VIRTUAL PROTOTYPING SMALL, MEDIUM AND LARGE SCALE ROBOTIC ARC WELDING CELLS


Abstract: The paper presents the works performed by the authors in the field of virtual prototyping arc welding robotic cell. The purpose of the research is to develop a systematic classification of various layouts of industrial scale robotic arc welding cells as well as developing for each category appropriate virtual prototypes. The systematic classification and virtual models presented in the paper constitute the basis for successive works performed by authors including development of specific solutions for process and system layout optimization as well as cell’s off-line programming and simulation.

Key words: Industrial robot, arc welding, manufacturing cell, virtual prototyping

1. INTRODUCTION

Implementation of industrial robots and the design of the robotic arc welding cell / systems are strongly related to the application’s specificity as well as welded part’s shapes characteristics. From this point of view, a robotic arc welding cell classification and cell structure are influenced by:

- the size (specific dimensions) and geometric configuration of the processed parts;
- the welded joints geometry (planar / spatial as well as parametric / non-regular curves);
- the manufacturing batch structure (number of parts per batch and timetable / schedule) and it integration into the overall manufacturing process scheduling all above issues being reflected in optimal selection of:
  - industrial robot location inside the application (fixed to the ground / overlapped on a support fixed to the ground, suspended on a fixed structure, suspended on a mobile (1/2/3 linear axis) structure);
  - type and number of numerically controlled (NC) axes of the positioner system (part orienting system during / between arc welding stages);
  - positioner system’s workstation number (1/2 workstations).

Considering above mentioned aspects, the robotic arc welding cells can be primarily classified as:

- small scale systems;
- medium scale systems;
- large scale systems

each of these categories having specific subdivisions according with robot’s specific location, types / number of positioners / workstation number (Nicolescu, 2005).

2. SMALL SCALE ROBOTIC ARC WELDING CELLS VIRTUAL PROTOTYPES

Small scale robotic arc welding cells typically include a small size robot and a positioner having 2 workstations (***, 2009).

They are specially designed for processing small size individual / groups of parts, having simple / complex welded joints geometry. Simple geometry of welded joints involve limited number of positioner’s NC axes (Fig. 1a), while complex geometry of welded joints involve increasing the number of positioner’s NC axes on 2 / 3 NC axes (Fig. 1b, c). Usually, part’s arc welding having complex shape joints is individually performed (Fig. 1c) while medium complexity shape joints (Fig. 1b) and simple shape joints (Fig. 1a) are individually / group performed.

Three virtual prototypes of (industrial) small scale robotic arc welding cells including above mentioned positioners having 2 workstations with 1/2/3 NC axes are shown in Fig. 2 (Nicolescu, 2010).

Fig. 1. Typical 2 workstation positioners used in small scale robotic arc welding cell having: a) 1 NC axis, b) 2 NC axes, c) 3 NC axes

Fig. 2. Small scale robotic arc welding cells virtual prototypes
3. MEDIUM SCALE ROBOTIC ARC WELDING CELLS VIRTUAL PROTOTYPES

Medium scale robotic arc welding cells are able to process medium size parts of various geometrical configurations. This category of robotic cells typically includes: two or more positioners (***, 2008), usually up to four or six (Fig. 3) disposed on both sides of a robot tracking module (***, 2008) in case of ground tracking robots (Fig. 4 a), or a rotating and tracking column (***, 2010) for suspended tracking robots (Fig. 4 b). The robot / column tracking modules are used for horizontally extending robot’s working envelope (to reach all in-line disposed positioners), while the robot / column base rotation modules are used for allowing full robot access on two sides disposed positioners. Ground / suspended on column location of robot is selected accordingly part’s size, respectively positioner’s overall dimensions and typically serviceability (ground tracking robots for medium to small size part’s welding and front access / operated positioners, respectively suspended robots on column tracking modules for medium to large parts welding and top access / operated positioners). Higher cell’s flexibility and productivity may be reached due to greater number of (two sides, in-line) included positioners allowing overlapping of heavy part loading and welding cycle times (Nicolescu, 2010).

Two virtual prototypes of (industrial) medium scale robotic arc welding cells including above mentioned components are shown in Fig. 5 (Nicolescu, 2010).

Fig. 3. Typical positioners for medium / large scale robotic arc welding cells

Fig. 3. Solutions for extending the work envelope of robots included in medium scale arc welding cells

Fig. 5. Virtual models of various types of medium scale robotic arc welding cells and robotic arm details

4. LARGE SCALE ROBOTIC ARC WELDING CELLS

Large scale robotic arc welding cells are designed for processing a wide range of large size parts attached to different large size positioners. Usually, a cell in this category include similarly positioners as used for medium scale cells, however larger size for allowing heavy parts robotic welding. In order to allow top access for positioner serviceability / part welding, the robots are exclusively suspended by mean of 3 axes gantry structure / column structures allowing three dimensional robot’s work envelope extending. Two virtual prototypes for this cell type are illustrated in Fig. 6.

Fig. 6. Large scale robotic arc welding cell virtual models

5. CONCLUSION

The paper illustrates works performed by the authors in the field of systematic classification and virtual prototyping of robotic arc welding cells. From classification point of view the paper has synthesized main design features of three groups of robotic cells (small / medium / large scale) by tacking into account specific industrial requirements for robotic arc welding systems. For all arc welding cell categories virtual prototypes have been accomplished by taking into account industrial components specific features of industrial robots, positioners, auxiliary axes and complementary equipment.

All of these welding cells have been afterwards imported in specific software for off-line programming and control robotic arc welding cells, in order to test operation of designed systems preliminary to real (industrial scale) systems configuring.

6. REFERENCES


