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CHECKING OF TIPS OF WELDING ELECTRODES BY USING VISUALIZATION

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***Abstract*—**This article discusses the use of machine optical vision in the control of tip of welding electrodes for resistance spot welding. The aim of the research was carried out to design a fully functioning device for the assessment of immediate functional area of dimensional quality welding tip using the visualization process. The main objective of this work was the proposal of sensing device which satisfies the conditions of functionality, high precision, rapid assessment, reliability, minimum dimensions, production costs and maintenance costs. The launch of the device is the ability to reach a comprehensive solution in production, such as planning the appropriate exchange of tips electrodes, evaluation of area before and after renovation. The output is to ensure a longer lifetime of tips thereby reducing production costs.

***Keywords*—**welding electrodes, visualization, surface quality, CCTV

I. Introduction

THE issue of automatic exchange of tips of electrodes for welding heads is still relevant today in terms of economic efficiency resistance spot welding operations with industrial robots. Due to the need of renovation and its frequent mechanical replacement, the lifetime of the electrode surfaces is limited. Differences between new, worn and restored tip are shown in Fig. 1. The new tip is characterized by a glossy surface and symmetrically rounded work surface with a smooth transition from spherical to cylindrical surface. The desktop of the worn tip has a dirty and deformed functional - contact surface caused by welded material. Noticeable notches on the sides of the tip of the Fig.1c are created by the dismantling of the plant. After renovation milling the tip has traces of chip roughing, glossy surface after finishing of a slight change in surface from the original starting shape. Rounded upper part is slightly skewed, which does not affect the quality of welded joints, because the shape and size of the area is preserved.

In standard operations robotic resistance spot welding cycle is selected by setting the renovation of the basic technological parameters of welding, a pair of materials and the machined mechanical operations, the type and quality of material of tips of welding heads, possibly affecting weld using sealants and adhesives in the vicinity of welds.

