the mold surface and the baling chamber.

The lubricating device is a casting machine part designed for cooling molds and greasing their work face with release agent. This device consists from a

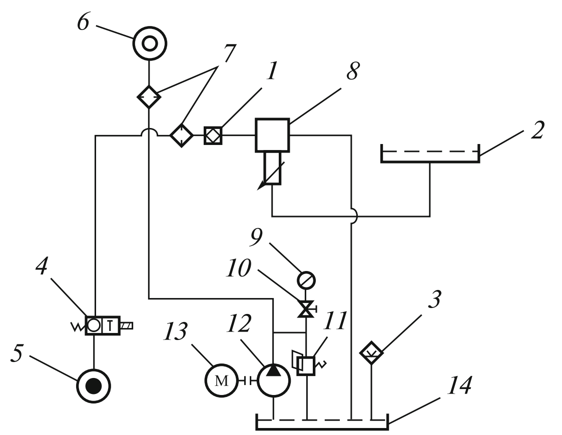

Fig. 2. Individual supply of release agent to the molds: (*1*) the flow check valve; (*2*) the hydraulic tank; (*3*) the level sensor; (*4*) the on/off control valve; (*5*) the hydraulic circuit; (*6*) the lubricating device; (*7*) the filter; (*8*) the dispenser; (*9*) the pressure gage; (*10*) the crane; (*11*) the safety valve; (*12*) the hydraulic pump; (*13*) the electric motor; (*14*) the intermediate tank.

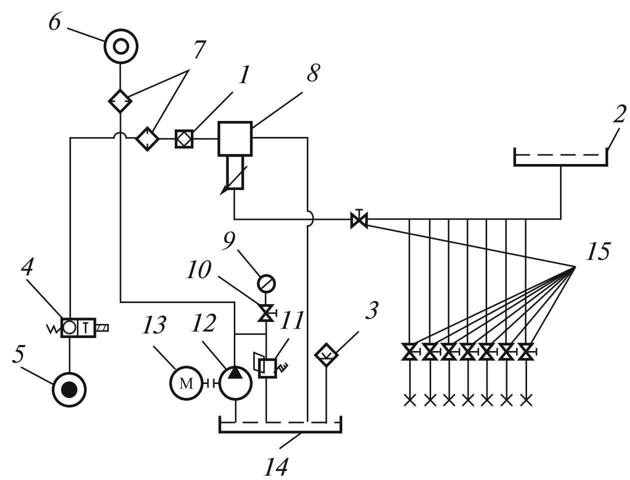

Fig. 3. Centralized supply of release agent to the molds: (*1*) the flow check valve; (*2*) the hydraulic tank; (*3*) the level sensor; (*4*) the on/off control valve; (*5*) the shop line; (*6*) the lubricating device; (*7*) the filter; (*8*) the dispenser; (*9*) the pressure gauge; (*10*) the crane; (*11*) the safety valve; (*12*) the hydraulic pump; (*13*) the electric motor; (*14*) the intermediate tank; (*15*) the emergency crane.

group of nozzles with an injection system. This group is fixed on a frame moving along the vertical and the horizontal axis at a certain speed set by the operator through the control system. The mold is automatically greased with a greaser spraying release agent FONDEROL FK-F-002 on the work face of the movable and stationary parts of the mold. The quality of casthouse products largely depends on the preparation of the emulsion before use. A prerequisite for their high quality is a right concentrate-to-water ratio. If the emulsion is not concentrated enough, the blanks will be scuffed or the molds will stick and a large number of defective aluminum radiator sections will be produced.

An integral solution of this problem is possible by upgrading the emulsion feeding at the casthouse of CJSC Rifar. Given the lack of material resources for retrofitting, special attention should be paid to the time spent on filling intermediate tanks with the concentrate. To mix the concentrate with water, a sophisticated dispensing system is used that maintains a necessary concentration of release agent in water.

At the moment, the release agent for lubricating the molds is taken from an individual intermediate tank near each casting facility (Fig. 2). The tanks are filled with the lubricant once, and it is used throughout the shift, after which the forklift lifts the tank for refilling.

To supply the release agent to the casting facilities, it is more preferable to use a centralized line (Fig. 3).

This variant is more commercially beneficial because it makes it unnecessary to fill each intermediate tank, which will cut the time on filling each separate intermediate tank. In addition, the quality control of the supplied emulsion is simplified [27–32].

