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WHEEL AND SHOE FORCED COOLING AT CONFORM INSTALLATIONS

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ABSTRACT

A current trend in nowadays metallurgy is to create combined technologies that cover several metallurgical treatment procedures or various operations performed on a single device dedicated to manufacturing required products and thus ensuring the manufacture of competitive products at minimal production costs. The forms in which the technological operations in metallurgical production are combined may vary. Most effective is the combination of casting and plastic metal working processes. However, during the crystallization of molten metal in an annular groove of the disc and subsequent pressing, a considerable amount of heat is generated, and part of it shall be removed to establish the isothermal conditions while carrying out the continuous casting and pressing process. Otherwise, unstable temperature in the pressed articles exiting a die channel may lead to mechanical properties' dispersion and the distortion of their geometry in length as well as at cross section of the pressed articles, thereby lowering the products' quality. It should be noted that the pressed article is destroyed when a temperature similar to the melting temperature of the pressed metal is achieved, which shall be considered as an ultimate defect. Moreover, increased pressing temperature decreases the strength of the tools, which leads to their premature failure. One of effective ways to solve this problem is forced cooling of both the pressing tool and metal section. This paper presents various technical solutions aimed at solving this problem.

Keywords: conform installation, combined continuous metal casting and pressing, forced cooling, and installation structures.

INTRODUCTION

The beginning of Conform's industrial development process dates back to the mid 1970s. During this period, several installations [1] for nonferrous metals extrusion were created. The operating practice of the majority of Conform machines' modifications exposed one of the reasons why the growth of their technical and economic performance was stunted. This primarily refers to the restriction of temperature and speed parameters of a deformation process and intense metal sticking on the tool caused by a considerable amount of heat generated from the deformation and forces of contact friction. Therefore, the solution to the problem of increasing the pressing speed at Conform installations by way of developing effective heat diversion systems from the deformation zone during metal extrusion is a pertinent question for researchers.

METHODOLOGY

At current stage of metallurgical production evolution, development, introduction and management of innovation processes including flexible, compact, energy-saving automated lines for metal ware manufacturing move to the forefront. Their functioning is based on combining the operations related to continuous casting and pressing in one technological cycle.

It defines the appropriateness and, at the same time, the great need for a thorough study of combined methods of metal works at pilot plants [1-4] carried out by a group of Siberian Federal University (Krasnoyarsk) employees. The obtained laboratory results allowed to design the equipment for industrial manufacturing of non-ferrous metal shapes by conform method. The structure is provided of the installation developed according to the technical assignment of a metallurgical plant in Figure-1.

SUMMARY OF RESULTS

A bandage 400 mm in diameter with an annular groove 16x20 mm section was installed on a drive shaft. The shaft shall be installed at two housing posts on roller bearings. The power of the shaft's DC motor is 120 kW. There is a mounting pad for the shoe between the posts, which is fixed in an operating position with help of steel rods and eccentrics. The die is inserted into a tapered hole, a circular segmented insertion in the shoe. The forced cooling of the shaft with a bandage and the shoe with an insertion is envisaged in the pressing block during the continuous metal pressing process. A motor drive was completed via gear system with a drive ratio of 44 to increase the torque at the shaft of the working unit. The gear box driven shaft is connected to the shaft of the working unit with coupling.

During continuous pressing, forced cooling of wheel 3 is performed with the liquid coming to the blind hole of the shaft installed on roller bearings in housing posts 2 via a pipe 1, the diameter of which is a bit less than the inner diameter of the hole (Figure-2). This structure ensures the continuous circulation of the cooling liquid in the gap between the feed pipe and the internal surface of the shaft hole.

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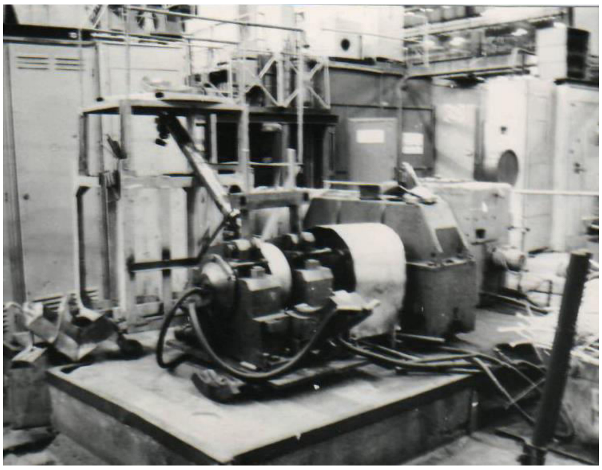

Figure-1. The conform installation at the section dedicated to the alloy bars' Al-Ti-B manufacturing from grains [1].

