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РОЗРОБКА ТЕХНОЛОГІЇ ВІДНОВЛЕННЯ ЧАВУННИХ КРИШОК І ПОРШНІВ СУДНОВИХ ДИЗЕЛІВ

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Анотація: *Розробка та застосування сучасних технологій та обладнання для відновлення чавунних деталей суднових дизелів є актуальним напрямом в судноремонті. Внаслідок інтенсивного використання суднових дизелів, їх деталі піддаються зносу, корозії, ударним та термічним навантаженням. Це може призводити до зниження ефективності двигуна, втрати потужності та скорочення терміну служби. Однак, заміна цих деталей новими є витратною та часоємною процедурою. Відновлення деталей є економічно доцільним рішенням, забезпечуючи високу якість відновлених компонентів та збереження ресурсів. Сучасні технології відновлення, включаючи термічний спрей, плазмове напилення та лазерне зварювання, забезпечують відновлення деталей до їхньої оригінальної форми та функціональності. Технологія відновлення деталей суднових дизелів допомагає продовжити термін їхньої служби, знизити витрати на обслуговування та забезпечити ефективну роботу суден. Завдяки своїй актуальності, ця технологія сприяє підвищенню надійності та ефективності суднових дизелів у морській промисловості. Чавунні кришки циліндрів і поршнів мають широкий спектр дефектів, що виникають внаслідок експлуатації. З метою відновлення зазначених відповідальних деталей було визначено способи холодного і гарячого зварювання чавуну, а також розроблено для реалі-зації цієї технології нагрівального пристрою. Була розроблена та виготовлена електрична піч, необхідна для запобігання появи тріщин при гарячому зваренню чавунних деталей. Приведені експерименти дослідження та розробка обладнання дозволили розробити технологічні процеси відновлення чавунних кришок циліндрів і поршнів суднових дизелів.*

Ключові слова: *Відновлення деталей, чавун, зварювання, суднові дизелі, нагрівальні пристрої.*

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DEVELOPMENT OF TECHNOLOGY FOR THE RESTORATION OF CAST IRON COVERS AND PISTONS FOR MARINE DIESEL ENGINES

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Abstract. *The development and application of modern technologies and equipment for the restoration of cast iron parts of marine diesel engines is an important area in ship repair. Due to the intensive use of marine diesel engines, their parts are subject to wear, corrosion, shock, and thermal loads. This can lead to a decrease in engine efficiency, loss of power, and a reduction in service life. However, replacing these parts with new ones is a costly and time-consuming procedure. Parts remanufacturing is a cost-effective solution, ensuring high quality of remanufactured components and conservation of resources. Modern remanufacturing technologies, including thermal spray, plasma spraying, and laser welding, ensure that parts are restored to their original shape and functionality. The technology of marine diesel engine parts remanufacturing helps to extend their service life, reduce maintenance costs and ensure efficient operation of vessels. Due to its relevance, this technology contributes to the reliability and efficiency of marine diesel engines in the maritime industry. Cast iron cylinder and piston covers are subject to a wide range of defects arising from the operation. To restore these critical parts, the Company identified methods for cold and hot welding of cast iron and developed a heating device to implement this technology. An electric furnace was designed and manufactured to prevent the appearance of cracks during hot welding of cast iron parts. The presented experiments of research and development of equipment allowed to development technological processes for the restoration of cast iron cylinder heads and pistons of marine diesel engines.*

Keywords. *Restoration of parts, cast iron, welding, marine diesel engines, heating devices.*

The analysis of the inspection materials of the cast iron cylinder covers and pistons showed the presence of a wide range of defects. In order to restore these critical parts, it is necessary to determine various methods of cold and hot welding of cast iron, as well as the need to develop heating devices to solve this problem. Experimental work on the repair of these ship parts revealed the need to develop a heating device (furnace) for preliminary and subsequent heating. Such an element in the restoration technology should be used to prevent cracks during hot welding of cast iron parts.

Electric furnaces ensure high accuracy and uniformity of heating through the rational placement of heat sources, as well as high heating performance.

