Laser Projection Positioning Improving at a Machine-Building Manufacturing Enterprise Method

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Abstract. The goal of this work is to research a possibility of laser projection system adaptation to a machine-building manufacturing enterprise. A model example of the use of a computer vision system in production is the task of reducing the labor intensity of installing welded elements on a product, reducing the production time, and reducing the cost of work. A formal statement of the problem is given - to use a laser projection system in the conditions of assembly and welding production for positioning welded elements on the main product with respect to dimensional accuracy. For experimental research, a section of a machine-building production enterprise with a pre-defective product and welded elements was used. The research took place in two stages. As a result of the research, the results were obtained, confirming the efficiency of the method.

1. Introduction
Nowadays, the implementation of new technologies is a common process. Any spheres of human activity is inevitably faced with the necessity of development in any direct, for example science, engineering, medicine or something else. The existing equipment and working methods are constantly have a necessity of improvement, optimization in order to radically change the capabilities of existing production enterprises. These improvements include: financial costs, time costs, labor costs of the amount of work performed, improving the quality of products, etc. Considering that all these factors are extremely important for manufacturing enterprises, it is necessary to start solving these problems by using the most modern ways.

Since the digitalization of various fields of activities developing in the 21st century, the solution of issues of improving production indicators at enterprises also requires the intervention of digital technologies. New technologies, equipment, techniques and software that form the basis of production today. There are a lot of examples of using digital solutions in manufacturing enterprises: the use of augmented and virtual reality technologies, robotization using complex robotic systems and
manipulators, machine learning, the Internet of things, the digital twin of a manufacturing enterprise, CAM systems for robotic laser-cutting and plasma-cutting, etc. It is the current trends that are driving manufacturing into the digital future.

One way to reduce labor intensity, manufacturing time and reduce financial costs is implementation and using laser projection technology. This technology is unique and has the ability to be widely used in a manufacturing enterprise: laser projection can be used to highlight contours on a product in order to weld additional elements, cut a product, or be as an assistant locksmith and welder to follow the sequence of operations according to the technological process, and exclude human factor (for example, skipping the welding of the required part).

2. Ease of use

Despite all the advantages of using laser projection technology in a manufacturing enterprise, the implementation this type of systems entails a several problems to solve: the lack of up-to-date design documentation and 3D models to create a projection template for a separate part; products for the manufacture for which a laser projection system was implementated may be discontinued. But the most important problem is the low quality of the workpieces - some products and parts may be outside the tolerances specified in the design documentation. The reasons for such defects are various, for example, product’s temperature and impact deformations, which are subsequently corrected when the product is welded to the main object (for example, a deformed end wall is welded to the body of an electric locomotive using welding machines and a sledgehammer to improve the end wall). Sometimes, manufacturing plants set up an annual plan aimed at making a large number of products. As a result, the quality of products is greatly reduced.

This science work shows the part stage of laser projection system implementation, the main tasks of which are technological process of the assembly modernization and optimization, and welding operation of manufacturing a product, reducing the labor intensity of the operation of marking the installation sites of welded elements and increasing productivity. Operator working with laser projection system algorithm is: the product is installing in the working area (on the welding table), than site operator binding the laser projector to the working area (welding table) using retro tags, checking the correct positioning of the product on the welding table, and starting the laser projection control program. With the remote control, site operator performs a sequential projection of the contours of the installation sites, to which the elements are welding with high accuracy. In this case, the absence of the necessity to use rulers, calipers, chalk and other improvised means can significantly reduce the installation time of the welded elements. An illustration of the projection process is shown in the figure 1.

![Figure 1. Laser projection process.](image-url)
3. Working principle

At the stage of identifying the problem of projection accuracy due to various deformations of the product, it was decided to carry out experimental work to improve the projection accuracy. Since the product basing operation on the welding table can be performed along any contours, at the first stage, the contours of the left and upper sides of the product were highlighted for basing, as shown in Figure 2. This step was taken with the assumption that most of the welded parts are on the left side of the product and are the most important. The projection of the left and top sides of the product was supposed to maximize the positioning accuracy of the elements on the product, but the deformations shown by the red arrows in Figure 2 do not allow the product to be displayed correctly.

Despite this, an attempt was made to install (tack) the welded elements on the product and measure the dimensional chains. As a result, most of the dimensions are not within the tolerance range, which is a critical indicator for a manufacturing enterprise.

To solve this problem, it is necessary to completely revise the dimensional chains and dependencies of the elements on the product, draw up an approximate deformation map, and, on its basis, generate a projection template file. If the deformations are not typical (deformations may appear in different places on each product), the measurement map cannot be a solution to the problem. In this case, it makes sense to revise the principle of basing the part on the welding table: it is necessary to start basing and dimensional chains from the hardest part of the product, which can be made not by hand, but, for example, on a machine using laser cutting with high accuracy. In this case, on the product, the hardest and most accurately cut part is the doorway, from which you should start basing the product (along the red and green lines, as shown in Figure 2)
As a result of the work carried out, the most problematic dimensions were selected, the accuracy of which is extremely important in the next stage of the technological process. These dimensions were entered in the table for accounting for the results of the experiment and the calculation of the identified deviations from the nominal values in both parts of the experiment. Tables of accounting for nominal and actual sizes are presented, as well as the calculation of deviations are presented in Figure 3 (WEID – Welding Elements Installation Dimensions).

![Figure 3. Highlighting doorway lines.](image)

![Figure 4. Nominal & actual WEID and calculated WEID deviations.](image)

According to the results obtained in the table, it can be seen that the method of basing on the most unchanged part of the product allows increasing the positioning accuracy of other parts. Visually, the results of the work are shown in the figure 4 and figure 6.
Based on the graphs and diagrams obtained, it can be assumed that the method of basing on the invariably rigid part of the product can significantly improve the quality of laser projection of the places where the welded elements are installed on the product. For clarity, in Figure 7, presented a check-list of important dimensions for each of the experiments on basing the part on the welding table (WEID-1, WEID-2).
Figure 7. WEID-1 & WEID-2 check-list.

The resulting check-list demonstrates a significant difference between the two types of basing. Visually on the check-list showed the number of dimensions within the tolerance and dimensions outside the tolerance. The number of "green" sizes in WEID-2 is much larger than that of WEID-1. This can be concluded that the positioning of the part on the welding table very much depends on the product’s base parts.

4. Conclusion
The implementation laser projection system into machine-building manufacturing enterprise will contribute to reduce labor intensity, manufacturing time and financial costs. This technology is unique and has the ability to be widely used in a manufacturing enterprise. Despite the presence of difficult problems in solving, the laser projection system can be adapted to various production conditions and actively used in everyday work. The results of the experimental work showed that the adaptation of the system is possible even though the supplied parts can be produced with deformations.

5. References
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