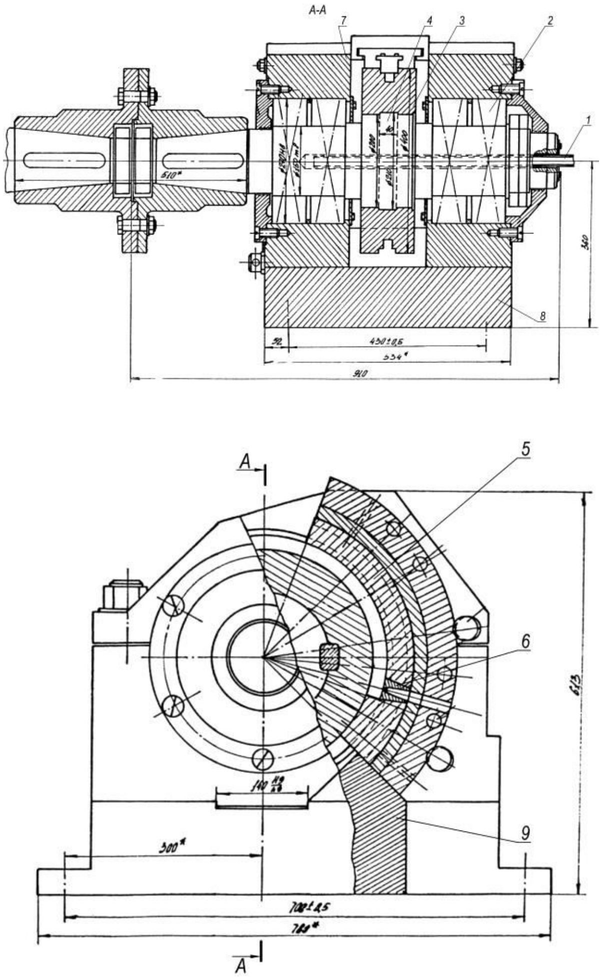

Figure-2. Conform installation pressing unit elements: a - frontal view section; b - lateral view; 1 - coolant feed pipe; 2 - bearings; 3 - bandage; 4 - shaft; 5 - insertion; 6 - die; 7 - post; 8 - base; 9 - support.

Theoretical and experimental research, the results of which are presented in the papers [5-8], showed that the metal temperature in the deformation zone during pressing in Conform installations mainly depends on the shaft speed and is controlled by the removal of heat from the tool using forced cooling. A way to improve the performance of the pressed articles' production using this method with increased pressing speed is provided in the technical solution [9] of the pressing tool cooling system, which differs from the one depicted in Figure-2, because the circular grooves made in the wheel impression form at least two circular channels together with the section insertion. At the edges, they are equipped with moving and fixed sealing elements. Meanwhile, the moving elements are located on the die's side and are spring-pressed against the section insertion toward the die. Deformed metal 10 temperature control and removal of heat from the pressing wheel 1 and a fixed insertion 2 and die 3 are performed by feeding the coolant 11 to annular channels 4 via holes 8 (Figure-3). Elements 5 and 7 cover the cross section of annular channels 4, thus sealing them hermetically at the ends. The section insertion 2 hermetically seals this part lengthwise by mating with the annular channels. To decrease the temperature of the metal 10 in the bore of wheel 1, the consumption of the liquid 11 coming into annular channels 4 should be increased via the holes 8. At that, moving elements 5 driven by pressure of liquid 11 travel for a certain distance along the annular channels increasing thus share of the channels surface that contacts with a coolant, and vice versa, to increase temperature of metal 10 it is necessary to reduce consumption of liquid 11. The liquid is removed from the cooling system via a hole 9.

