

## Reconfigurable Manufacturing Systems-What can Industrial Engineering and Management do?

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Towards the end of the 20<sup>th</sup> century, the concept of reconfigurable manufacturing systems (RMSs) rocked the world of manufacturing and promised a global revolution in the 21<sup>st</sup> century manufacturing landscape. Since then, a lot of research on RMSs was conducted and numerous research papers were archived. In addition, a number of international conferences, workshops and seminars were organized to discuss, share and exchange highly focused, technical, and cutting edge theoretical research results and perspectives on RMSs. While a lot of research works are commendable, the realization of a true reconfigurable manufacturing system (RMS) is still elusive [1]. Consequently, a gap between archived theory - academia and practical realization - industry exists to date. This gap has led to 'doubts' and 'disquiet' with respect to limitations, practicality and applicability of reconfigurable manufacturing concepts and techniques. In order to create a platform for bridging this gap, this paper suggests some answers to the question; "what can industrial engineering and management do to prevent reconfigurable manufacturing concepts from being yet another archived buzz word?" Perspectives and discussions which follow attempt to provoke industry, students, academia and researchers into high quality and highly valuable discussions aimed at redeeming and advancing RMSs concepts and techniques towards the realization of the full benefits of true reconfigurable manufacturing systems. Such discussions can be facilitated through this Industrial Engineering and Management journal by the Omics group.

The term reconfigurable manufacturing systems can be attributed to Dr. Koren who, with other researchers at the Engineering Research Center for Reconfigurable Manufacturing Systems (ERC/RMS) at the University of Michigan, College of Engineering, invented or initiated the concept of an RMS as early as 1995. Since then, a repository of reconfiguration science has been accumulated. The repercussions of this invention went as far as forcing changes in the engineering curricula at the University of Michigan to integrate reconfigurable manufacturing concepts and techniques. However, to date only isolated "islands" of reconfiguration based technologies have been implemented in the following areas; controls, inspection, sensing, machines and machine tools. With the seemingly 'disquiet' and relatively less 'enthusiasm' on the part of both industry and academia, there is an imminent danger of collapse and relapse of the novel ideas of reconfigurable manufacturing. It is now the time to use industrial engineering and management tools and techniques to combine the various "islands" of reconfigurable manufacturing technologies scattered in various databases in a bid to develop and advanced current research results towards the realization of true reconfigurable manufacturing systems.

The ERC/RMS has defined a RMS as follows [2,3]:

A reconfigurable manufacturing system (RMS) is one designed at the outset for rapid change in its structure, as well as its hardware and software components, in order to quickly adjust its production capacity and functionality within a part family in response to sudden market changes or intrinsic system change.

If one analyzes this definition, it can be noted that the rapid change of the structure has two parts, i.e. hardware and software. As was the

case with 'islands of automation' in the history of manufacturing, current research results and most of the case studies reported in the public databases mainly focus on either the hardware or the software side of reconfigurable manufacturing technologies. However, in order to advance the current state of reconfigurable manufacturing technologies, these isolated "islands" of reconfigurable manufacturing technologies must be integrated into an operating system - one of the major roles of industrial engineering and management. Therefore, the responsibility of scaling heights in RMSs concepts and techniques lies, among others, in the hands of industrial engineering.

The RMS goal has been summarized by the phrase [2,3] - "exactly the capacity and functionality needed, exactly when needed". While this phrase is critical with respect to the need to respond to the changes in production requirements, it positions RMSs in a dimension of its own into seemingly "untouchable" realms of practical reality. In addition, operationalizing this goal of RMSs requires reconfigurable hardware, reconfigurable machine elements, reconfigurable control systems, as well as reconfigurable software. Although they are scattered in different databases, most of these technologies are currently available. What is required now are demonstrable industrial engineering case studies that combine both the hardware and software issues in order to confirm, verify and validate this noble goal of RMSs. While manufacturing systems that exhibit certain parts of this goal have been implemented [4], a lot is yet to be desired before this goal can be fully and truly realized. A mere look at the goal of an RMS may cause one to fail to differentiate an RMS from a flexible manufacturing system (FMS). Moreover, one wonders whether an RMS is more flexible than an FMS or whether a more flexible RMS is actually an FMS. Such and similar ambiguity need to be further discussed in order to keep the vision of a true RMS alive.

What sets RMS apart from FMSs? An RMS can be differentiated from other manufacturing systems by examining the six core characteristics, namely; (a) modularity, (b) integrability, (c) customized flexibility, (d) scalability, (e) convertibility, and (f) diagnosability [5]. While these characteristics define ideal RMS, industrial engineers managers and the academia should be in a position to evaluate a given set of operations based on these six characteristics. Although an ideal RMS is still currently at large, evaluations based on these characteristics can be used to assess, measure and determine the degree

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of reconfigurability in any given production system. This can allow a gradual and iterative addition of reconfigurability in production systems thus allowing the learning curve to progress naturally rather than a radical stance that aims at an ideal RMS. Moreover, as these six characteristics are thoroughly investigated from both the software side and hardware side, these characteristics can be incrementally added to manufacturing systems thereby advancing the functionality of current and emerging production systems towards achieving the RMS goal wherever necessary. The time for industrial engineering academics to fully exploit reconfiguration science is now, before these concepts and ideas on reconfigurable manufacturing are yet again relegated to the long list of buzzword archives.

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