REPAIR OF THREADED SPINDLE ON FRICTION SCREW PRESSE FZP-160

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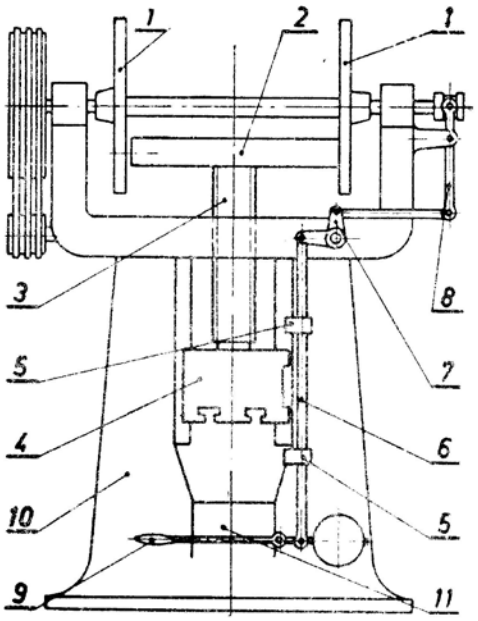
Abstract: *The threaded spindle of the friction screw press is an important structural element that has a function of achieving an operating stroke for deformation and a return stroke and to receive all the strain that appear while working. During this operation of the threaded spindle, its vibrations appear which are undesirable. In accordance with the load of the threaded spindle and the source of vibration, the lower unthreaded part of the threaded spindle is a critical local spot where the appearance of initial cracks is possible. These cracks allow that the operating tensions at the sepceific spots of the cracks overcome critical tensions, which leads to the fracture of the spindle during exploitation. In accordance with this problem, in this paper the engineering approach has been presented of the performed reparation of the threaded spindle of the FPZ-160 friction srew press in practice.*

Keywords: *press, threaded spindle, crack, reparation*

INTRODUCTION

This paper describes the repair of the threaded spindle of the FZP-160 friction screw press of the nominal workforce of 1600 kN, which represents the basic structural element of the press for achieving the working stroke of the deformation and the return stroke, and to receive all the stresses that occur during operation. Picture 1 shows the construction of a friction screw press with its basic elements. More details about this press are in the references [1-3].



Picture 1. – Friction screw press [2]

1 - Friction wheel, 2 - Flywheel, 3 - Threaded spindle, 4 - Pressure gauge, 5 – Handles of the pressure gauge, 6 - Governor lever, 7 – Angle lever, 8 - Yoke, 9 – pedal, 10 - Body of a press, 11 - Press table

The threaded spindle is a very important structural element of the given press and it is made with triple square thread. During the exploitation of the press, the vibrations of the threaded spindle appear which are undesirable. The analysis of the load of the threaded spindle and the source of vibrations indicate that the lower slick part of the threaded spindle is a critical local site on which the initial cracks can occur. These cracks allow working stresses in local cracks to overcome critical strains, which further leads to spindle fracture during exploitation. The problem of this nature has arisen in the company AutoValve J-SC from Uzice. During the exploitation of the friction screw FZP-160, the fuse spindle failed, so the pressure gauge

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(piston) with the slick part of the threaded spindle remained in the lower end position, while the second part of the threaded spindle with the flywheel made a return stroke in the upper end position. In accordance with the previously defined problem, the following subchapters provide an engineering approach to the realized reparation of the threaded spindle of the friction screw press type FPZ-160 of the nominal workforce of 1600 kN.

ANALYSIS OF THE STATE OF THE THREADED SPINDLE AFTER FAILURE IN EXPLOITATION

After the failure in the exploitation of the threaded spindle of the friction screw press FPZ-160, an analysis of its condition was carried out. References [5, 6] were used as the basis. As the first step, in order to determine the condition of the damaged threaded spindle of the FZP-160 friction screw press, a preliminary visual inspection was carried out. As the second step, the condition of the threaded spindle was tested. The preliminary visual inspection of the condition of the damaged spindle of the press pointed to the presence of serious faults (discontinuity) of the type of cracks, fractures and deformations on the surface of the threaded spindle. The concentration of these errors was at the lower end of the threaded spindle which is associated with the pressure gauge (piston). Some of the mentioned errors are shown in Picture 2 (a - c).