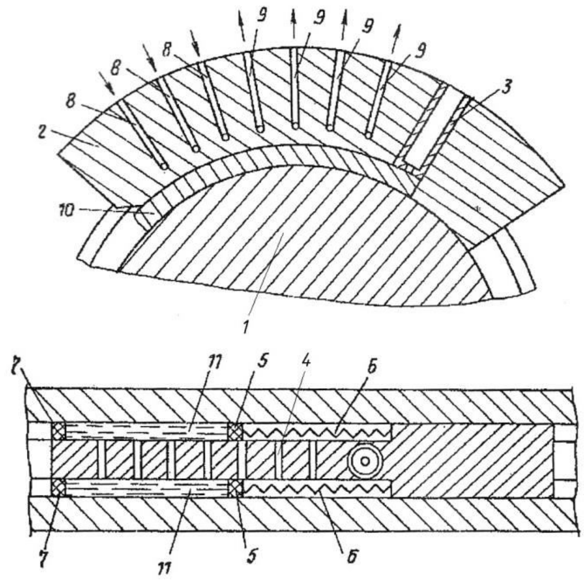

Figure-3. The cooling system for the continuous metal pressing device at the Conform installation [6].

The use of this cooling system for pressing unit enables the continuous metal pressing with increased rotation speed of the wheel and achieving performance of up to 1 t/h for the pressed aluminum shapes [10] using the bandage with 400 mm outer diameter and 16×20 mm cross section of impression.

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The pressed shape is cooled with help of a sprinkler after exiting the die. The metal temperature in the deformation zone is controlled using a thermocouple, the hot end of which is located at the dedicated hole for the ring insertion.

A way to improve the Conform process is to combine the continuous casting and continuous pressing processes by feeding the metal melt into the wheel impression, its crystallization, and extrusion of the ingot's solidified portion out of the die hole. Attempts to implement this scheme at the Conform installation with wheel rotation horizontal axis have led to destabilization of the melt metal casting in a two-part container caused by the pickup of the solidified melt at the fixed ring insertion. Using a carousel type casting mold wheel with a vertical rotation axis [11-13] may eliminate this effect.

The results obtained in the experimental studies conducted at Siberian Federal University laboratory underlie the design of the operating tool, the system of its forced cooling, and a pilot plant drive [14] for combined casting and pressing of the non-ferrous metals (Figure-4).

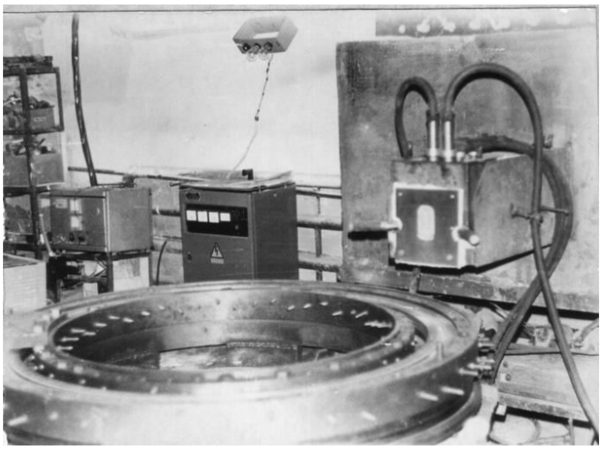

Figure-4. The pilot plant for continuous metal casting and pressing assembled in Siberian Federal University laboratory [14].

The rotating platform of a truck-mounted crane with a capacity of 10 tons was adopted as the base element for a carousel type casting mold structure. The ring component of the casting mold with an annular groove made of heat resistant tool steel 5XHM is concentrically fixed with bolts to the gear face plate of a plenatary gear set. The diameter gauge along the axis of the annular groove's bottom is 1, 200 mm. A trunk is provided for in order to collect the coolant located beneath the rim component of the casting mold. A collector with nozzles is provided for its feeding to the rim component of the casting mold. The torque's transfer to the face plate with an attached rim component of a DC motor is performed via the worm gear and planetary gear reducer with a total reduction ratio of 320. According to the precomputation results, the rim component size and torque value provide a means to make the annular groove, the width of which is up to 40 mm in order to cast the molten aluminum, to form it properly, to ensure the ingot's crystallization, and to feed it into the container and the die for further pressing at the predetermined temperature.

