AUTOMATIC HANDLING EQUIPMENT FOR LASER CUTTING

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Abstract: The article is devoted to the presentation of the results of the research project Req-00163-003 entitled “Research of CNC technology nodes for cutting materials using energy-beam technologies”. The aim of the project is a conceptual design of an automatic loading and unloading system. The system will be designed for machines with a work area of 3x1.5m and 4x2m. The authors devote themselves to the design and development of the construction nodes, in particular the automatic sorting system, the problem of the operation of the vacuum suction cups, their correct distribution and correct choice of the individual types of suction cups. The paper presents partial results of the design of an automatic sheet metal loading and unloading system.

Key words: laser cutting machine, loading and unloading unit, fully automatically systems, sorting, automated pallet changes

1. INTRODUCTION

The article presents the results of the project focused on the research of state-of-the-art technical solutions in the area of CNC machines for the cutting of materials by energy technologies - plasma, oxygen, high-pressure water and laser. The project focuses on the development of nodes allowing modular construction of complex cutting centers with a combination of splitting technologies, additional drilling, thread cutting and labeling technologies, with the possibility of automatic loading of semi-finished products and automatic unloading of finished parts. Part of the solution is also the automatic removal of waste emerging from the cutting process.

In the solution, a modular system for automatic loading of material to the working area of the cutting heads, a system of automatic gripping, shifting and filing of the material in the cutting process and its sorting after the cutting process has been designed. The modular system is designed for case cutting sheets and for the division of open and closed profiles of different cross sections. Moving and pivoting modules in the work zone are interpolated moving axes of the CNC system. These modules are equipped with automatically operated sensing grip units for accurate positioning of the material and for accurate identification of its dimensions.

The goal was to create automated cells for fully automated cutting workstations with a material flow customizable to customer requirements. Special robotic kinematics are incorporated into the cutting system to extend the cutting capabilities of more complicated spatial formations controlled directly from the CNC machine control system as well as to manipulate and sort the finished parts.

In addition to the development of the control system of the individual modules of these nodes, the development of an information system for the production management of such a node, group of nodes creating automatic cutting workplaces. Such a subsystem can easily be connected to the enterprise information system. In the system, apart from input operations for dividing the parts into individual blanks, a complex database is kept containing information about the subsequent operations necessary to make the final products, bending, assembly, dyeing, the individual operations being defined by its capacity, and the way and capacity of moving the blanks thereto. It is possible to include the transfer of semi-products on pallets, handling devices or conveyors into the system. This system allows automatic sorting of products at the cutting centre exit as the products are further processed or processed. dispatched, which increases the efficiency of the entire production process. The user always has information on the current state of production and the position of individual parts in the production. This system also allows for more efficient planning of the cutting process with regard to the capacity of the workplaces carrying out subsequent operations as well as the capacity of the handling operations.

The application area of such complex cutting nodes is characterized by the need for a great deal of cutting, such as the production of ships, wagons, steel structures of production halls, bridges, wind power plant nodes, in the world, is growing the demand for them and is related to the effort to increase the degree of automation of production.

2. AUTOMATIC LOADING AND UNLOADING SYSTEM FOR LASER CUTTING MACHINES WITH TOWER STORAGE

The aim of the project was to create a modular automatic handling system for the productive operation of MSF
laser cutting machines. In cooperation with STU at the workplace of the solver, MicroStep the final stage of the design of the loading and sorting system for laser cutting machines was carried out in the third stage of the solution (2017), as well as the development of the software of such complexes. The proposed modular system under the name MSLoad is described in the next section. In the next stage of the solution, the solution will be fine-tuned according to the experience gained from the functional models. The assembly completes the system for automatic sorting of cut out parts. The automatic sorting system is labelled MSSort. In the third stage, work on the creation of software for the management of such a complex was carried out in parallel.

2.1. MSLoad

MSLoad is a modular assembly designed for automatic loading and unloading of MSF laser cutting units that are in the product portfolio of the solver. This loading and unloading unit can be assembled in a simple version without a tower or in a more complex version with a 6-pallet tower. The MSLoad set is standard for machines with a work area of 3 x 1.5 m, 4 x 2 m, and 6 x 2 m. However, the system can also be modified for other dimensions. In the following, there are briefly described the various alternative assemblies - the system version and the functionality of the developed software.

MSLoad with tower stack - V1T version

The assembly of the MSF laser cutting machine with the MSLoad automatic tower loading and unloading system is illustrated in FIG. 1, while the orientation of the assembly may be opposite - mirror.

