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System of video observation for electron beam welding process

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Abstract. Equipment of video observation system for electron beam welding process was developed. Construction of video observation system allows to reduce negative effects on video camera during the process of electron beam welding and get qualitative images of this process.

Methods and systems of machine vision are being actively implemented for automation of process technology and manufactures. Modern systems of machine vision allows to effectively recognize visual information. On the basis of analysis this information complicated problems of control and monitoring are solved. Very often, such systems are used where human presence is limited or not possible, or the possibility of monitoring process are limited

For example, equipment for electron beam welding (EBW) is complex, which includes electromechanical manipulators, vacuum equipment and powerful energy equipment. The high welding speed of 25 mm/s, limited visual observations pose problems to operator in control of the welding process.

Machine vision systems can be used not only for monitoring the EBW process, they also can be charged different control tasks for the process, for example, the positioning of the beam at the junction of the welded parts and the tracking of the joint during welding, runing the beam parallel to the joint or edge of the product, visual quality assessment of the welding without removing the product from the vacuum chamber, etc

However, such systems must withstand harsh conditions of electron beam welding high vacuum, the impact on the video camera thermal radiation, dust on optical system metallic vapor. And the system needs to obtain a high quality picture, avoiding exposure from the weld pool and glare from the electron beam.

Industry operating experience of television monitoring systems showed that these systems do not allow obtaining high-quality images of the welding process, because television systems cannot get rid of the exposure of weld pool, glare and degradation of image quality due to dust the lens or its protective elements. The system maintenance in industrial conditions is difficult and expensive.

Another way of monitoring EBW process [1], combining tracking of the joint, uses secondary electron emission. The electron beam scans surface of product, causing a stream of secondary electrons collected the metallic plate (collector of secondary electrons), fixed under an electron beam gun. According to the readings of this sensor forms image of the product. Further on the basis of the image, the system select the joint and brings him under the electron beam. However, the main function of this system is the pointing of the beam on the joint. Therefore, picture quality is enough to select joint, but to monitor the EBW process its not enough.

There are system video observation [2], where ordinary video camera is used as sensor. The video camera is placed directly on a movable electron beam gun, in order to adjust the optical axis of observation and the axis of the electron beam. To prevent influence of heat radiation during welding, system is equipped with water cooling. To prevent influence of metal vapor rotating glass disk is used. To obtain high-quality image used small power quartz lighter with water-cooled. However, the high level of glow of the weld pool is remain.

Consider requirements given above, system video observation for electron beam welding process, different from existing in its simplicity and accessibility for industrial exploitation, is developed [3].