(a) *(b)* *(c)*

Picture 2. – Faults (cracks, deformations and breaks) on the threaded spindle

It was necessary to decide whether to repair the damaged threaded spindle or to obtain a new threaded spindle (new spare part). Purchase price of the new threaded spindle from MIN FAM J-SC on 05.12.2016. was 3.715,00 EUR. The price of the repaired threaded spindle was 477,00 EUR. Taking into account the ratio between the purchase price of the new threaded spindle and the price of the repaired threaded spindle (C_n/C_r=7,8), the decision was made to repair the damaged threaded spindle. By this way, savings are significant. The justification of the repair of the damaged spindle from an economic point of view is even greater because AutoValve J-SC posses great number of friction screw presses. The basis for the examination of the economic aspects of reparation was also found in reference [7].

REPARATION OF THE DAMAGED THREADED SPINDLE OF THE PRESS

Based on the results of testing the damaged threaded spindle, on the one hand, and analysis of the economic aspect, on the other hand, it was decided to repair the observed faults (cracks, deformations and breaks) on the threaded spindle.

Conceptual solution for reparation

Taking into account how serious the damage to the threaded spindle end (which is attached to press piston) is, the conceptual solution for the reparation of the damaged threaded spindle is to do reparation of the threaded spindle. Reparation is a precisely defined sequence of operations that should be consistently implemented in order to restore lost operational ability to worn and / or broken machine parts.
The reparation of the damaged threaded spindle included the following main operations:

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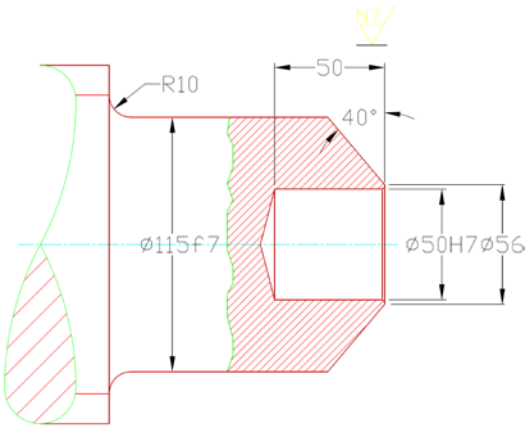
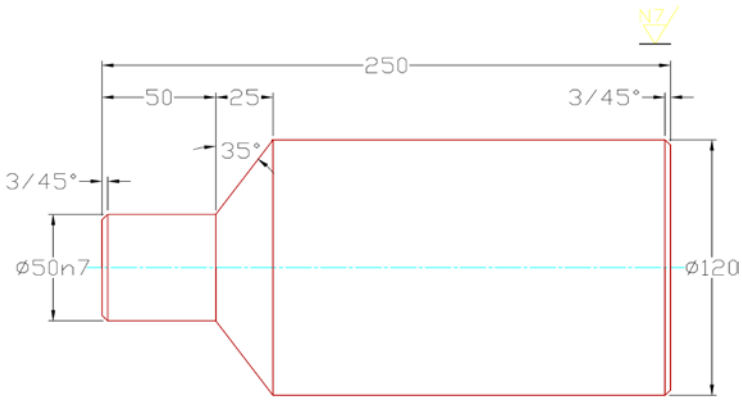
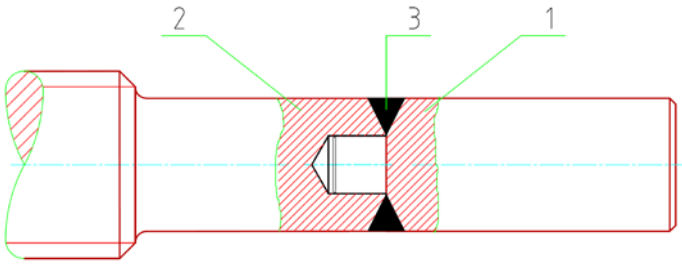
- Calculation of the conceptual solution of the welded connection;
- Preparation and making of the technical documentation on which basis the repair of the threaded spindle of friction cutting press FPZ-160 will be performed [8];
- Treatment of the healthy part of the threaded spindle at the fracture point in order to make the connection to the attachment (Picture 3 (a));
- Making a threaded spindle extension (Picture 3 (b));
- Heat treatment a threaded spindle extension [9];
- Connecting by welding the healthy part of the threaded spindle with the threaded spindle nut (Picture 3 (c));
- Treatment of the welded threaded spindle extension on the lathe HN-500 [9]; and
- Inspection of the performed reparation.



