Qualitative and quantitative comparisons on reconditioning by welding of crankshafts from auto industry

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Abstract. One of the goals of modern society is represented by reducing the cost for the maintenance of cars. One of the pieces that break down most often on the engine block is the crankshaft, in various areas of it. Due to the fact that the price of a crankshaft is very high, specialists seek solutions for repairing and not replacing them. In this study, it is presented a comparison in terms of hardness obtained at recovering the counterweight by welding by using two methods of welding, WIG and SMAW through various techniques: normal, WTO, lateral depositing.

1. Introduction

The present 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, shown in figure 1.

Figure 1. The components of a crankshaft [1]

For rebuilding the geometric dimensions, the favorite repair processes of crankshaft are welding and metallization.

The metallization process presents as main disadvantages, the high cost and the thorough preparation of the piece.

The main problem when applying the technology of repairing by welding is represented by the
overheating of the support material which leads to irreversible mechanical and structural transformations.

In order to perform the experiments we opted for 2 repairing techniques, Weld Toe Tempering Technique and depositing lateral layers on counterweight components on a crankshaft from automotive industry, where we used 2 welding processes with electric arc SMAW and WIG.

Weld Toe Tempering Technique involves depositing a layer or an additional passage (supplementary) at the surface of the cord to ensure the recovery effect of the interlayer HAZ deposited above [2,3]. The technique seeks mainly to improve resilience of heat affected zone (HAZ/ZIT) by reducing its enlargement. The additional layer deposited must not form a liquid metal bath with the base material [4].

The depositing technique of lateral layers (left-right), aims to achieve similar effects on the ZIT as and in the previous case, but with a higher consumption of added material by depositing and subsequent removal of the layers [5].

Both techniques seek to improve the structure and hardness of the heat affected zone that appears when using welding processes [6].

2. Experimental data
The basic material from which the counterweight was made is a cast iron, type EN-GJS-600-3 according to DIN EN 1564: 2012.

Regarding the purpose of applying the techniques of reconditioning exposed above the surface of the counterweight, a channel has been made with all the dimensions of 16 mm width and depth of 5 mm, figure 2, which simulates the removal of an area with nonconformities, which will be subject to repairing by welding. Realizing the channel took place through mechanical processing with continuous cooling in order not to influence the thermal structure of the material.

![Figure 2. The achieved channel.](image)

The parameters used in the experiments are indicated in table 1.

| No. | Parameter                              | Process | SMAW  | WIG |
|-----|----------------------------------------|---------|-------|-----|
| 1.  | Filler material                         | E10-UM-60-CZ |       |     |
| 2.  | Filler material diameter [mm]           | 3.25    | 3.25  |     |
| 3.  | The intensity of welding [A]            | Layers  | 140   |     |
|     |                                        | Additional Layer Depositing | 100   |     |
|     |                                        | Lateral Layers Depositing   | 100   |     |
| 4.  | ARC voltage [V]                         | Depositing Layers           | 22    | 14  |
|     |                                        | Additional Layer Depositing | 24    | 16  |
|     |                                        | Lateral Layers Depositing   | 22    | 14  |

3. Results and discussions
The encoding of samples was: P1- the resulting normal deposit sample using the SMAW procedure; P2 – the resulting sample in Weld Toe Tempering Technique using the SMAW procedure; P3 – the sample resulted by depositing lateral layers using the SMAW procedure; P1’- the resulted sample by
normal depositing using the WIG procedure; P2'- the resulted sample through the Weld Toe Tempering Technique using the WIG procedure; P3'- the resulted sample by depositing lateral layers using the WIG procedure.

After completing the experiments, the test results, figure 3, were subjected to examination of optical-visual and penetrant liquids, not finding any non-conformity.

The reconditioned welding counterweights have been debited in the central area to obtain samples that were subjected to macroscopic examination and measurement of hardness. The samples after processing are shown in figure 4, in which it is indicated with numbers, the order of the layers in the channel provided for in the counterweight, as follows: 1 - the first layer, 2 - the second layer and so on.