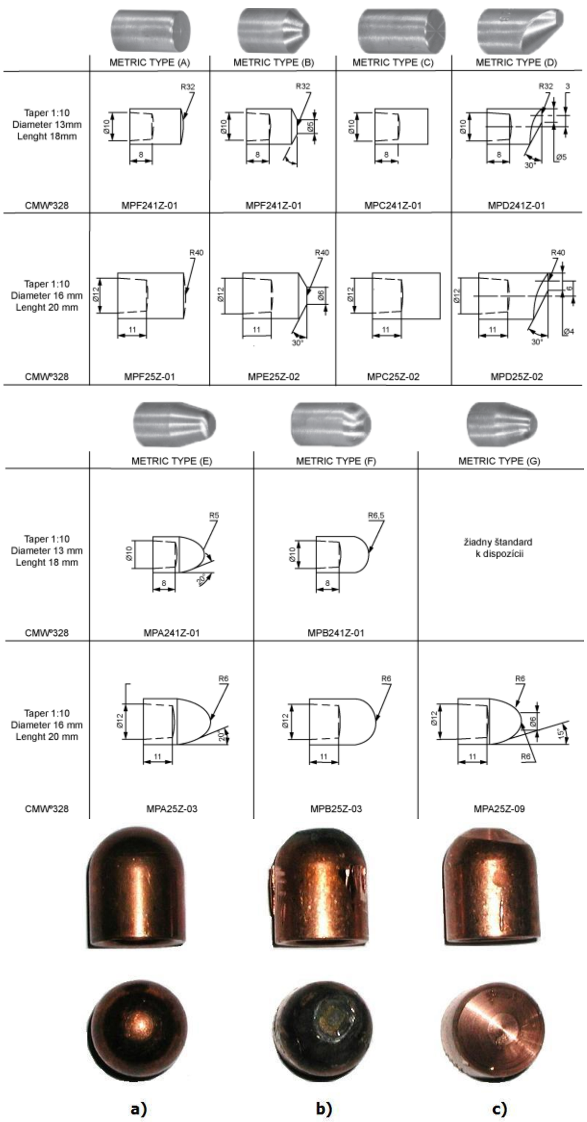


Fig. 1 Welding electrodes [6] tips comparison: a) new, b) worn, c) restored

In standard operations robotic resistance spot welding cycle is selected by setting the renovation of the basic technological parameters of welding, a pair of materials and the machined mechanical operations, the type and quality of material of tips of welding heads, possibly affecting weld using sealants and adhesives in the vicinity of welds. At present renovating contact surfaces of the electrodes of robotic heads is controlled by preselected mode as defined by the number of spot welds made by operators in robotic technology workplace. Today the principle of the routine program of tip renovation performs regular cycle of maintenance work of worn tip surfaces after the chosen number of operations regardless of its real wear. In terms of quality of welded joints welding tips are often exchanged prior to their life cycle is reached only because of planned maintenance. The aim of the research conducted by the authors of this work was to propose a method for sensing the real state of the tips of welding electrodes and subsequently to design and implement a device that is capable of real-time evaluation of the state of the contact surface of the electrode tip.

II. METHODOLOGY, APPARATUS, MEASUREMENTS, RESULTS

Research conducted at the authors aimed to ensure high quality welding tip as one of the most important factors for quality and consistent spot welds. The proposal method was to suitable, easily and effectively monitor and ensure the proper tips exchange, the treatment of working desktop, to maximize the number of welding cycles, while observing high quality weld. Own solution consists of a theoretical design of the sensing device in several design versions.

Option 1 The most important endpoint is the tip electrode contact area through which electrical current flows. Sensing geometry of a surface is protected by CCTV brand Guppy F-033 B / C (Fig. 2) oriented parallel to the surface of the welding tip.

a b c d

Fig. 2 Showing sensing methods of welding tip geometry - version No.1

Fig. 2b is a realistic 3D view of a tip through sensing camera is parallel to the flat tip (Fig. 2c). Fig. 2d resulting graph showing the red segment, from which it is possible to calculate the average wear or retrofitted area. The advantages of this option lie in simplicity and such that when shooting of tip geometry only one camera is required. The proposed variant allows you to shoot first bottom electrode tip and after capturing the welding head rotates 180 degrees and sensing is repeated for the upper tip. The second option is to capture both tips at the same time by controlled clamping of the electrodes arms. The disadvantage is the lack of a constant distance between the tip and the sensed sensing device. Tip wear is not always constant (symmetrical). This non uniform wear influences the final processing of the scanned tip that will not be correct, because shooting from another camera view tip will be worn differently, which would cause the outcome to be always different. This applies equally to tip wear in the form of holes on the welding area. In the side shooting it is problematic to determine whether it is an ideal flat surface or in a cavity therein.

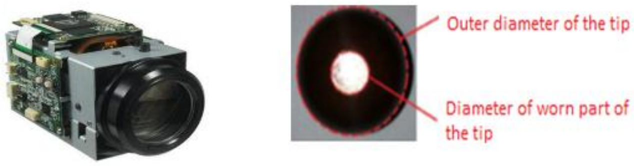
Option 2 is implemented by camera, which scans the surface of the tip face (Fig. 3a) and real 3D image shot with the camera (Fig. 3b). On Fig. 3c is the result of record from the camera. Fig. 3d is highlighted by the red circle to the diameter of the worn surfaces evaluated. The scanned area is in this case more accurate than in option 1 as it is scanned and evaluated directly from the record and not indirectly via size in conversion-line.

This method allows displaying the area of the tip generated by the program easier and more accurate than the subsequent recovery. The disadvantage is that the distance between two opposing tips there is a limit to expansion of arms of the electrodes of the welding head. It follows a small, insufficient distance for the direct placement of cameras between the jaws. In order to capture the surfaces of the two tips is therefore necessary to use an image by a series of fold mirrors, which represents a lot simpler design variants.

a b c d

Fig.3. Showing sensing methods of welding tip geometry - version No.2

Option 3 is principally a copy of option 2, but changing the sensing device of the classic industrial camera to a device equipped with a camera autofocus lens mechanism (Fig. 4). The advantage is the auto-focus of image, which can be used in measuring the varying length of the lens - a flat tip. Implementation of the calculation takes place due to the ratio of the outer diameter of the tip and the tip of the circular area (Fig. 4b). The outer diameter of the tip surface is fixed; circular surface tip varies due to wear. Created a methodology based on the establishment of the maximum permissible ratio between the outer diameter and a circular flat tip electrode. Ratio varies according to the circular region of the tip which means that during the scan of the area of the tip from different distances, the resulting ratio will always be precisely evaluated. When shooting both tips of the jaws at the same time for reasons of space it is required to use a system of mirrors to repel / refractive scanned image. Disadvantage occurs at a greater distance between the lens and the area of the tip, because the intensity of the incident light may be small. The downside is when inappropriate focus range.