(a) Healthy part of the threaded spindle



(b) Threaded spindle extension



(c) - Velded joint: 1 - Threaded spindle extension, 2 - Healthy part of the threaded spindle, 3 - Weld

Picture 3. – Reparation of the threaded spindle

Prior to the realization of reparation of the threaded spindle of the press, the following preparatory activities were carried out:

- Disassembling the friction screw press in order to remove the damaged threaded spindle [3];
- Cleaning of all surfaces of the threaded spindle with degreasing agent in cold conditions FAMIN ECO, as well as cleaning from asphalt and resinous particles that are collected in the threads of the spindle and the corners of the screw;
- Providing the equipment for the processing of a healthy part of the threaded spindle and making the extension;
- Providing the equipment for joining by welding a healthy part of the threaded spindle and extension;
- Providing the equipment for gas preheating and heating of welded joints and contact measuring of the temperature;
- Providing fire resistant material to cover the welded joint after welding;
- Forming the team for the doing the reparation of the threaded spindle.

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Welding technology

Inevitable companions of reparation are additional strains and deformations. Optimal application of all of the procedures is sought while repairing (for example, welding). This reduces the influence of additional strains and deformations to a minimum. Welding technology defines all the basic elements of welding and inspection of welded joints. From the aspect of ensuring the required quality is obtained during the execution of welding works it is necessary to strictly follow the provisions of the welding technology, which are made according to ISO-International, EN-European and SRPS-Serbian standards in the field of welding.

The threaded spindle is made of high quality steel with a finely processed self-propelled screw. Basic material (old material), threaded spindle H162×3×40 made of steel for improving 50CrMo4 (SRPS EN 10083) has the following chemical composition: C-0.5%, Mn-0.65%, Cr-1.05%, Mo-0.22%.

The mechanical properties of the basic material are:

- Stretching range, $R_{eh,min}$=500 N/mm^2,
- Tensile strength, R_m=850…890 N/mm^2, and
- Dilatation, A_{min}=13 %.

The steel 50CrMo4 belongs to a group of improved steels (C> 0.20%) that have poor weldability.

According to the given conceptual solution for the reparation of the threaded spindle, the connection of a healthy part of the threaded spindle and attachment is achieved through a frontal sealed welded joint. The healthy part of the threaded spindle and the extension lie in the same plane, which means they are faced to each other. Since the thicknesses of the parts which are being connected are larger the V-seam is applied.

The following factors were analyzed in the selection of the welding process of a healthy part of the threaded spindle to the extension:

- Quality and dimensions of the basic material,
- Quantity and quality of the threaded spindle,
- Available equipment, and
- Geometric complexity of the threaded spindle.

In accordance with these factors, the of REL procedure (manual electric arc welding) was applied. Welding was carried out with the appliance Varstroj VARUS 400 manufactured by Gorenje. Welding devices have been previously checked from the aspect of working environment safety and from the aspect of maintaining the required welding parameters. Electrical characteristics must be reliably maintained and, if necessary, changed with the possibility of their reading and control.

While selecting the additional material for the manual electric arc welding process of a healthy part of the threaded spindle and the extension, the following factors were analyzed:

- Quality and dimensions of the basic material, and
- Complexity of construction and welding position.

