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Design of the Welding Fixture for the Robotic Stations for Spot Welding Based on the Modular Concept

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ABSTRACT

The article describes the methodological approach to design of welding fixtures for robotic cells based on principles of modularity. In further states the basic preparation components, their functions and possible board types in terms of shape and dimensional characteristics. The proposed methodology was tested for robotic training workstation with robot KUKA for spot welding of car bodies.

KEYWORDS

fixture, flexibility, modularity, robot, welding.

INTRODUCTION

Welding fixtures are intended to fix and stabilise the welded components into the solid assembly. Their function is to achieve the highest possible accuracy of the mutual positions of the individual connected components, to eliminate the forces originated from the internal tensions in welds and compressive forces in course of spot welding. Another important requirements include the speedy adjustment according to the alternations in the welded components. Recent construction design of the welding jigs is in majority of cases drawn as single-purpose device, individual parts of which can be repeatedly exploited only few times. This technical and economical drawback of the fixtures design in case of frequent change of produced welded parts may be eliminated applying the approach based on the principles of the modularity. The individual building elements of the actual case are designed in such way, that the large number of variants of fixture may result from small number of the compatible modules, [2, 3, 7, 9].

DEFINITION OF THE PRINCIPAL SET OF MODULES

The fixture is composed of several principal elements, which after being connected form the complex functional device able to assume the static position, orientation and accuracy of the welded components.
Principal assembly of the elements of the fixture is presented in Fig. 1.
These are [10, 11, 12]:

- Basic frames, or tables; they serve as carriers of the fixing bases and even when the fixture modification is changed, these are not changed frequently. They are mostly made of steel or aluminium profiles. Their joints are fixed or demountable.
- Fixing basis; these are fixed to the frame construction and serve as the basis for fixing the clamping track elements, but they are also exploited for the assembly of the adjusting positioning or fixing elements.
- Horizontal and vertical clamping tracks, designated also as carrying supports. They

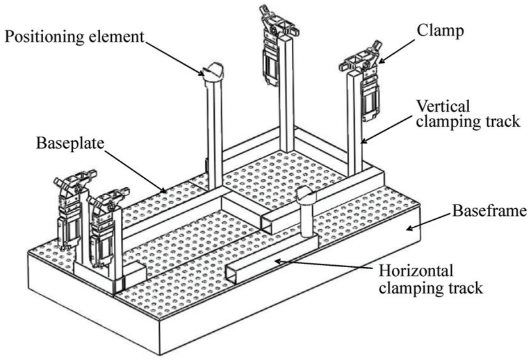


Fig. 1: *Principal assembly of the elements of the fixture.*

are fixed to the basis applying the speedy fixing method, however this connection must be assumed by fixed joint. They may be formed by the same profiles as the basic frame, in practice these are mostly represented by various profiles or cubes or rectangular consoles. Profiles have most frequently square or circular cross section. Along their length there are mounting holes for fixing the positioning and clamping elements.

- Positioning and clamping elements serve to safeguard the precisely defined positions and orientation of the welded components.
- Clamps assume a safe stability of the welded components in the required positions. Most frequently these are pneumatic double positions units. In case of heavy weldments applied are hydraulic clamps.

General problem in the design of the above mentioned part of the fixture is the determination of the basic concept of modules and the method of joining them with regard to vast range of possibilities coming into consideration. The type sets of the individual elements should be selected in particular from point of their functional and dimensional characteristics. To achieve high flexibility when joining them applied are fast joining principles [5].