a b

Fig. 4 Example of industrial camera with autofocus lens from SENTECH STC-AF133A [4]

Option 4 - scanning the surface of the tip electrode is implemented by contactless laser scanning functional surfaces of the electrode by sensing device Absolute Tracker AT901 of LEICA, in combination with a handheld laser scanner T-Scan TS50. Leica Tracker provides high accuracy, resolution and can scan a wide range of different types of surfaces without powdering. Fig. 5 shows the results of a new 3D surface scanning tip welding electrodes and on Fig. 5b the final result consisting of the sum of the individual partial scans can be seen. Using this option the tip surface calculation is lengthy, complicated and the equipment is financially the most demanding of all the previous options.

a b

Fig. 5 Showing sensing methods of welding tip geometry - version No.4

III. CONCLUSION

The paper briefly describes four proposed methods of tip geometry sensing. The first three options are using to capture by industrial cameras - tips are detected visually. Fourth option uses non-contact 3D laser surface scanning of the tip. Option 1 represents a simple design implementation, but the accuracy of the shooting is poor. Good starting point is therefore option 2, which satisfies the necessary requirements for reasonably accurate and efficient sensing methodology. Although it is structurally more complex it provides more accurate sensing and evaluation. Option 3 is similar to Option 2, but requires higher investment demands. Option 4 represents contactless 3D laser surface scanning, which is very costly therefore it can fulfill the function of the standard. For industrial practice the most appropriate solution appears to be Option 2. In this follow-up is the result of designed and developed evaluation program in an NI Vision Builder (Fig. 6). Functional operation is provided by controller NI CVS-1454 manufactured by company "National Instruments" into which a proposed program of NI Vision Builder is loaded. On the picture below there is a print screen of NI Vision Builder window that shows an image taken with an industrial camera, toolbar for image processing and the program sequence. The red frame shows the images created by using industrial cameras. The green frame shows in individual tabs the most widely used tools for image processing consequently offers the possibility to create your own custom made toolbar. Turquoise frame represents tools that are configured for image processing and evaluation of results. In order to achieve a successful evaluation, each individual operation must be compliant otherwise an error will occur. This can be further configured as to what action to take after the event has occurred. Large green rectangle with the word "OK" on the top right of the image is the result of image processing program.

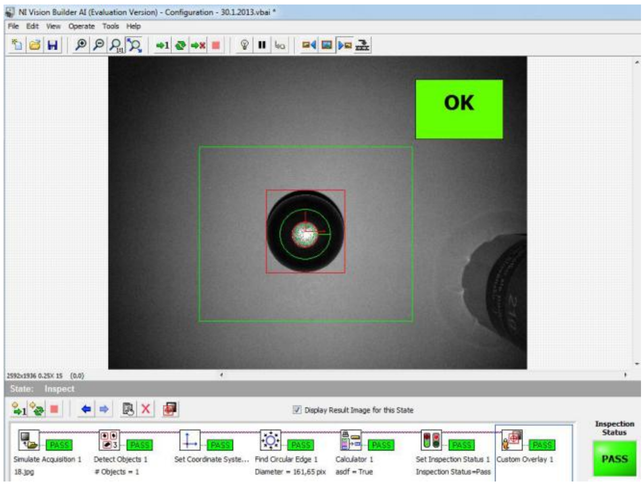


Fig. 6 Showing the working environment of the program Vision Builder with successful image processing

Designed model of the measuring device (Figure 7) is a 3D concept of sensing device (Option 2) comprising of:

1) industrial camera GUPPY F-033 B / C with manual lens Tamron 23FM16SP
2) a series of polished flat mirrors (providing picture angle of refraction of 45 degrees)
3) high-power LED lighting with stand
4) rack for defining the position of the tip
5) plastic cover

The control unit of machine vision NI CVS-1454 with the established program for the evaluation process of shooting is needed during its operation and individual performance of this equipment.

