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Innovative method of post weld surface finishing

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ABSTRACT: The post weld surface finishing method by moving of the innovative multi-edge cutting tool along the weld bead is presented in this article. In this method the machining allowance is treated as the weld bead height, which is removed flush with the base material in one step during one pass of the cutting tool. The adjacent teeth height of changing and increasing according to the direction of feed, and the difference in height between the first and last tooth is equal to the weld bead height. Number of cutting teeth necessary to finish flush the weld bead with the base metal surface depends on the difference in the first and last tooth height and how it is divided. Tooth length is greater than half the distance between adjacent cutting teeth which enables finishing the heterogeneous post weld surface with many defects and increased hardness.

KEYWORDS: weld bead surface, physical model, broaching, multi-edge cutting tool

1. Introduction

In industrial enterprises the most common method of post weld finishing of surfaces is grinding with an abrasive tool of different shapes and using different abrasive materials. This finishing method leads to the occurrence of faults on the treated surface. The faults include locations missed or hardened twice, which creates structural notches in the surface layer, also collecting residual stress (stretching) in these locations. The faults mentioned lead to the creation and development of ordinary as well as fatigue cracks and seizing and other damage. During the operation of welded constructions the fatigue limit can be reduced, which can result in the destruction of the welded elements [1]. In addition, grinding is a process that often involves manual labor, which significantly increases the time required for finishing and impossibility of automating this process. Also, grinding is a process that is damaging for both people and the environment and necessitates the use of additional protective measures.

In contrast to the grinding and other innovation methods of post weld surface finishing, the process of weld bead broaching, which is the subject of this article, does not have the faults and inconveniences previously [2, 3].

2. Research materials and methodology

For processing various complex surfaces of different dimensions, shape and quality within one machining cycle (e.g. welded surfaces), it is necessary to use a non-standard cutting tool with a specialized design adapted to specific conditions. Intermittent cutting is characteristic of the shape and properties of the weld bead surfaces, uneven machining allowance, the variable number of simultaneously working (active) teeth, periodical changes or impact loads cutting and the heterogeneity of the weld bead material.

A tool which is a physical model of the broaching process was used for the research in the first phase [4-6]. Therefore, in order to carry out the research, a cutting tool of a special design was manufactured with changing cutting elements made of high-speed steel SW7M (HS6-5-2). The cutting element geometry was identical to the innovative cutting tool geometry which was used for weld bead broaching.

Four samples made of S235JR steel, were prepared for machining on the SZ-400 Planer, with welded samples using the following technologies (Fig. 1):

1) semi-automatic welding machine, $I_{weld} \approx 95A$;
2) semi-automatic welding machine, CO2, $I_{weld} \approx 110A$;
3) semi-automatic welding machine, CO2; Corefil 100R Metalweco wire Ø 1.2 mm; I weld ≈ 90 – 110A;
4) manual metal arc welding (MMAW), $I_{weld} \approx 90A$.

1) 2) 3) 4)

Fig. 1. Photos of welded beads before and after machining

The experiment has shown a stable cutting process with good quality of the treated surface. Therefore, we started the second phase of the research related to the calculation and design of the non-standard multi-edge cutting tool, the fixture for its fastening and the choice of the machine for testing of the innovative method in an industrial environment.

3. Calculations and design

In order to prepare the multi-edged tool for post weld surface finishing intended for machining a specific batch of weld-joins, it is necessary to design it using existing calculation methods [7, 8], but also applying new non-standard solutions.

First of all, the machining allowance q_p is determined. When finishing the weld bead flush with the base metal surface, the allowance q_p is treated as the weld bead height H_s, (Fig. 2) which is limited by the surfaces of the finished object a_p and the weld bead a_s and is equal to the difference in the first and last cutting tooth height.

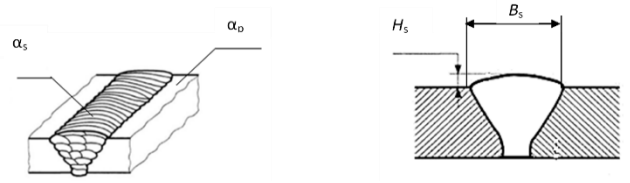

Fig. 2. Weld bead elements

In order to determine the machining allowance q_p is necessary to measure the weld beads height H_s, then statistical analysis of measuring results is carried out. Before calculations and designing of the cutting tool, the maximum dimensions of the weld beads are determined for processed seams in the batch. On the basis of the analysis performed, the extreme weld bead height H_s and the weld bead width B_s are determined (Fig. 2) The next step in the design of the tool is to determine the geometry of the cutting edge and teeth. To ensure reliable operation of the tool under shock loads, it was necessary to strengthen the teeth of the tool. The approximate value of the cutting teeth pitch P_p is determined using the formula:

$$P_p = (2{,}25 \ldots . 3)\sqrt{L} \tag{1}$$

At the same time, tooth length dimension g was increased, strengthening the cutting edge, without changing the length of flute k, which is set using the formula:

$$k = (1{,}05 \ldots . 0{,}95)\sqrt{L} \tag{2}$$

The total number of teeth Z_o necessary to finishing the weld bead flush with the base metal surface depends on weld bead height and is increased by adding the penultimate and last tooth which have the same height to eliminate cracks, craters, pores and other weld defects.

4. Technology development

As a result of the research and calculations, the weld beads broaching technology was developed in accordance with the innovative method (Fig. 3).

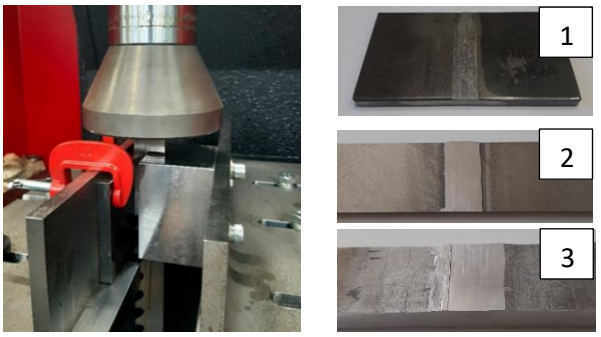

Fig. 3. The innovative method of post weld bead surface broaching: 1) non-alloy structural steel S235JR (1015); 2) stainless steel 1.3964; 3) aluminum alloy PA47 (7020)

5. Conclusions

The innovative method is characterized by short machining time of the weld bead and high efficiency. In addition, the innovative multi-edge cutting tool is used for weld bead broaching and ensures a low level of deviations in terms of shape and position as well as exceptionally high machining accuracy and high quality of the surface layer. While helpful eliminating welding defects on the bead surface due to the presence on cutting tool of the last two teeth of the same height and special geometry of cutting teeth. Wear of a properly designed tool is slow as its edges have a long service life thanks to increased resistance to shock loads caused by specialized tooth geometry based on strength calculations. The innovative weld bead broaching method provides economical machining, not requiring qualified operators, as well as the ability to cut many weld beads set in a row (continuous cutting), and the possibility of automating the finishing process. The versatility of the solution allows for the post weld surface broaching of various types of steel and alloys using the overwhelming majority of welding methods. This solution does not show signs of nuisance to people and their environment, and does not interfere with any regulations of emission standards. This invention provides accurate, efficient and economical post weld finishing.

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