An electric furnace [1] was developed and manufactured for heating cast iron covers of MAN marine diesel engines (Fig. 1).

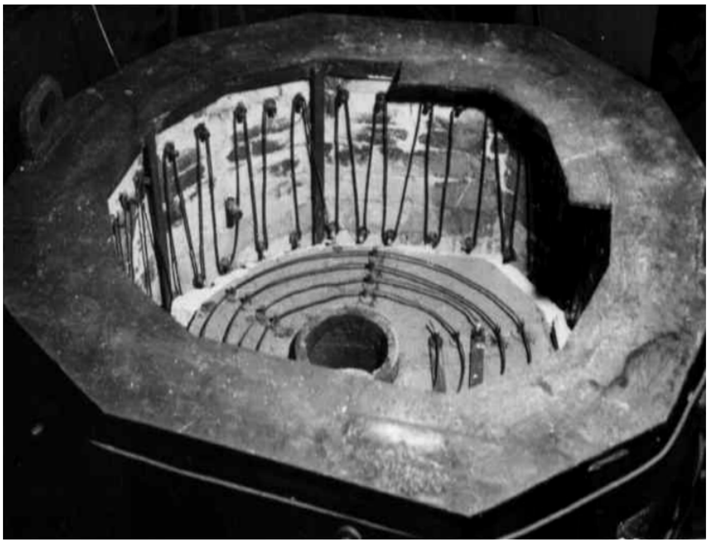


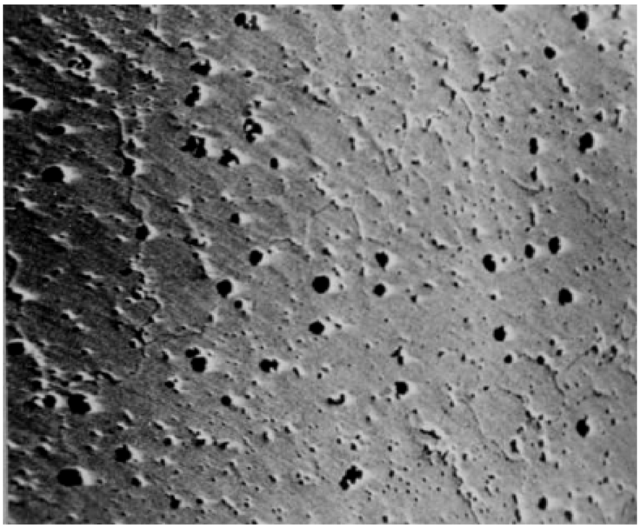
Fig. 1. Electric heating furnace for MAN K6Z57/80F diesel engine covers (cover removed)

After conducting studies of the weldability of gray and high-strength cast irons on plates, experimental studies were conducted to develop technologies for the restoration of real cast iron parts of marine diesel engines.

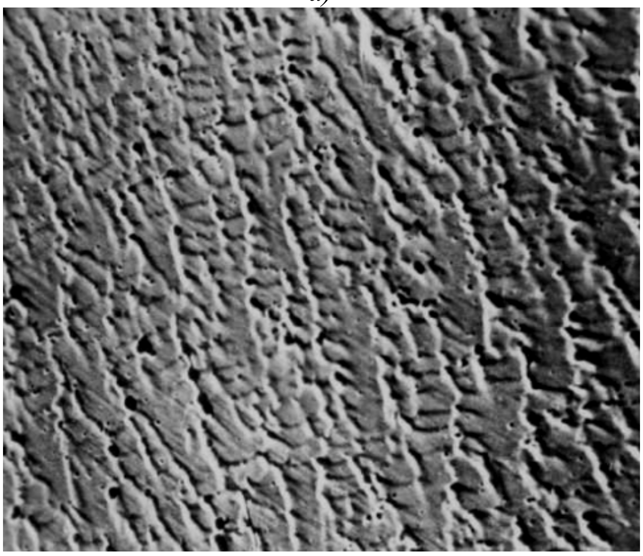
The covers of 6CH18-22 and 6CH26-34 diesel engines made of gray cast iron and covers of K6Z57/80F diesel engine made of high-strength cast iron were selected.

