Repair of Worn-Out Parts of Auger Presses by Surfacing Method

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Abstract — In the briquetting process of various finely dispersed materials using the auger pressing method, an important issue is extending the service life and repairing worn-out elements, such as the auger, die, and lining. This study provides a literature review and industrial experience in repairing worn-out parts of industrial presses. It formulates the main approaches for restoring abrasive surfaces and presents the results of experimental studies aimed at prolonging the lifespan of augers in briquette presses using surfacing methods, including using powders obtained from solid alloy waste.

Keywords — Auger Press, Lining, Plasma Powder Surfacing, Repair, Surfacing Method.

I. INTRODUCTION

Cold-bonded auger pressing is a method of agglomerating metallurgical by-products for sintering, steel making, and blast furnace (BF) use. The production methodology of briquettes and their applications, and the main technological equipment, are presented in the works of several authors [1], [2]. During industrial operation, the working parts of the press undergo substantial wear owing to the presence of abrasive materials. Fig. 1 illustrates the wear-prone components of the auger press: lining, auger, and die. Among these components, the discharge sections of the auger and the lining exhibited the highest degree of wear.

In addition to the lining and auger, the mixer blades and die are also subjected to abrasive wear. This study focused on the wear and restoration of a briquette press auger.

Although the hard-faced auger and lining with added Cr can operate without maintenance for up to 3,000 motor hours in Zone II (Fig. 1) and up to 5,000 motor hours in Zone I, their repairs remain necessary. This is particularly relevant for models composed of black steel or cast iron with wear-resistant alloy surfaces.

The economic feasibility of repairing worn-out parts has been discussed in the literature [3], [4]. This feasibility is justified because approximately 45% of the machine parts sent for repair are worn within acceptable limits and can be reused. Furthermore, approximately half of the parts can be reused after restoration at 15%–30% of the price of new parts. Only 5%–9% of the parts were deemed unsuitable for restoration.

The restoration of parts is the main source of economic efficiency in repairs because it is a technically justified and economically viable measure. By restoring parts, repair and maintenance enterprises and workshops can reduce machine downtime, improve the quality of their maintenance, and positively affect reliability and utilisation indicators.

Several studies [3], [5]-[8] have explored the primary methods for restoring worn-out parts using welding, surfacing, and related technologies. In addition to restoring the original dimensions of the working elements of the parts, these methods also improve the operational properties of the worn surfaces.

The use of composite materials (metal-polymer composites) for the rapid restoration of working surfaces under on-site conditions is a promising approach in auger pressing technology [9], [10]. The book by Išchenko [11] presents various examples and methods of equipment restoration using composites that enable quick and efficient repair of faulty components and assemblies. This allows on-site repair of the lining or auger, preventing excessive wear.

Various welding and surface methods have been reported in the literature. Similar to welding techniques, these methods can be classified based on three characteristics: physical, technical, and technological. Among these, the most common and convenient classification is based on physical characteristics, specifically the heating source used.
According to this classification, the primary welding and surfacing methods can be classified into three groups:

1. Thermal methods (arc, electroslag, plasma, electron beam, laser, induction, gas, furnace);
2. Thermomechanical methods (contact, roll bonding, extrusion);
3. Mechanical methods (explosive, friction).

Furthermore, most of these methods can be further subdivided based on technical characteristics (metal protection during welding, degree of process mechanisation, and continuous surfacing) and technological characteristics (type of current, number of electrodes, presence of external influences, etc.).

One important approach for restoring machine parts is the formation of a wear-resistant surface using flux-cored arc welding (FCAW) [12] and wire arc additive methods [13]. Prysyazhnyuk [14] demonstrated the application of an Fe-Ti-Mo-B-C system for repairing auger presses in the ceramic industry. Industrial testing of the clay confirmed the laboratory research results. The authors recommended using systems based on Fe-Ti-B-C and Fe-Ti-Mo-B-C to increase the lifespan of parts and their abrasion resistance.

Laser-aided direct metal deposition (LDMD) [15] is a manufacturing method that utilises a powerful laser to melt and fuse metal powder or wire into a 3D shape. This manufacturing technique offers several benefits, including the ability to produce accurate and precise parts with minimal distortion of the base material, which is particularly useful for thin-walled structures with intricate dimensions. Moreover, LDMD can create fully dense parts that exhibit exceptional strength. Simultaneously, plasma powder surfacing is currently undergoing development [16].