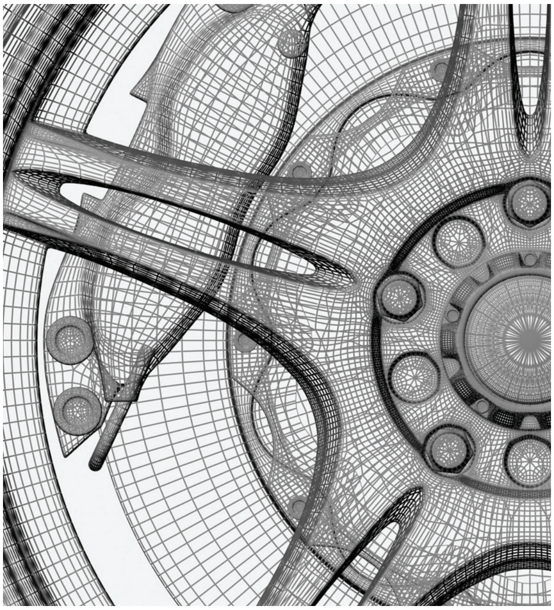
The example of the estimation of the type sets of the clamping basis, clamping tracks, positioning and establishing elements for the robotized station for the spot welding is given in Table 1 [6].

METHODICAL PROCEDURE OF THE FIXTURE DESIGN AND THE MUTUAL RELATIONSHIP ROBOT-FIXTURE

Proposed modules and the standard elements for the construction of fixtures are designed in CAD software. Modules for the construction for fixture, which are presented in Table 1, are designed in CAD system "proEngineering" as 3D models. The individual type sets of elements are designed using the function "Relations and Family Table". Methodical procedure of the fixture design is given in Fig. 2 [4].

1. *Determination of the succession of placing the components into the fixture*
   Based on the input parameters of welded components determined is the succession of their placing into fixture and the position and orientation in the space of their final assembly. The output from this analysis is the definition of the dimensional characteristics of the fixture (maximal length, minimal height of the weldments adjustment in the fixture) and working access of robot.