Technological studies were carried out on the surface of the 6Ch18-22 diesel engine cover (wall thickness – 12 mm), on which a non-through U-shaped development with a depth of 10 mm was made with a volcanite wheel. Welding was performed with a cold wire PANCH-11 Ø 1.2 mm at I_w = 180 – 200 A, U = 18 – 20 V. The development was filled in four passes. The cut samples were subjected to metallographic studies.

In Fig. 2 shows the structures of the deposited metal of the first and second layers. It can be seen that with each subsequent weld the structure improves, the amount of carbides and non-metallic inclusions transferred to the weld from the base metal decreases.



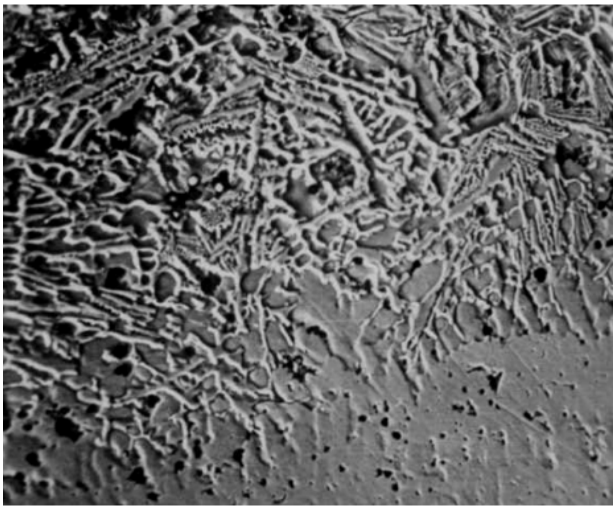
x 400
a)



x 400
b)

Fig. 2. Structure of the deposited metal of the sample from the 6CH18-22 cover: a – first deposited layer; b - second deposited layer

The study showed the presence of cracks and hardened structures of martensite and ledeburite (Fig. 3, a) in the heat affected zone, as well as cracks (Fig. 3, b) between the layers.



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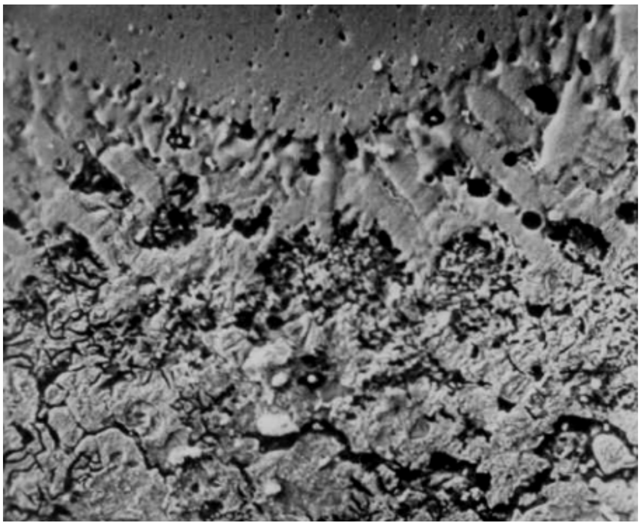
a)



x 400
b)

Fig. 3. Hardened structures and cracks
in the heat-affected zone of the 6CH18-22 cover sample:
a – ledeburite; b – a crack in the heat-affected zone

Since the method of welding with PANCH-11 wire did not give satisfactory results at the moment, further studies were carried out using PANCH-2 flux-cored wire. Due to the absence of covers with cracks, a 6CH25-34 gray cast iron cover with a simulated crack was prepared for surfacing.

The development (and through) was performed by a cutter, the development scheme is shown in Fig. 4. Welding was carried out in the following sequence: the lid was installed on one electric furnace and covered with a second furnace, the heating temperature of the lid was controlled by a chromium-nickel thermocouple [2]. When the temperature reached 573 ºK, the upper furnace was turned off and the development was welded in three passes at I_w = 350-370 A, U = 34-36 V.

