World Academy of Science, Engineering and Technology
International Journal of Electronics and Communication Engineering
Vol:14, No:01, 2020

Multi-Agent System Based Solution for Operating Agile and Customizable Micro Manufacturing Systems

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Abstract : The Industry 4.0 initiative has been launched to address huge challenges related to ever-smaller batch sizes. The end-user need for highly customized products requires highly adaptive production systems in order to keep the same efficiency of shop floors. Most of the classical Software solutions that operate the manufacturing processes in a shop floor are based on rigid Manufacturing Execution Systems (MES), which are not capable to adapt the production order on the fly depending on changing demands and or conditions. In this paper, we present a highly modular and flexible solution to orchestrate a set of production systems composed of a micro-milling machine-tool, a polishing station, a cleaning station, a part inspection station, and a rough material store. The different stations are installed according to a novel matrix configuration of a 3x3 vertical shelf. The different cells of the shelf are connected through horizontal and vertical rails on which a set of shuttles circulate to transport the machined parts from a station to another. Our software solution for orchestrating the tasks of each station is based on a Multi-Agent System. Each station and each shuttle is operated by an autonomous agent. All agents communicate with a central agent that holds all the information about the manufacturing order. The core innovation of this paper lies in the path planning of the different shuttles with two major objectives: 1) reduce the waiting time of stations and thus reduce the cycle time of the entire part, and 2) reduce the disturbances like vibration generated by the shuttles, which highly impacts the manufacturing process and thus the quality of the final part. Simulation results show that the cycle time of the parts is reduced by up to 50% compared with MES operated linear production lines while the disturbance is systematically avoided for the critical stations like the milling machine-tool.

Keywords : multi-agent systems, micro-manufacturing, flexible manufacturing, transfer systems
Conference Title : ICIRIEC 2020 : International Conference on Industrial Robotics, Industrial Engineering and Control
Conference Location : Zurich, Switzerland
Conference Dates : January 13-14, 2020