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ABSTRACT

Twenty first century manufacturing companies must prepare themselves to cope with the rapid changes in the market dynamics such as, economic globalization, large fluctuations in product mix and volume, and introduction of new technologies, etc. In this context, Reconfigurable Manufacturing Systems (RMS) is seen as an emerging mechanism, which has the capability to deal with these issues by incorporating changes in machine tools, layout, material handling and machine configurations considering cost effectiveness. It comprises of six core characteristics such as; scalability, modularity, convertibility, integrability, flexibility and diagnose-ability. Reconfigurable Machine Tools (RMT) are the heart of RMS and these principles are used to develop RMT. Nevertheless, despite their importance, the achievement of RMT in practice, i.e. the implementation of reconfiguration mechanism in actual manufacturing systems is still in nascent stage. This work is intended to contribute to a better understanding of RMS/RMT along with the reconfiguration principles to develop RMT, the relative importance of core characteristics and its implementation in current manufacturing technologies. Using this futuristic mechanism and this work the manufacturing companies will be better equipped to face the onslaught of the market forces.

This thesis is divided into four parts. The first part of this study adopts reconfigurable mechanisms pertaining to RMT. Different RMT modules (both basic and auxiliary) are discussed

and developed to understand the concept of core characteristics that are mentioned above resulting in development of reconfigurable machine tools. In the second part of study, the relative importance between these six core characteristics in the context of RMS and RMT are analysed. To do so, a systematic literature review was done to identify all sub factors of core characteristics, which directly or indirectly influence both RMS/RMT. After that, all these factors were mapped together through multi criteria decision making approach known as Best-Worst Method (BWM) to find out the relative importance among them. Finally, sensitivity analysis was done to validate the results. The proposed multi decision approach is quite versatile considering that, it provides an opportunity to integrate all possible factors and sub-factors, which could impact manufacturing processes. Once the relative importance of all the factors is assessed; an optimal RMT configuration at production stage is required in a real world industrial environment for production of the product. Therefore, the third part of this study deals with optimal machine configuration, which is based on various performance parameters such as reliability, production rate, cycle time and line balancing algorithm. The developed approach is demonstrated using a case study. In addition to that, the new era of Industry 4.0 technologies can accelerate manufacturing industries to cope with abrupt market changes. Therefore, implementation of Industry 4.0 based technologies is a powerful driver for RMS /RMT to meet the requirements of a digital world. The fourth part of this study provides the basic knowledge of Industry 4.0 based technologies such as Cyber Physical System (CPS), augmented reality, cloud computing, Internet of Things (IoT), additive manufacturing, etc. and their deployment in RMS/RMT.

The contributions of this research have both theoretical and practical implications. It is expected that, this work will be valuable to the manufacturing industry by contributing to the design and achievement of actual RMS/RMT.

FINDINGS

- Reconfiguration techniques were enumerated to convert a traditional machine tool into a reconfigurable machine tool that could carry out multiple functions without the need for additional capital deployment.
- In this research, a new design of multi-function slotter cum shaper machine tool was proposed.
- Towards developing another reconfigurable machine tool a novel design of reconfigurable drill machine tool was done. This had many features of re-configurability.
- The present work modelled and evaluated the significant factors & sub-factors of re-configurability that could have the maximum impact on re-configurability of a manufacturing system during the design stage.
- Further, this work proposed and validated the technique to reconfigure the production line for optimizing and maximizing the throughput based on change in product and its scale of production.

Lastly the research discussed the Industrial Revolution 4.0 and its components and the mechanism to synchronize the benefits of RMS with its components