After welding, the lid was cooled on the lower furnace. The heating temperature decreased gradually.

Visual inspection revealed longitudinal cracks in the weld and craters. Preheating the lid to 573 ºK is not sufficient and further research on the initiation for repair of gray cast iron lids should be carried out at an increase in the preheating temperature to 873 ºK. In addition, further research should be conducted on lids with cracks rather than on simulators with a through slit, since there are different conditions for weld pool crystallization in the simulator and a real lid with a crack.

The appearance of the 6CH25/34 lids with a weld is shown in Fig. 5.

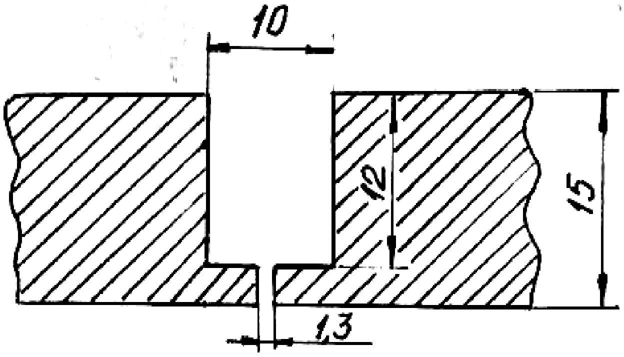


Fig. 4. Scheme of development for welding of the cover 6CH25-34

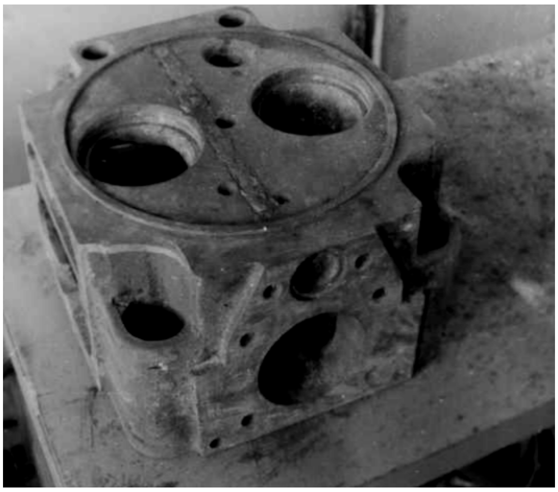


Fig. 5. Cover 6CH25-34 with welded seam

It is known that high-strength cast iron has its characteristics compared to gray cast iron, which also causes a difference in weldability. Therefore, before proceeding with the development of the lid welding technology, a roller was welded onto a plate of high-strength cast iron of VCH42-12 grade (identical to the chemical composition of the MAN lid) with PANCH-11 Ø 1.2 mm wire. Visual inspection showed no pores, cracks, undercuts, or other visible defects. The microstructure of the deposited metal is satisfactory (Fig. 6).

Many difficulties were encountered in developing the technology for cold welding the MAN lid from high-strength cast iron of large thicknesses. They are primarily related to the fact that welding is performed in several passes. The resulting multi-pass austenitic welds are prone to hot cracking.

In addition, when welding large-thickness cast iron, the effect of welding deformations increases significantly, exacerbated by the fact that the cover was not subjected to heat treatment after cold welding.

To detect cracks before welding, color flaw detection was performed on the working surface of the lid from the side of the fire cavity.

Cracks ranging in length from 50 to 30 mm were detected. The beginning and end of each crack were precisely drilled. A vulcanite wheel was used to develop the crack until it completely disappeared (the cracks were not through). The depth of development was about 15-17 mm. The lid is placed in a special electric furnace, where it is heated to a temperature of 453-473 ºK (Fig. 7). Welding is performed by a semi-automatic machine with PANCH-11 wire, Ø 1.2 mm at I_w = 180 - 200 A, U = 19 - 21 V.