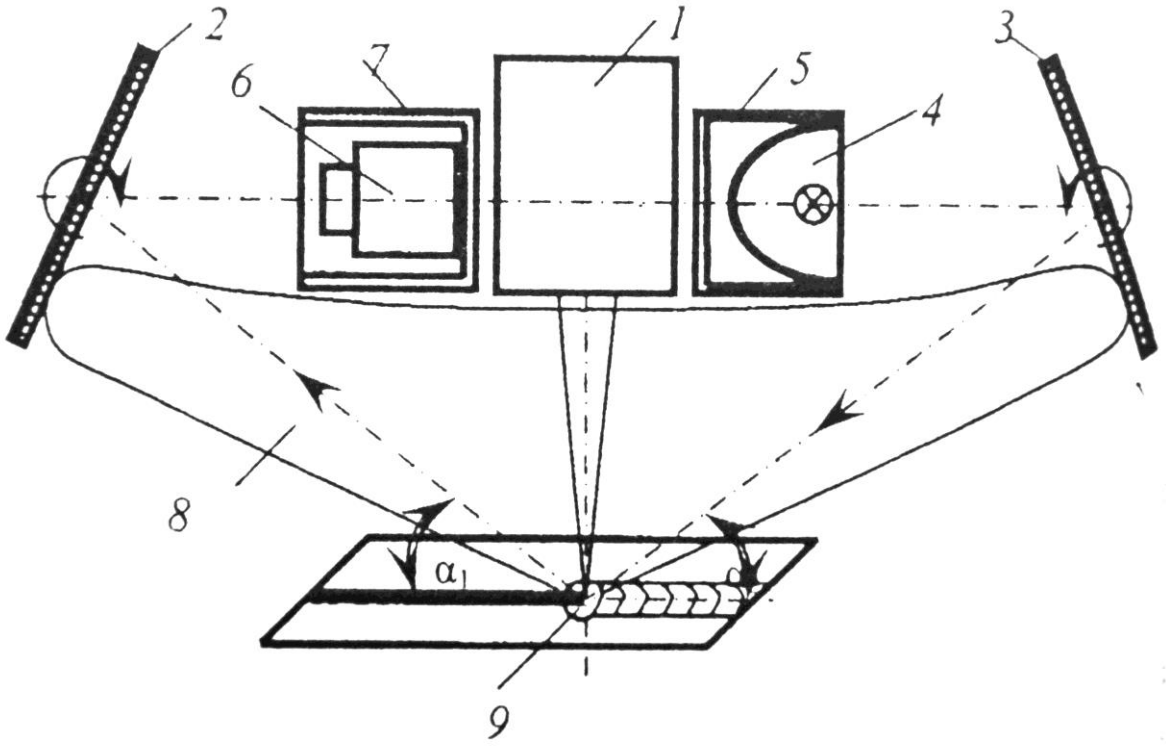

Figure 1. System of video observation for electron beam welding process:
1 – electron beam gun; 2, 3 – folding mirrors; 4 – lighter;
5 – body of lighter; 6 – video camera; 7 – thermally insulated shell; 8 – vapor cloud; 9 – welded joint

The video system (Fig. 1) consists of the video camera, the lighter and the folding mirrors. The camera and the lighter are mounted on the electron beam gun. For protection from thermal radiation and contamination of the optics, the camera placed in the thermally insulated shell. Protection against dusting of metal vapor is provided by the deviation of the optical axis of the camera and lighter from direct view of weld pool using mirrors. In view of the fact that the optimum angles of illumination and observation are provided with adjustable mirrors, placement of the protected elements is limited only by the design and dimensions of

the vacuum chamber of the welding equipment. If vacuum chamber allows to place elements of a video system outside zone of expansion of vapors of welded metal, it increases the availability of the system. Also to ensure the stability of the luminous flux from the welding zone it is advisable to use a mirror with a mirror layer of welded material that can be produced by any suitable known method. Since the brightness of the radiation of the weld pool is high, the system uses a concentrated light source, avoiding the exposure of the camera from glare and radiation of the weld pool.

The system of video observation can be assembled on the basis of the video cameras produced by companies specializing in video surveillance and security systems. However, there are a number of conditions that need to be considered at choosing a camera. The video camera's resolution should be not less than 520 TVL for analog cameras and not less than 720×540 for digital. The minimum sensitivity of video camera should be 0.01 to 1 Lux. The video camera should be suitable for effective observation day and night. The video camera must be equipped with an auto-iris or have a block to control the aperture. The auto-iris is used for observations of objects with variable illumination, which is suited to the observation of weld pool, brightness of which changes rapidly during the welding process. The distance from the electron beam gun to the welded parts average from 80 to 200 mm, therefore, to monitor the welding process ideal camera mast have dynamic focal length. The exploitation of the video system revealed that the increase in 4 – 5 times is enough for observation of the welding process. And only in rare cases, the zoom lenses change focal length more than six times are needed. You should also consider that system of video observation must operate in a vacuum, so the choice of video camera is fulfilled with the absence of many elements that are critical to low pressure.

The appearance of the system of video observation shown in Fig. 2

Figure 2. The appearance of the system of video observation for electron beam welding process

Industrial designs the system of video observation for electron beam welding process are implemented in production and successfully used by JSC " Krasmash."

References

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