The individual functional parts of the MSLoad assembly are numbered as follows:
1. Part of loading and removal of cut material.
2. Part of the tower stack
3. Part of pallet lifter part.
4. The pallet moved by the lifter.
5. Place of the semi-finished products into the system and the removal site of the cut material.
6. Ridge of the cut material.
7. The cutting table of the cutting machine.
8. Loading carriage with vacuum cleaners.

This numbering is preserved for all the following images. The MSLoad system consists of a part of the semi-product loading and removal of the cut material along with the waste. This part, designated as Part 1, consists of a ridge of the cut material 6 and the loading carriage 8 (it is pushed up to part 2 below the tower).

The ridge tumbler located above the interchangeable table of the laser cutting machine is formed by two opposing floor combs which can be motorized as shown in Fig. 2. The whole set of ridges is moved in the vertical direction. The drives allow to open the open ridge assembly to the level of the exchange table grids, inserting the combs into each other between the lamellae to resemble the cut-out material and lifting it above the grate of the exchange table. Under this lifted system, the loader can be driven. A pallet is placed on the top of the loading trolley, onto which the cut-out material is unloaded. Unloading is accomplished by expanding the combs, causing the cut out of the pallet to fall. At the same time as the cut-out of the cut-out material, a new blank is deposited on the grates of the exchange table, which is captured by vacuum cuts at the underside of the loading carriage.
Fig. 2. MSLoad - a detail of a ridge with closed and open combs

The view of the loading carriage, which is provided on the underside with a vacuum clamping system with suction cups, is shown in Fig. 3. In addition, the trolley is fitted with a measuring sensor for the thickness of the material to be loaded and for the separator of the intermediate products to be loaded. The separator function fills one of the corner suction cups together with its pneumatic cylinder. This separator eliminates the possibility of bonding thin blanks - to separate them.

Fig. 3. MSLoad - Vacuum clamping system for loader with suction cups

Thus, for the operation of the system, the loaded material must be placed in the position below the extended loading carriage, and a pallet must be placed on the loader on which the cut-out material is unloaded. In a complete system this is assured by the tower stack assembly - top part 2 and part 3 - in Fig. 1. In Part 2, the pallets with semi-finished products and pallets with cut material are deposited, and in part 3 there is a manipulator by means of which the pallets with the blank are moved under the loading carriage and the pallets on which the cut material is to be unloaded are moved to the top of the loading trolley. Then they move back to the tray.

Short description of system activity:

In the tower 2 are placed pallets with semi-products and pallets intended for unloading the cut sheet. The pallet stacker 4 moves the pallets with the blank into the position below the loading carriage 8 equipped with vacuum cutters. The pallets on which the cut sheet is unloaded move the handling lifter 4 to the top surface of the loading carriage 8. Then, the blank is then gripped and lifted by means of the vacuum tines and the pneumatic cylinders. After cutting the previous blank in the cutting machine and pulling out the grate into the exchange table 7, the ridge boom 6 raises the cut sheet and the loading carriage 8 with the gripping new blank is slid over the exchange table 7. Then the new blank is placed on the grate of the cutting machine and the cut sheet is a ridge by a tumbler 7 placed on a pallet which is located at the top of the loading carriage 8. The loading carriage 8 is then moved into the tower 2. The pallet from which it is loaded and the pallet to which it is unloaded can then be moved to another location in or exchanged for another.

There are also sensors for the presence of the half-finished product. In Fig. 4 shows a loading trolley inserted above the exchange table of the MSF machine. In this position, a new blank is placed on the exchange table grids and at the same time the cut material is stored before being lifted by the comb on the pallet located on the loader.
2.1.1 MSLoad without Tower Tray - V1

MSLoad can also be supplied in a simplified form without a tower. Such a simplified version is shown in Fig. 5 and Fig. 6, the individual parts being designated as follows:

5. Place of semi-finished products in the system
6. Ridge of the cut material
7. The cutting table of the cutting machine
8. Loading carriage with vacuum cleaners
9. The trolley (in case it is unloaded from one side and sideways)

As with a complete tower stack, the left and right versions can be made. The assembly of the blanks (each sheet may have a different thickness) is placed on the mandrel 5, during which operation the loading carriage is inserted over the machine’s table. From this place, the blank is gradually taken off into the cutting machine. The cut-out material is laid out on a pallet laid on the loader. This palette is removed from the pallet by the forklift truck. The MSLoad automatic loader has a separate control system with its own MMI console and is connected to the machine control system by the MSF communication line.
2.1.2 **MSLoad without tower stack - version V2**

If it is necessary from the point of view of the material flow for the exit from the cutting to be on the other side of the system, then the assembly is completed with a separate motorized truck - a trolley 9 on which a pallet for the cut material is placed. FIG. 6. It should be remembered that versus the version of Fig. 5, the service cycle of such an assembly extends the time required to handle the unloading carriage.