YUWELD 303 has been selected for the manual electric arc welding process. YUWELD 303 is a special high alloyed austenitic-ferrite electrode for welding of hard-to-weld, easy-to-weld steels, high-strength steel, armor steel, springs steel, spindles and similar. It is especially applicable for welding of various types of steels (e.g. unalloyed or alloyed structural steels with high alloy chromium and chromium nickel steels, for direct welding or overlapping welding of manganese steel as well as welding with other steels.) YUWELD 303 is an electrode which successfully weld steels of an unknown composition and origin and YUWELD 303 solves many welding problems. Welding with YUWELD 303 does not require a special technique, it is sufficient to apply the same technique as with stainless steel electrodes to determine that manipulation is easier than with other types. The welded joint and clean metal of the seam made by the YUWELD 303 electrode, regardless of the high content of chromium, prevents carbon diffusion and hardening in the heat-extinguishing zone, which prevents the formation of cold and hot cracks or porosity while welding cold and oiled parts during reparation. The metal weld seam done by YUWELD 303 electrode does not change the characteristics to temperature of 1180 °C.

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Mechanical properties of pure metal seams are:

- Stretching range, R_{eh}=680 N/mm2,
- Tensile strength, R_m=900 N/mm2, and
- Dilatation, A=40%.

The used parameters of manual electric arc welding procedure are:

- Type of welding current - AC/DC,
- Welding current strength - 40…150 A,
- Voltage of the arc - 20…32 V.

During the reparation work, the welding of the threaded spindle of the press is carried out with a final assessment of the suitability for exploitation in three phases, as follows:

1. Inspection before welding,
2. Inspection during welding, and
3. Inspection after welding.

Inspection before welding covers:

- Insight into the quality assurance of basic, additional and auxiliary materials,
- Checking the geometrical dimensions of parts of a healthy threaded spindle and extension,
- Checking the geometric shape of the groove and joint,
- Checking surface cleaning,
- Checking devices and equipment for welding,
- Checking the professional ability of the welders,
- Certificate of the qualification of the welders (SRPS EN 287-1),
- Checking the measures taken to ensure safety at work,
- Verification of the prescribed welded joint welding technology and material quality (SRPS EN ISO 15614-1),
- Insight into the documentation on the contractor's authorization to perform welding work (SRPS EN ISO 3834).

Inspection during welding covers:

- Checking the application of the prescribed elements of technology (welding parameters, welding mode).

Inspection after welding covers:

- Dimensional inspection of the threaded spindle as a whole and control of the geometric shape of the welded joint - 100%,
- Visual control of welded joints - 100%,
- Magnetic or penetrant inspection of welded joints in the range of 100% for quality level B and 10% for quality level D (SRPS ISO 5871),
- Radiographic or ultrasonic inspection of welded joints in the range of minimum 75% for quality level B (SRPS ISO 6520).

After welding, no heat treatment is required to eliminate residual voltages.

TESTING THE PRESS OPERATION AFTER REPARATION OF THE THREADED SPINDLE

After completing of all inspections of the repaired threaded spindle, the FPZ-160 friction screw press was installed, which included the installation of the repaired threaded spindle. Afterwards, trial tests were carried out on the operational force of the press, which confirmed that the repair of the threaded spindle was successfully performed. After this press was put back into exploitation (Picture 4).

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Picture 4. – Repair of threaded spindle in exploitation

CONCLUSION

This paper presents the realized reparation of the threaded spindle of the friction screw press type FPZ-160 of the nominal workforce of 1600 kN. In order to reduce the influence of additional strain and deformation to the minimum during the reparation of the threaded spindle, the optimal application of the procedures was sought.

By applying the described reparation, the threaded spindle of the subject press was successfully repaired. It was first confirmed by trial tests of the work force of the press. Finally, the confirmation that the repair of the threaded spindle has been successfully realized is the fact that the press with the reconditioned spindle is in operation for two years without any problems.

The aim of this paper was to illustrate the process of reparation of the damaged threaded spindle. The continuation of this paper will show the following research results:

- Metallographic examination of the surfaces of the fracture of the threaded spindle,
- Calculation of the welded connection of the repaired threaded spindle, and
- Analysis of the stress state of the repaired threaded spindle.

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