As with the Conform machines, a two-part container is arranged at the transition area of the casting mold's groove and the fixed segment with the die installed there and ending with a shoulder that blocks the groove's cross section. The container's fixed part is mounted with bolts to the body of the rotating platform and is fixed there in an operating position with additional supports that reduce the cutting force affecting the bolt bodies. The die is installed at a taper hole made near the shoulder that blocks the groove's cross section. Meanwhile, the larger hole base is directed toward its bottom. The ingot's height forming prior to its feeding into the container is controlled via regulation of the annular groove's blocking with the segment and its shoulder. The press roller is installed in front of the container's fixed part to increase friction at the contact surface of the ingot and the groove. The metal is melt in the holding furnace. The electric resistance heating units allow augmenting the bath furnace temperature to up to 950^{o}C. The furnace burden is fed for melting via a lading door. The tap hole with a head pressure regulator is envisaged for the tapping.

The continuous pressing process via a combined method is arranged for as follows at this installation: the wheel is rotated by the motor's starting; the molten metal is cast into the wheel's groove via the pouring gate system. While moving to the deformation zone, the metal crystallizes, takes the shape of the groove's cross section, and cools down to the pressing temperature. In the pressing chamber, the front end of the blank reaches the segment's shoulder. Then, the blank material is pressed along the chamber's cross section, thus increasing the contact friction between the groove's walls and the blank up to the one required for the article's extrusion out of the die mouth. The processes of metal casting, crystallization, and cooling and feeding the ingot into the pressing chamber, its pressing, and its extrusion are performed continuously while the wheel rotates. The pressed article leaving the die via the guiding rollers is fed into the device for cooling.

The forced cooling of the tool, including the casting mold wheel, the shoe with a support, and the die is a necessary condition for the continuous casting and pressing process' stability [15-17]. The structure of the installation presented in Figure-4 envisages cooling only for the tire rim of the casting mold via nozzles and limits the rotation speed.

To improve this parameter determining the performance of the combined process, the cooling system was suggested for casting and pressing installation [18] tools, as presented in Figure-5.

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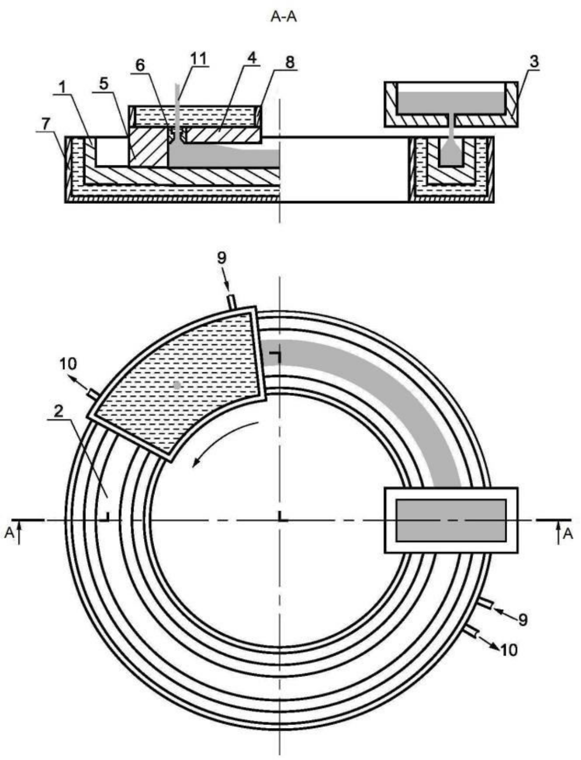

Figure-5. Cooling of the tools of the continuous casting and pressing installation [18]: 1 - casting mold wheel; 2- impression; 3 - dispenser; 4- shoe; 5- support; 6 - die; 7, 8 - manifolds; 9, 10 - joining pipes; 11- pressed article

CONCLUSIONS

The device operates as follows: the molten metal is fed into an impression 2 of casting molt wheel 1 via a dispenser 3, which crystallizes while the wheel rotates and then goes under the shoe 4 and arrives at the support 5. Then, the pressed article 11 is extruded out of the die hole 6. After that, the coolant is fed into manifolds 7 and 8 via joining pipes 9 and contacts with tool and then leaves through joining pipes 10. This cooling system has been assembled and used to produce soldering wire made of aluminum alloy [19-21].

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