2. *Selection of the positioning, setting and clamping points and surfaces*



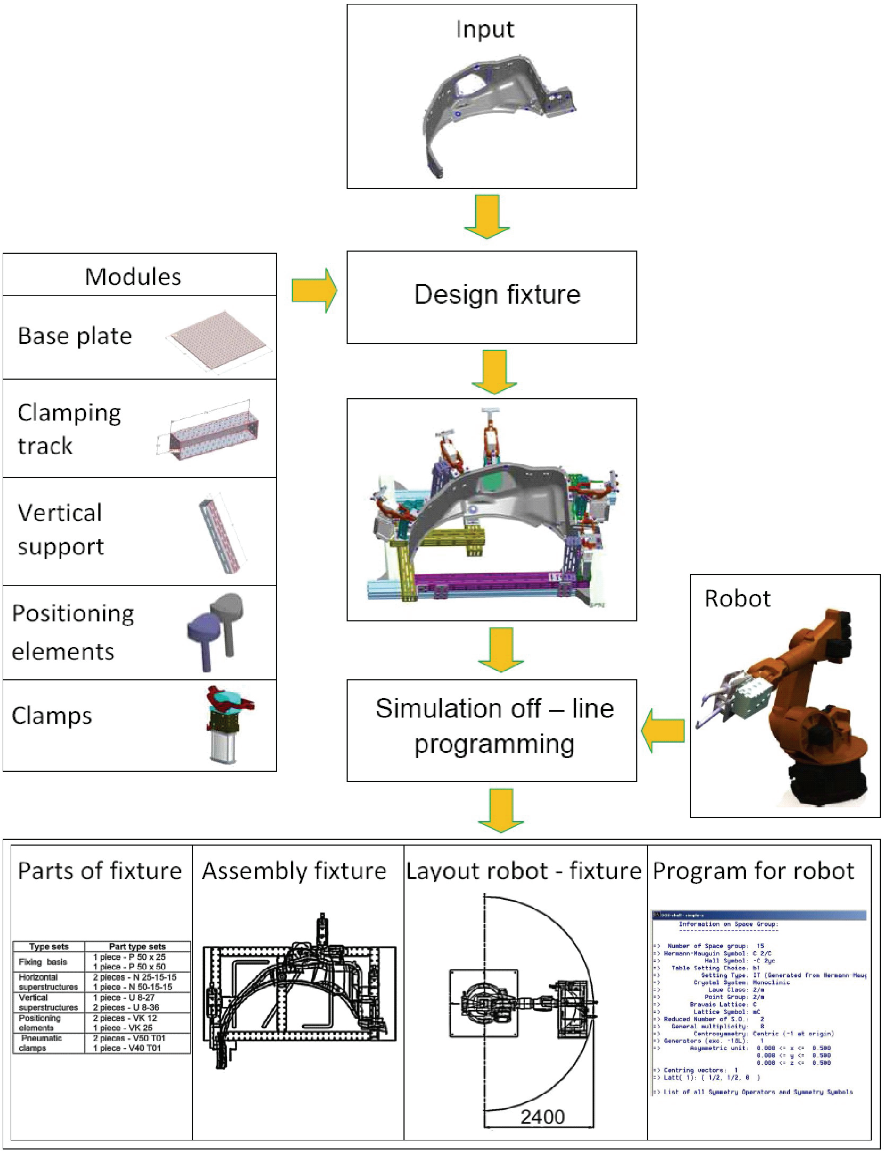


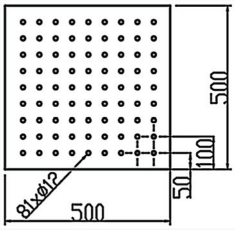
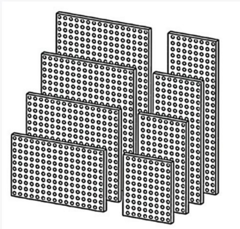
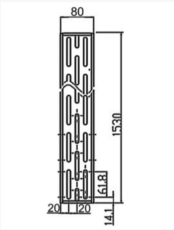
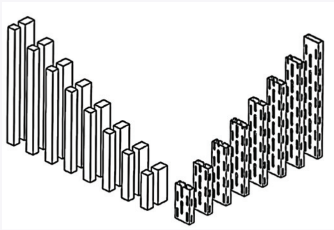
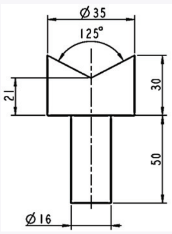
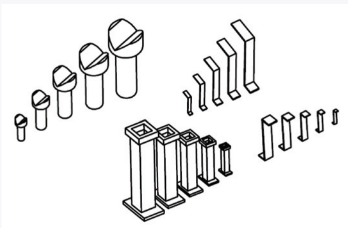
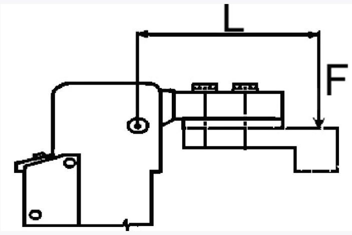
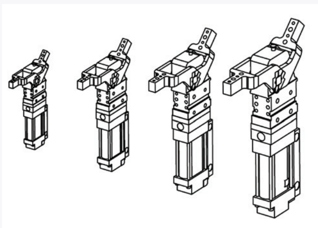
Fig. 2: *Methodical procedure of the fixture design.*

In this step, preliminary are determined possible points or surfaces for the setting and positioning and their shape as well. Further, determined are also the possible clamping points, necessary clamping force and possible positions of the clamps.

3. *Selection of the modules for fixture*
   Outputs from the first and second step define the requirements placed on the selection of the individual modules of fixture. The selection is created from the formed database of the individual modules applying the interactive method. The result is a set of the suitable modules, which can be used for the jig setting.