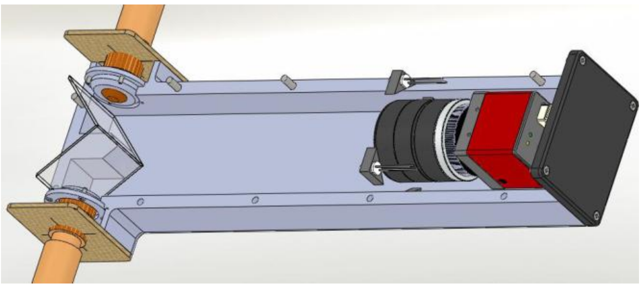


Figure 7 showing a 3D model for recording and evaluation of the surface of both tips of welding heads

The sensing device assembly equipped with Guppy F-033 B/C camera that has a manual focus lens Tamron 23FM16SP and LED illumination of electrode tips is shown on the Figure 7. As you can see there are two polished mirrors assigned for light refraction. The run of this experimental device provides controller CVS-1454 manufactured by National Instruments which executes program developed in NI Vision Builder environment.

With regard to the positive results and low cost indicators the device is ready to be applied in production.

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REFERENCES

[1] KAMENCAY, M.: *Vyuzitie strojoveho videnia pri kontrole hrotov zvaracich elektrod pre bodove odporove zvaranie*, STU v Bratislave. Strojnicka fakulta, 2013. 58 p.
[2] KYOKUTOH CO.,LTD.: Dresser option. [online]. [cit.03. 02.2013]. Available at <http://www.kyokutoh.com/html_en/product05.html>
[3] AF133A [online]. [cit. 15. 04. 2013]. Available at http://www. sentechamerica.com/cameras-autofocushd/STC-AF133A.aspx.
[4] AVT Guppy Pro F-031C [online]. [cit. 03. 02. 2013]. Available at http://www.spectratech.gr/en/product/27412/AVT_Guppy_Pro_F-031C.
[5] STC-AF133A [online]. [cit. 15. 04. 2013]. available at http://www.sentechamerica.com/cameras-autofocushd/STC-AF133A.aspx.
[6] EN ISO 5821: 2009, *Zakladne tvary, rozmery a geometria spiciek*.
[7] VAGAS, M., HAJDUK, M., SEMJON, J., PÁCHNIKOVA, L., JÁNOŠ,R. :The view to the current state of robotics / - 2012. In: Advanced Materials Research. Vol. 463-464 (2012), p. 1711-1714. - ISSN 1022-6680.
[8] PACHNIKOVA, L., HAJDUK, M., BELOVEZCIK, A.: *Possibilities of Use of Virtual Reality in the Field of Manufacturing Systems* - 2012. In: Applied Mechanics and Materials. Vol. 186 (2012), p. 188-193. - ISSN 1662-7482.
[9] HAJDUK, M., SUKOP, M.:*Multi-Agent Robotic System – Robotic Soccer in Category Mirosot* - 2012. In: Applied Mechanics and Materials. Vol. 186 (2012), p. 12 -15. - ISSN 1662-7482.
[10] DANISOVA, N., RUZAROVSKY, R., VELISEK, K.: *Design alternatives of intelligent camera system for check parts at the intelligent manufacturing-assembly cell* - registrovaný: Scopus. In: Applied Mechanics and Materials. - ISSN 1660-9336. - Vol. 58-60 (2011), s. 2262-2266.
[11] DANISOVA, N., RUZAROVSKY, R., VELISEK, K.: Design methodology of automation equipment and control system in the intelligent assembly cell. In*: Applied Mechanics and Materials* - ISSN 1660-9336. - Vol. 58-60 (2011), s. 2407-2412.
[12] SVETLIK, J., DEMEC, P.: Mathematical modeling of machining by decomposition of lathe on modules . 2012. In*: Metalurgija* Vol. 51, no. 2 (2012), p. 285-288. - ISSN 0543-5846.