The effect of reconditioning techniques by welding on the quality of deposits on crankshafts, case study SMAW

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Abstract. Currently, we are searching for a range of solutions for repairing the crankshafts that had snapped during operation. The paper deals with the extension of the two methods for reconditioning by welding in the energy industry in the field of repairing the crankshafts in the automotive industry. The results obtained through the application of methods for reconditioning Weld Toe Tempering Technique and filling layers of sidings, which was used as a welding procedure SMAW. Qualitative and quantitative comparisons between the results of the two methods based on the criterion of rigidity are carried out.

1. Introduction

The defective metal products in conjunction with the price of new products led to the search for and development of various technological processes which help to restore the original dimensions and form of damaged product [1].

Another principle that underlies the choice of repairing by welding and replacement of defective components is that we can get the repair parts with the original superior properties (which have not withstood the conditions of use).

The success of repairing operation by welding depends mostly of the conditions under which it will carry out the analysis of the information related to the pieces to be repaired. One of the reasons for performing this analysis is to establish the causes of cracking for repairing by welding situation, or wear of parts in case of filling by welding.

Once the decision to repair by welding was taken is necessary to determine the causes which have led to the faults from the following possible causes: accident, improper use, abuse and operating conditions over the maximum limit allowed.

In the event that damage has occurred due to accident or operating conditions values being exceeded, the renovation will aim only restoring the shape and characteristics of the component.

The work aims to offer solutions for repairing by welding in a situation in which the non-compliance occurs, which may endanger the safety of operation, on the counterweight on the crankshaft from automotive industry [2].

2. Techniques of reconditioning

Worldwide, there are several methods of repair by welding for various products obtained from various ferrous materials or non-ferrous. In the present paper, two such techniques are used, Weld Toe Tempering Technique and filling on layers sides the counterweight components on a crankshaft from automotive industry.
The technique of Weld Toe Tempering Technique, figure 1, involves filling a layer or an additional channel at the surface of the bead to ensure the recovery effect of the previous interlayer ZIT filed.

![Suplementary layer](image)

**Figure 1.** The application of the technique “of an extra layer” in the repairing by welding: 1 - root layer; 2 - fill layer; 3 - layer sealing; 4 - layer of heat treatment.

To illustrate the effect of extra layer, in figure 2 is represented the section by two layers of a welded joint. From this figure it can be seen that the second layer provides the heat necessary to carry out a “thermal self-treatment” the first row microstructure, [3,4,5].

![Figure 2. The Section through 2 layers of a welded joint](image)

**Figure 2.** The Section through 2 layers of a welded joint [5]. B - Boundary Layer fusion II; U - Boundary Layer fusion I; C - Median value of aggradation layer 1; R - the maximum value of the finishing layer depth 2; The stitching material; The overheating layer of the ZIT; The layer with the fine film grain of the ZIT; Partial transformation area of the ZIT.

The technique of filling layers on the side (left-right), figure 3, involves obtaining similar effect on the ZIT, as in the previous case, but with a higher consumption of filler material. In this way, basically, we get the same effect on both sides [6].

![Figure 3. The principle of the technique of lateral filling of additional layers](image)

**Figure 3.** The principle of the technique of lateral filling of additional layers. 1 - filled layer in order to repair; 2 additional layers arranged along the left-right of the reparation; ZIT 1 – the heat influenced area due to layer 1; ZIT 2 – the heat - affected area due to layer 2.

3. Experimental data
The basic material from which counterweight was made is cast iron, type EN-GJS-600-3 according to DIN EN 1564: 2012 [7], whose chemical composition and mechanical properties are given in tables 1 and 2.

| Material designation | C [%] | Si [%] | Mn [%] | P [%] | S [%] |
|----------------------|-------|--------|--------|-------|-------|
| EN-GJS-600-3         | 2.5-3.6 | 1.8-2.8 | 0.3-0.7 | ≤0.08 | ≤0.02 |
Table 2. Material properties measured on test pieces according to DIN EN 1563:2012.

| Material designation | Tensile strength $R_m$ [N/mm²] | 0.2% Proof stress $R_{p0.2}$ [N/mm²] | Elongation $A$ [%] | Microstructure  |
|----------------------|-------------------------------|-------------------------------------|-------------------|----------------|
| EN-GJS-600-3         | 600                           | 370                                 | 3                 | Pearlite/ ferrite |

The purpose of the application of the techniques of reconditioning exposed above, on the surface of the counterweight a channel on all the piece has been performed with the dimensions of 16 mm width and depth of 5 mm, figure 4, which simulates the removal of a range with nonconformities which will be subject of repairing by welding. Realization of the channel took place through mechanical processing so as not to influence the thermal structure of the material.

Figure 4. The channel achieved.