![Image](image1.png)

**Fig. 6. MSLoad - simple towerless tower - version 2 - single-side loading, unloading**

2.1.3 **MSLoad without tower tray - version V3**

MSLoad without the tower can also be assembled in another version as shown in Fig. 7. In this solution, the removal rack system is combined with vacuum suction cups for gripping the blank in one assembly. The individual times of such a version are marked as follows:

5. Place of semi-finished products in the system
6. The ridge sleeve of cut material with vacuum cuts of the blank
7. The cutting table of the cutting machine
8. Place of unloading cut out semifinished products

In this version, the handling system - a vacuum rack with vacuum suction bags for loading a semi-finished product is placed on a trolley that moves between the loading positions, the exchange table and the landing position. The places of loading and unloading may be interchanged. In Fig. 8 and Fig. 9 shows detailed views of the handling part of the system in various situations. This solution is suitable, for example, where there is a need to operate multiple machines with one loading system.

![Image](image2.png)

**Fig. 7. MSLoad - alternate towerless tower - one-side loading, unloading to the other - version 3**
3. MSSORT

The MSLoad automatic loading system can be supplemented with an automatic sorting system as shown in Fig. 10. The individual parts of the system are marked as follows (following the previous numbering):
- 10. Pallets, containers for sorted parts
- 11. Sorting - sorting position of the grate of the cutting machine
- 12. Portal of the sorting section
- 13. Sorting - sorting support with gripper head

It is a gantry system 12 with one or two working supports 13 which are fitted with grippers. Below this gantry system, there is a place 11 where the working rack of the MSF cutting machine extends. In Fig. 10 is a version of MSLoad with a tower stack. The system can also work in a tower-free assembly. In the sorting section, the individual parts are gripped from the cut material and deposited on the pallet-container 10. Removal of the remainder of the material after the parts are removed is carried out by the ridge bolt after returning the sorted pallet into the laser exchange table. This amount is interpreted on a pallet located at the top of the loading trolley simultaneously with loading a new blank as well as described above.

The MSLoad + MSSort + MSF assembly works with three working palettes (grids) that run in the cutting system. At this point, one pallet in the cutting machine can be cut, the second pallet is on the exchange table (the remainder of the sheet is cut or cut into a new blank) and the third pallet is in the position of the shredder from it). If you realize that the exchange table has two positions, the top and the bottom, then three jobs are available for three pallets. If the system works without sorting and the cut blank is interpreted along with the remainder on the pallet, then the system works with two pallets. If the system is working with sorting, then the pallet always comes out of the cutting machine to the upper position of the exchange table, and a pallet from the bottom position of the exchange table enters the cutting machine. The palette from position 11 is always entered into the lower position of the MSF exchange table and the palette from the top position of the exchange table goes into the sorting machine. The remainder after sorting is interpreted from the bottom position of the exchange table and a new blank is then loaded into it.
The grip head is designed to be adapted to the particular class of parts to be grasped. In addition to moving in the XYZ rectangle, the head also shoots. The universal solution of this node can not exist and therefore, in the MSSort system, the possibility of automatic exchange of grip units is considered.

The grip units are automatically changed (dimension change or whole unit replacement), depending on which part is to be unloaded. The CAM cutting-out system for the entire automated complex generates, in addition to the cutting plan itself, a splitting plan that will also include information about the type of gripper, its parameters (the head itself can be automatically configured), its orientation. The heads must be designed for a specific class of parts of a particular customer. The gripper cartridge may be located beneath the parking part of the grading portal.

4. APPENDICES

MSSort and MSLoad have a separate control system with their MMI console unit. With the MSF cutting machine, this control system communicates via the communication line.

It should be noted that not every piece is automatically selectable from a cut out assembly. As an example, bevel-cut parts can be mentioned.
Work on developing the design of automatic loading systems was completed in the third stage of the solution. At present, the complete system assembly shown in Fig. 10, and in the fourth stage of the solution it will be possible to verify this complete solution to the consequences.

At the workplace of the co-founder of the SJF STU, the work during the third stage was aimed at finding alternative design solutions for the whole classroom and gripper assembly, including the system of their automatic exchange. The knowledge gained from these works will be further exploited to build even more sophisticated systems such as the system in Fig. 10th.

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REFERENCES