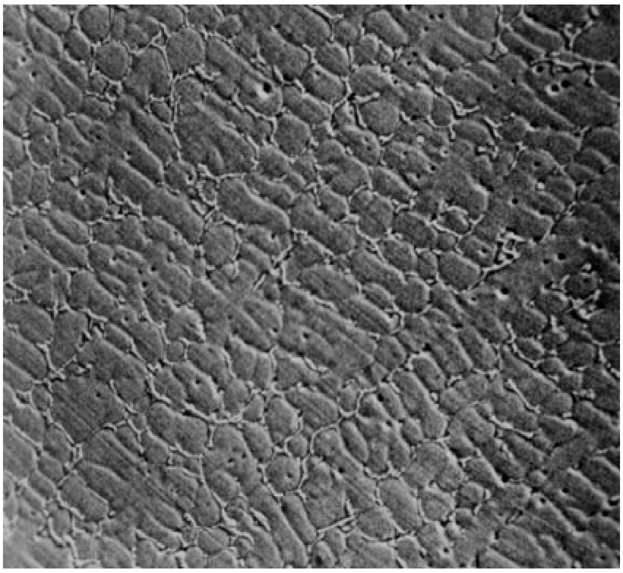


Fig. 6. Microstructure of welded metal on high-strength cast iron

Fig. 7. MAN diesel engine cover placed in an electric heating furnace. Exterior of the repaired cover

The surfacing is performed on individual 100 mm long rolls with mandatory forging to partially relieve welding stresses. External inspection showed the satisfactory formation of the rolls without pores, cracks, undercuts, or other defects.

The reconditioned covers were subjected to a hydraulic test for 5 minutes on a special stand. The test pressure from the side of the water cooling cavity was 10 atm. No leaks were recorded.

The presented technology for the restoration of MAN K6Z57/80F diesel engine covers made of high-strength cast iron by the reduced welding method with PANCH-11 self-shielded wire or another with the same chemical composition can be recommended for the repair of similar covers that have non-through cracks on the side of the combustion chamber up to 16-20 mm deep and no more than 500-700 mm long.

Cast iron pistons on 6CHSP18-22, Bukau-Wolf 4DV224, Sulzer, and other marine diesel engines wear out in the area of the caps during operation. For some time, the cast iron pistons have not been repaired. If we draw an analogy with steel piston heads, defects of the same nature can be repaired in them using one of the existing methods: 1 – the complete destruction of the bridges with subsequent surfacing to the same height in a continuous layer and re-grooving the caps; 2 – partial removal of the bridging metal with subsequent surfacing to the required thickness.

Since the cast-iron piston is a body of rotation, it is possible to restore the worn parts of the jumpers by surfacing according to the following scheme: the piston rotates - the welding head is stationary. For the selected scheme, the piston is fixed in the lathe chuck. To do this, a rotator is made based on a lathe, which includes a DC motor, gearbox, unit, and control panel. The rotation from the motor is transmitted to the gearbox through a belt drive, and from the gearbox through a clutch to the lathe shaft.

The control scheme (Fig. 8) allows you to smoothly adjust the speed of rotation of the part. For preheating the pistons before surfacing, a heating device, an electric resistance furnace, was manufactured (Fig. 9).