In the following sections, we will discuss our experience with using the surfacing method for repairing the auger of a briquette press and an experimental study on the surfacing of powders obtained from solid alloy waste. The surfacing process was performed using the plasma powder surfacing method within a specialised experimental setup consisting of a robotic complex equipped with a plasma torch and an external powder feeding system.

II. AUGER WEARING

A. General

The experience gained from operating laboratory, pilot-scale, and industrial auger presses of various designs, along with data from literature sources [14], has allowed the generalisation of their restoration practices. The presence of abrasive materials, such as mill scale, aspirational dust from steelmaking processes, metallurgical slags, and fine fraction scrap, causes wear on the leading surface of the screw blades, as shown in Fig. 2a. This wear reduces the thickness of the auger flank, eventually leading to significant deformation or complete failure. Furthermore, as the lining wears down, the clearance between the auger and lining increases, decreasing pressing efficiency.

B. Laboratory Augers

During the continuous operation of a screw press, natural wear occurs on the inner surface of the screw cylinder to a lesser extent but more significantly on its flanks. Consequently, equipment productivity decreases, and the quality of the produced samples is affected.

Augers of laboratory presses are typically made of carbon steel, which facilitates their repair and restoration. Build-up welding can be performed using conventional methods, such as manual arc or semi-automatic welding in a shielding gas environment. Additionally, electrodes based on tungsten carbide or chromium carbide, which contain hard-phase inclusions that enhance the resistance of the restored parts to abrasive wear, can be used.

Turning operations were performed to correct the auger and adjust it to the required size. The excess metal formed after the build-up welding was removed from the side surfaces of the auger flanks.

Based on operational experience, the service life of a restored auger exceeds that of a new one by 2–3 times (Fig. 2b).

C. Industrial Augers

Currently, the main method for restoring the functionality of auger presses is replacing worn-out parts. However, pursuing more efficient and sustainable production poses the challenge of maximising the service life of industrial equipment by repairing rather than replacing worn-out components.

The use of manual arc welding electrodes in industrial presses is very limited, primarily because of the alloys used in manufacturing the parts. Additionally, the high pressures exceeding 25 MPa in the pressing barrel make the application of metal polymers feasible only for the localised repair of elements.

Therefore, surfacing welding remains the main method for restoring the lining elements and augers. The compositions obtained from solid alloy waste, as proposed in Section III, are considered promising in this regard.

Fig. 3 shows an example of restoring sections of a multicomponent auger in an industrial press using a tungsten-carbide-based electrode overlay.
The auger operated for over 2,000 motor hours, processing a mixture of BF dust and mill scale. Restoring the auger made it possible to prolong its service life by an additional 1,500 motor hours before replacing the components with new ones. Thus, auger restoration increased the operational lifespan of the assembly by approximately two times compared with its original characteristics.

D. Recommendation for Industrial
The general requirements for the repair of briquette press augers can be formulated. The auger repair process consists of the following stages.
1. Before commencing repair, a comprehensive diagnostic assessment is conducted to identify any damage and microdefects.
2. Damaged parts are restored through the surfacing process.
3. The component is brought to the necessary dimensions through machining.
4. The final stage involves quality verification of the repairs carried out.

To effectively organise the component preparation and execution of the deposition work, creating a technological process map for the repair is necessary. This map should include information such as the causes and nature of wear; operating conditions of the components; scope of work; type and method of surfacing; electrode, wire, or powder grade and diameter; deposition parameters and techniques; time required for the work; sequence of operations; machining allowances; and the need for pre- and post-heat treatment.

III. HARD FACING ON LABORATORY SAMPLES
A. Experimental Study
A schematic of the robotic complex used for plasma powder surfacing is shown in Fig. 4.

The spindle assembly is designed to allow tilting of the chuck's rotation axis relative to the horizontal axis within 0–90 degrees. As a result, welding can be done in any spatial orientation.