4. *Design of the assembly of the fixture*
   Design of the assembly of the jig is conducted in CAD system applying 3D modelling and when selected the modules, decision is made based on

Table 1: *Crack types and crack evaluation criteria.*

Type sets	Dimension (mm) / Type	Figure
Fixing basis 	*1. group:* Min: 500 × 250 Max: 500 × 2500 *2. group:* Min: 1000 × 1000 Max: 1000 × 2500	
Clamping tracks 	*1. group:* Min: 250 × 150 × 150 Max: 2500 × 150 × 150 *2. group:* Min: 250 × 250 × 150 Max: 2500 × 250 × 150 *3. group:* Min: 250 × 500 × 150 Max: 2500 × 500 × 150	
Positioning elements 	*1. group:* Consoles *2. group:* Pins	
Clamps 	*1. group:* Pneumatic clamps *2. group:* Electric clamps	

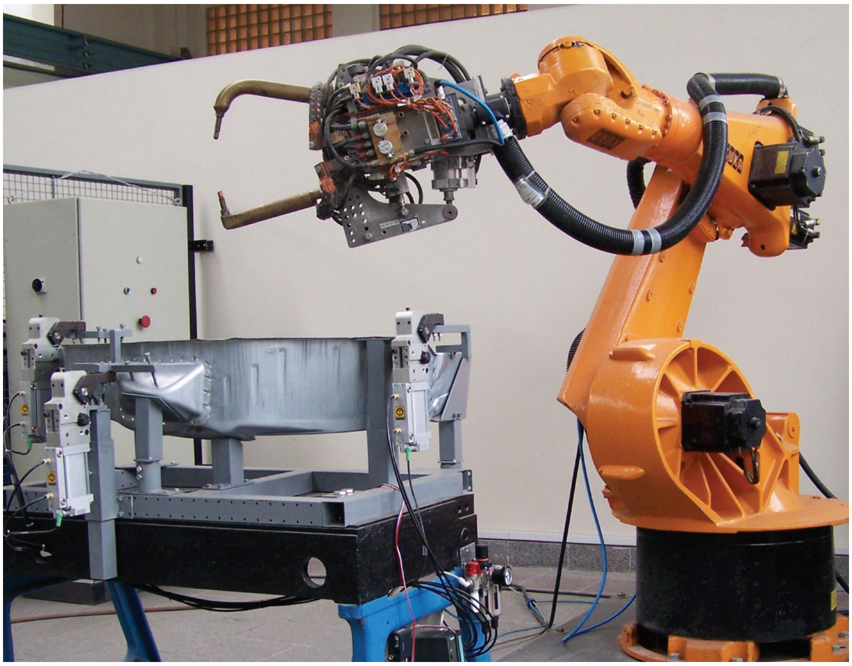


Fig. 3: *Working station with robot KUKA 125 for spot welding of the inner rear mudguard of cars.*

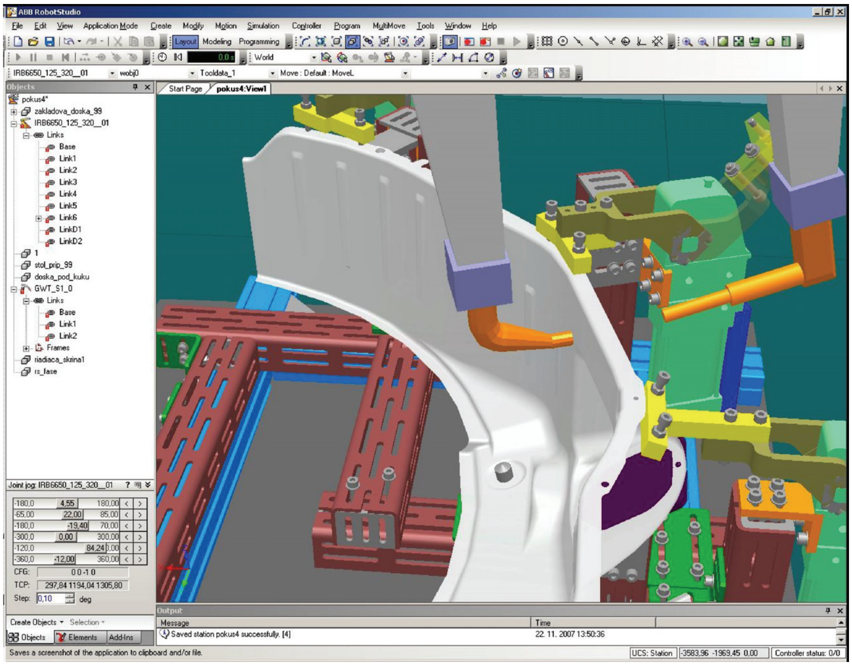


Fig. 4: *Testing of the collision relationships.*

the mutual dimensional and functional compatibility. The assembly of the fixture is in this step tested with the objective to assume requested accuracy, in 3D is tested the accessibility to the welded points and determined are the possible positions of welding tongs or determined is their optimum position.