Dispenser *8* is installed in the water supply network, uses water pressure as a motive force, and, as a result, sucks the release agent from hydraulic tank *2*, dispenses it at a required percentage ratio, and then mixes it with the driving water. The produced solution is supplied to intermediate tanks *14* that are installed on each casting facility. Hydraulic pump *12* feeds the solution from tank *14* to greasing device *6*. The water for dispensing is supplied from shop line *5*. The hydraulic tank is equipped with a fluid level sensor for release agent.

Release agent consumption Q_{ra}, mL/min, is determined as

$$Q_{ra} = C_{ra}Q_{wat} = 0.02 \times 3.4 = 0.068 \text{ L/min},$$

where C_{ra} is the amount of release agent in water, $C_{ra} = 0.02$ mL/L; Q_{wat} is the water consumption on mixing, $Q_{wat} = 3.4$ L/min.

Considering the determined release agent consumption, let us determine tank volume V_{tnk} necessary for running all of the eight casting facilities ($Z_{cf} = 8$) every day, that is, $T_{wk} = 24$ h = 1440 min:

$$V_{tnk} = Z_{cf}Q_{ra}T_{wk} = 8 \times 0.068 \times 1440 = 783 \text{ L}.$$

Thus, the item proposed for use as the capacity for release agent is a tank with volume $V_{tnk} = 800$ L shown in Fig. 4. The tank can be made from any available material because release agent is fairly inert and does not react with the tank surface. It is proposed to make the tank from Ct3 steel sheets by arc welding. The load on the tank walls is weak, which is why control calculations are unnecessary.

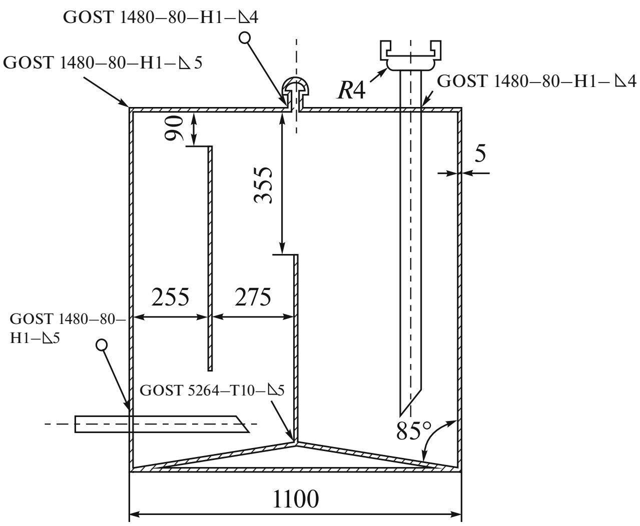

Fig. 4. Hydraulic tank for the concentrate.

Plastic pipes with an inner diameter of 4 mm and an outer diameter of 6 mm are used to feed the release lubricant from the tank to the dispenser. The minimal pipe diameter is determined based on the flow rate of the release lubricant and fluid flow rate $V_{ra} = 2$ m/s.

To assess the economic efficiency of implementing the centralized emulsion feeding system, a capital expenditure budget was set. As a result, it was established that the sum of capital investments amounted to about 80 thousand rubles. The main economic effect expected from adopting the centralized emulsion feeding system at the casting facilities is related to a reduction of fuel consumption for forklift trucks. Before modernization, the company spent 9.66 million rubles on fuel. The proposed modernization measures will reduce these costs by 1.15 million rubles, which will have a favorable effect on the economic standing of the enterprise, taking into account the growth of fuel prices. As a result, the prime cost of a battery section was cut by 0.1 rubles (0.02%), which had a significant economic effect at an output of 11.5 million articles. The cost of adopting the centralized emulsion feeder are outweighed 25 days after the beginning of its operation.

These indicators prove the cost-effectiveness of the developed project.

CONCLUSIONS

The centralized emulsion supply to the casting facilities of CJSC Rifar has been developed, which has allowed cutting the fuel costs and the time spent on filling the hydraulic tanks with release agent. The main elements of the hydraulic system have been selected, and the capacity of the concentrate tank and its design developed. The calculations show that the implementation of the design solution does not require large capital expenditures, and the proposed measures will cut the prime cost of production by 0.02%. The payback period of the proposed investment project does not exceed 1 month.

AUTHOR CONTRIBUTIONS

A.V. Nefedov contributed to shaping the main idea of the work and to the scientific guidance.

E.G. Novikov contributed to the patent search.

O.N. Chicheneva contributed to the search and analysis of publications included in the scientometric bases.

T.Yu. Gorovaya contributed to shaping the purpose and objectives of the study, preparing the text, and correcting the conclusions.

A.N. Fortunatov contributed to analysing the study results, generating the conclusions, and the final editing of the text.

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