The control panel, welding power source, and gas distributor are located on separate stands that can be positioned conveniently by the operator. The plasma torch mounting unit allows all necessary adjustments relative to the restored workpiece. The setup operates in the automatic mode based on a repeated cycle consisting of the following steps: activating the welding power source, preheating the workpiece if necessary, performing the desired angle of surfacing for the end weld, surfacing the desired section, and repeating the surfacing process for a specified number of passes. During the surfacing process, the workpiece rotates in the direction "towards the welder" to enable the welder to monitor the surfacing quality and make any necessary adjustments. If multiple passes are required, the plasma torch returns to the initial surfacing point and the cycle is repeated for a specified number of passes, ensuring precise and controlled surfacing of the desired sections of the workpiece.

To test the performance of the experimental setup, a component of the "shaft" type made of steel grade 45 was surfaced. The surfacing process involved the use of mixture of PV-1 and TK15 powders in the ratio of 75% and 25% with the following chemical composition: PV-1 - Fe(base), P(up to 0.15%), Mn(up to 0.1%), Si(up to 0.08%), C(up to 0.02%), S(up to 0.0115%); TK15 - W(base), TiC(7.6%), Co(4.5%), C_total (3.12%), C_free (0.471%).

The following parameters were employed during the test:
- Workpiece rotation speed: 20 RPM (revolutions per minute)
- Welding current: 200 A (amperes)
- Deposition rate of the surfacing powder: 50–55 g/min (g/min)
- Total flow rate of plasma forming and shielding gases: 10 L/min (L/min)

These parameters were selected to achieve the desired surface results for steel shaft components.

Fig. 3. Repair of industrial auger by surfacing welding method.

Fig. 4. Schematic of a robotic complex for plasma powder surfacing with external powder feeding to the plasmatron: 1) Plasmatron; 2) Powder hopper; 3) Gating device; 4) Surfacing powder layer; 5) Heat-affected zone; 6) Weld pool; 7) Compressed arc; 8) Stream of surfacing powder; 9) Workpiece being hardfaced; 10) Plasma arc power source.
B. Results

The outcome was a defect-free surface layer without pores and cracks and with minimal surface waviness, which minimised the post-processing of the part and allowed for immediate deployment, as shown in Fig. 5.

The repaired specimens were subjected to a metallurgical analysis and tested for Vickers hardness. The results are presented in Table I and Fig. 6.

<table>
<thead>
<tr>
<th>TABLE I: HARDNESS TEST RESULTS</th>
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<tr>
<td>Connection zone</td>
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<td>Main material</td>
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<td>Surfaced material</td>
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<td>Fusion zone</td>
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Fig. 6 shows the macrostructure of the fusion zone. In the fusion zone, where the surface metal joins the base metal, no defects such as cracks, pores, or discontinuities were observed. This indicated a successful fusion process.

In contrast, the hardness test results indicated that both the fusion zone and the bond between the surface metal and the base metal had a higher hardness than the base metal. Therefore, we can conclude that the surfacing of the worn-out parts not only allows for the restoration of the original geometric dimensions but also enhances their strength and resistance to abrasive wear.

C. Discussion

Surfacing welding methods with powders is promising in terms of the cost savings achieved by using powders obtained from solid alloy waste (recycling) and in terms of prolonging the service life of restored parts. It should be noted that powder surfacing allows for the adjustment of final characteristics by utilising various powders to achieve specific or desired properties. However, the application of this technology to industrial-scale samples require further investigation.

IV. CONCLUSION

The surfacing method has been proven effective in extending the operational lifespan of laboratory and industrial augers. Based on the results, the following conclusions were drawn:

1. The design of interchangeable components for auger presses is important for production, considering their potential for repair.

2. The surfacing process of tungsten-carbide-based electrodes successfully restores the worn sections of multicomponent inertial augers, allowing them to operate for an additional significant period before replacement. However, using various powders derived from solid alloy wastes is promising.

3. Experimental studies should be conducted to confirm the feasibility of using the plasma powder surfacing method with powders derived from solid alloy waste to restore augers in industrial briquette presses.

4. The hardness of the auger surface material should not be lower than 434–465 HV.

5. Further exploration and development of alternative powder compositions derived from different waste alloys show promise for restoring auger elements, warranting further investigation.

REFERENCES