3 samples were completed as follows:
- the first sample, coded P1, repaired by welding by normal filling of layers, figure 5.a.;
- the second sample, coded P2, which has filed a supplementary layer by technique Weld Toe Tempering Technique, figure 5.b.;
- the third sample, coded P3, obtained by filling on the side of extra cords, figure 5.c.

Figure 5. Tests results.

When filling the completed channels crossing, we used the following parameters of reconditioning by welding [8,9]:
- normal filling of the layers: $I_s = 140A$. $U_a = 20V$;
- the application of Weld Toe Tempering Technique: coatings filling $I_s = 140A$. $U_a = 20V$, extra layer filling $I_s = 100A$ and $U_a = 18V$;
- for filling on the side of extra cords: the filling of layers $I_s = 140A$. $U_A = 20V$, lateral filling two additional crossings $I_s = 100A$ and $U_a = 18V$.

4. Results
After the end of the experiments, the samples were subjected to examination of optical-visual and with penetrant liquids, not finding any non-conformity.
The reconditioned counterweights by welding have been debited in the central area to obtain samples that were subjected to macroscopic examination and measurement of rigidity. After processing, the samples are shown in figure 6, numbered in the order of the filling layers, in the channel provided for in the counterweight, as follows: 1 - the first layer, 2 - the second layer and so on.

**Figure 6.** Samples for microscopic examination and measurement of resulted hardness after appropriate processing.

After the macroscopic examination we took the hardness values HV 0.5, in the areas shown in figure 7. The values obtained are shown in table 3 and the graphs showing changes in hardness are contained in figure 8-15, for all areas surveyed.

**Table 3.** Hardness values - all samples.

| Area | Localization | Item No. | Sample | Area | Localization | Item No. | Sample |
|------|--------------|----------|--------|------|--------------|----------|--------|
| S1   | ZIT 1        | 1        | 689    | 496  | 723          | 36       | 331    | 337  | 327  |
|      |              | 2        | 653    | 524  | 726          | 37       | 348    | 368  | 314  |
|      |              | 3        | 677    | 508  | 737          | 38       | 329    | 355  | 328  |
|      |              | 4        | 647    | 494  | 760          | 39       | 347    | 350  | 315  |
|      |              | 5        | 611    | 562  | 728          | 40       | 341    | 376  | 316  |
|      |              | 6        | 535    | 414  | 466          | 41       | 508    | 330  | 441  |
|      |              | 7        | 527    | 374  | 402          | 42       | 428    | 333  | 402  |
|      | ZIT 2        | 8        | 437    | 376  | 382          | 43       | 503    | 392  | 426  |
|      |              | 9        | 420    | 365  | 375          | 44       | 492    | 354  | 412  |
|      |              | 10       | 409    | 382  | 392          | 45       | 415    | 325  | 391  |
|      |              | 11       | 632    | 471  | 752          | 21       | 261    | 618  | 431  |
|      |              | 12       | 665    | 561  | 762          | 22       | 273    | 610  | 427  |
|      | ZIT 1        | 13       | 687    | 527  | 740          | 23       | 240    | 584  | 370  |
|      |              | 14       | 644    | 591  | 710          | 24       | 250    | 598  | 466  |
|      |              | 15       | 615    | 524  | 751          | 25       | 275    | 616  | 434  |
|      |              | 16       | 520    | 337  | 387          | 26       | 251    | 505  | 253  |
|      |              | 17       | 470    | 340  | 353          | 27       | 233    | 491  | 259  |
|      | ZIT 2        | 18       | 399    | 312  | 351          | 28       | 238    | 508  | 248  |
|      |              | 19       | 347    | 327  | 334          | 29       | 245    | 474  | 255  |
|      |              | 20       | 374    | 356  | 367          | 30       | 238    | 500  | 250  |
Analysing the hardness obtained in the area ZIT 1, top area, figure 8 and figure 9, of all the samples, it can be seen that the higher values were obtained in the sample P3, a fact explained by the filling of side layers.

In of case ZIT-2, at the bottom area, figure 10 and figure 11, the maximum hardness values were obtained for the sample results through normal filling by welding, P1, a fact explained by the swinging movement of the layers filled.
From the analysis of the hardness values obtained in the upper layers, coded as C1 and C2, figure 12 and figure 13, it can be seen that the same phenomenon occurs, downwards, the resulted hardness values are: sample P2, sample P3 and sample P1.

5. Conclusions

From the research conducted and the results obtained we can draw the following conclusions:
- SMAW procedure can be applied to good effect in counterweights repair of the crankshaft in the automotive industry;
- the results, based on the criterion of rigidity, permits the extension methods for reconditioning by welding in the energy industry and other industrial products;
- the hardness largely depends on the order of transitions filling;
- we can note the extra layer filling importance, or the extra layer, on the hardness of the reconditioned area.

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