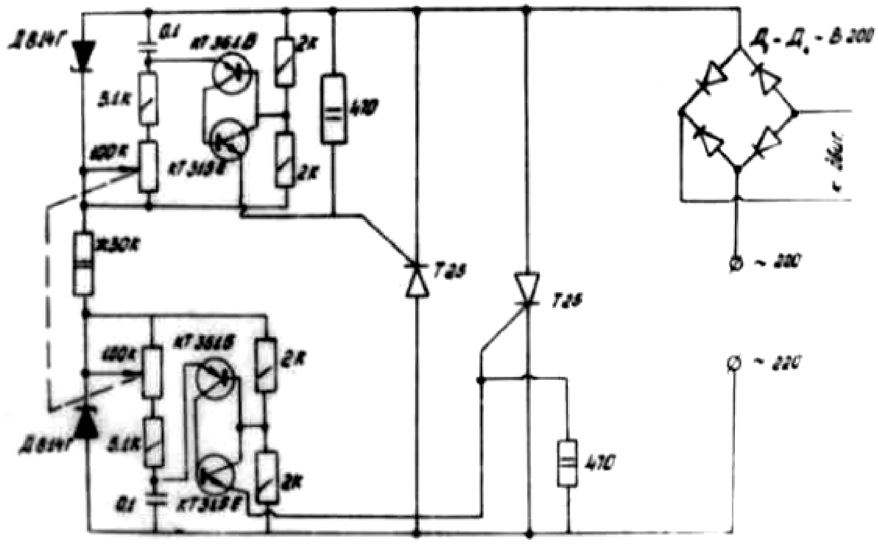


Fig. 8. DC motor speed controller P-32M

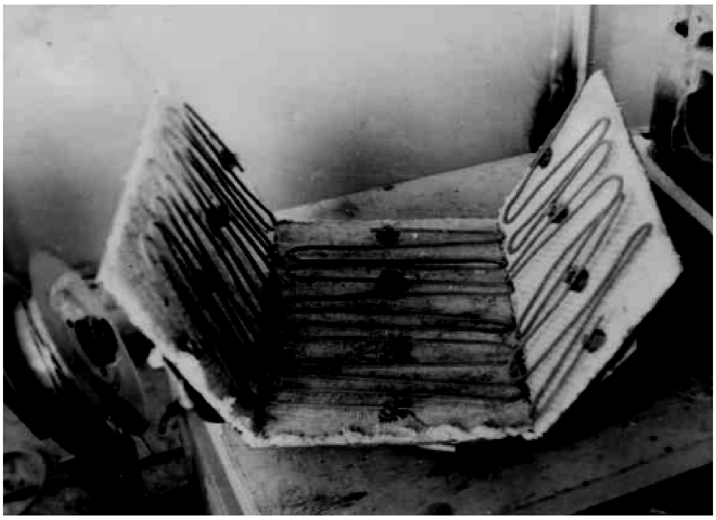


Fig. 9. Electric furnace for heating cast iron piston heads

The heating elements are nichrome wire Ø 4 mm. The furnace is designed in such a way that it grips the piston from three sides – from the bottom and sides. There is access to the welding torch from above. The furnace frame consists of three 3 mm thick steel sheets welded together. The inside of the furnace is lined with a layer of asbestos; three zigzag nichrome heaters are bolted and connected in parallel. The power source is a transformer. The furnace provides a heating temperature for the pistons of auxiliary diesel engines up to 573 ºK. A general view of a rotating device for surfacing cast iron pistons with an electric furnace and a piston is shown in Fig. 10.

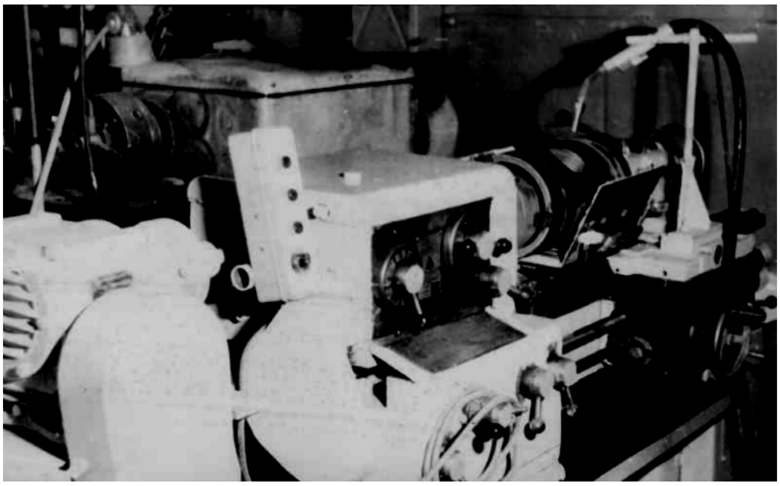


Fig. 10. Exterior view of the cast iron piston surfacing unit

The above experiments and equipment development made it possible to develop technological processes for the restoration of cast iron cylinder covers and pistons of marine diesel engines.

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