5. *Determination of the position robot-fixture*
For the given type of the robot, or even if this not given, and its selection is conducted in CAD simulation software is sought the optimum mutual position, position of weldments in robot working access to the welded points, determined is the succession of the individual welds execution. The starting position of robot is also defined in this step.

6. *Off-line preparation of software for robot*
The off-line preparation of software for robot is conducted in this final step. Excluded are the collisions relations and determined are the successions of the activities in the working station.

Output from this stage will be the final list of modules for the fixture construction, its assembly and software for robot.

Example of the design of the robotised working station for welding the parts of car body exploiting robot KUKA.

The given methodology was exploited in design of the working station with robot KUKA 125 for spot welding of the inner rear mudguard of cars Fig. 3, which consists from 5 components [8, 13].

The collision relationships and preparation offline program is made in 3D simulation software, Fig. 4 [1].

CONCLUSION

Modular approach towards the design of the welding fixtures upgrades the overall flexibility of the working station, reduces the construction activities in design of fixture and its realisation as well. The individual modules can be repeatedly exploited. To estimate the necessary types and dimensional designs of the individual modules it is possible the exploit the principles of the group technology and in such way reduced is the overall number of elements of fixture. For the proposed methodology was designed the software support for each step with the created database of the designed modules and commercially accessible elements.

REFERENCES

[1] Baláž V., Sukop M., Multi-training workstation with robot OTC., SAMI 2008, 6th international Symposium on Applied Machine Intelligence and Informatics, Budapest Tech, 2008.

[2] Bi Z.M., Zhang W.J., Flexible fixture and future direction, International Journal of production Research, vol. 39, 2007.

[3] Chan K., Banhabit B., Dai M., Reconfigurable Fixturing System for Robotic assembly, I. of Manufacturing Systems, no. 3, 1992.

[4] Hajduk M., Sukop M., Baláž V., Semjon J., Vagaš M., Improving the performance of manufacturing systems based reconfiguring and computer integration, Košice, 2006.

[5] Hajduk M., Tolnay M., Groholova M., Vojtech D., Methodological frame of reconfigurable manufacturing systems design, Acta Mechanica Slovaca, vol. 12, no. 2A, 2008.

[6] Janos R., Baláž V., Tuleja P., Semjon J., Measurement of contacts wear in spot welding, OPTIROB 2006, Bucharest, 2006.

[7] Kang Y., Rong Y., Yang J.C., Computer aided fixture design verification, Part 1, The framework and modeling, International Journal of Advanced Manufacturing Technology, vol. 21, 2006.

[8] Kumar A., Nee A., Probanpong S., Expert Fixture-Design System for an Automated Manufacturing Environment, I. of Computeraided design, vol. 24, 1998.

[9] Rong Y., Huang S., Advanced computer-aided fixture design, Elsevier Acadenic Press, Boston, 2005.

[10] Semjon J., Balaz V., Vagas M., Robotized cell for spot welding with robot KUKA, 2nd International Conference Optimization of the Robots and Manipulators, Bucharest, 2007.

[11] Tolnay M., Bednár T, Application of mobile models of the handling and conveyer devices, Acta Mechanica Slovaca, vol. 11, no. 2A, 2007.

[12] Trebuňa F., Šimčák F., Billý J., Theoretical - experimental methods research and development ultra light system, Acta Mechanica Slovaca, vol. 2, no. 2, 1998.

[13] Voronko A., Semjon J., Vagaš M., Lipcak M., Robot welding plant design jobs under mist for example welding modular concept, Lublin, 2009.