After the macroscopic examination we took the hardness values HV0.5, in the areas shown in the figure 5. The values obtained are shown in table 2 and the charts, some of the areas analyzed, showing the variation of hardness can be found in figure 6-8.
| Area         | Localization | No. Points. | Samples - SMAW | Samples - WIG |
|--------------|--------------|-------------|----------------|--------------|
|              |              |             | P1  | P2  | P3  | P1' | P2' | P3' |
| S1           | ZIT 1        | P1          | 689 | 496 | 723 | 434 | 700 | 584 |
|              |              | P2          | 653 | 524 | 726 | 439 | 620 | 581 |
|              |              | P3          | 677 | 508 | 737 | 460 | 618 | 590 |
|              |              | P1'         | 647 | 494 | 760 | 498 | 600 | 588 |
|              |              | P2'         | 611 | 562 | 728 | 495 | 655 | 515 |
|              | ZIT 2        | P1          | 535 | 414 | 466 | 311 | 333 | 324 |
|              |              | P2          | 527 | 374 | 402 | 317 | 338 | 333 |
|              |              | P3          | 437 | 376 | 382 | 315 | 356 | 326 |
|              |              | P1'         | 420 | 365 | 375 | 316 | 341 | 331 |
|              |              | P2'         | 409 | 382 | 392 | 321 | 343 | 331 |
|              |              | P3'         |       |     |     |     |     |     |
| S2           | ZIT 1        | P1          | 632 | 471 | 752 | 337 | 762 | 521 |
|              |              | P2          | 665 | 561 | 762 | 314 | 776 | 578 |
|              |              | P3          | 687 | 527 | 740 | 340 | 718 | 505 |
|              |              | P1'         | 644 | 591 | 710 | 337 | 728 | 589 |
|              |              | P2'         | 615 | 524 | 751 | 373 | 770 | 526 |
|              | ZIT 2        | P1          | 520 | 337 | 387 | 335 | 376 | 337 |
|              |              | P2          | 470 | 340 | 353 | 347 | 393 | 360 |
|              |              | P3          | 399 | 312 | 387 | 334 | 382 | 335 |
|              |              | P1'         | 347 | 327 | 334 | 321 | 382 | 335 |
|              |              | P2'         | 374 | 356 | 367 | 320 | 351 | 337 |
|              |              | P3'         |       |     |     |     |     |     |
|              |              | P1          | 261 | 618 | 431 | 291 | 380 | 370 |
|              |              | P2          | 273 | 610 | 427 | 260 | 386 | 359 |
|              |              | P3          | 250 | 598 | 466 | 262 | 372 | 357 |
|              |              | P1'         | 275 | 616 | 434 | 248 | 364 | 336 |
|              |              | P2'         |       |     |     |     |     |     |
|              |              | P3'         |       |     |     |     |     |     |
|              |              | P1          | 251 | 505 | 253 | 253 | 299 | 269 |
|              |              | P2          | 233 | 491 | 259 | 207 | 301 | 281 |
|              |              | P3          | 238 | 508 | 248 | 235 | 290 | 273 |
|              |              | P1'         | 245 | 474 | 255 | 206 | 297 | 283 |
|              |              | P2'         | 238 | 500 | 250 | 215 | 308 | 271 |
|              |              | P3'         |       |     |     |     |     |     |
|              |              | P1          | 259 | 457 | 324 | 240 | 461 | 353 |
|              |              | P2          | 280 | 501 | 386 | 232 | 493 | 376 |
|              |              | P3          | 268 | 492 | 358 | 271 | 439 | 355 |
|              |              | P1'         | 278 | 556 | 385 | 261 | 519 | 346 |
|              |              | P2'         | 261 | 546 | 366 | 240 | 501 | 362 |
|              |              | P3'         |       |     |     |     |     |     |
|              |              | P1          | 331 | 337 | 327 | 369 | 406 | 398 |
|              |              | P2          | 348 | 368 | 314 | 351 | 420 | 410 |
|              |              | P3          | 329 | 355 | 328 | 364 | 399 | 380 |
|              |              | P1'         | 347 | 350 | 315 | 358 | 400 | 383 |
|              |              | P2'         | 341 | 376 | 316 | 357 | 391 | 367 |
|              |              | P3'         |       |     |     |     |     |     |
|              |              | P1          | 508 | 330 | 441 | 427 | 352 | 414 |
| Bottom Part  |              | P2          | 428 | 333 | 402 | 420 | 358 | 372 |
|              |              | P3          | 503 | 392 | 426 | 431 | 363 | 373 |
|              |              | P1'         | 492 | 354 | 412 | 447 | 329 | 366 |
|              |              | P2'         | 415 | 325 | 391 | 423 | 340 | 374 |
After the macroscopic examination we took the hardness values HV0.5, in the areas shown in the figure 5. The values obtained are shown in table 2 and the charts, some of the areas analyzed, showing the variation of hardness can be found in figures 6-8.

In case of ZIT2, S1 area, in the lower part of the figure 6, it can be seen that the maximum hardness values were obtained for the samples resulted through normal depositing by welding, P1 and the minimum values are obtained when using the WIG welding process and the normal technique of depositing. The low values obtained are explicable by lower heat into the material.

From analyzing the hardness obtained in area ZIT 1, area S2, top, figure 7, it can be seen that the
highest values were obtained in the sample P2', and the minimum values as one would expect in the case of the P1'.

From analysing the hardness values obtained in the median area, encoded with C2, figure 8 shows the maximum values obtained in the case of the sample P2 in the implementation of which we used the SMAW process of welding and Weld Toe Tempering Technique and the minimum values in the case of the P1' realized by the procedure of normal depositing WIG.

![Figure 8. Variation of hardness - Area C2.](image)

4. Conclusions
On the basis of the information in the paper, the following conclusions may be drawn:

- Both welding processes can be used for reconditioning by welding of the elements associated with crankshafts in the automotive industry;
- The layers layout mode to restore the constructive shape, has a primary effect on hardness;
- Using the WIG process presents the major advantage of the introduction of a smaller heat quantities in the reconditioned part, so a more beneficial influence on hardness;
- The variations in hardness, for all 6 samples, are not linear;
- It is necessary to conduct research on the structure for a better correlation between the influence of techniques, procedures and delimitation of their applications.

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