2581-4575
International Journal For Recent Developments in Science & Technology
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A Peer Reviewed Research Journal

SWAY OF MANUFACTURING METHODALIGNMENT ON RECITALAND ECONOMIC EVALUATION OF RECONFIGURABLE MANUFACTURING SYSTEM

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Abstract

Reconfigurable manufacturing system (RMS) isintelligent and advanced manufacturing system, RMS is able tochange production functionality and capacity to meet withmarket demands by adjusting system configuration or addingnew components. The object of RMS is able to achieve optimaleconomic cost within the overall life cycle, therefore, it is veryimportant to study the system configuration and technology ofeconomic cost evaluation, and they are very important systemlevelenabling technologies of RMS. A systematic design structuremodel of RMS is presented to show the condition of configurationand economic evaluation. A RMS configuration model ispresented, and the configuration model performance is analyzedfrom reliability, convertibility, quality, productivity and materialtransmission ratio by using system engineering theory, Booleanalgebra and so on. A RMS production cost model is analyzed, amathematics model is presented to calculate the production costand a system investment evaluation cost model is presented basedon real option analysis theory, case study illustrates the affectivityof the proposed model and technology.

INTRODUCTION

Changing manufacturing environment characterized byaggressive competition on a global scale, and rapid changes ofmanufacturing technology requires creating productionsystems that are able to adjust their production functionalityand capacity. Reconfigurable manufacturing system (RMS) isan advanced manufacturing mode among them; RMS canallow adding, removing or modifying specific processcapabilities, controls, software, or machine structure to meetmarket demands. The objective of an RMS is to provide thefunctionality and capacity that is need rapidly and costeffectively,when it is needed.

Machines of a manufacturing system can be arranged inmany different configurations such as serial, parallel, orhybrid. System ability and flexibility are influenced by systemconfiguration; different system configurations have differentimpact on system performance. The selection of systemconfiguration is very important to achieve systemcharacteristic. As pointed out in the 3rd InternationalConference on RMS held in 2005, hybrid parallel-seriesconfiguration is more advanced and should be studied widely.However, how to evaluate their performance of hybrid seriesparalleland hybrid parallel-series configuration, and develop aconfiguration model to meet requirement of RMS, is still anopen issue.

It is known that any manufacturing system is able to havereconfigurability and responsiveness ability withoutconsidering system cost [1]. Similarly, as pointed out in the3rd International Conference on RMS held in 2005, systemcost is most important issue among all manufacturing systemquestions and it must be considered firstly [2]. Therefore,economic evaluation is important to actual application,economic evaluation can be divided into two factors, one isproduction cost, and the other is system investment cost. Inthis paper, a calculated method of investment cost is presentedto study relevant manufacturing system cost field.

The manufacturing industry is facing challenges that include unpredictable product demand, many customizations in product designs and short product life cycles[1].Hence, manufacturing sector is under intense pressure to meet the fluctuating necessities of a manufacturing system. A large number of products are produced utilizing dedicated manufacturing systems (DMS) or flexible manufacturing systems (FMS). DMS is based on fixed automation intended for producing a single product at high volume [2]. Despite the fact that DMS produces a low-cost product at high volume but is unable to handle frequent product design changes. Other than DMS, FMS is capable of taking care of product design rapidly. However, the cost of FMS is high and accordingly, it finds less worthiness among the manufacturers due to its complexity and low production rate [3]. Because of low production rate, FMS cannot deal efficiently with huge production volume fluctuations. Owing to these limitations of DMS and FMS manufacturing industry is focusing towards a new perspective known as Re-configurable Manufacturing System(RMS)[4]. RMS was proposed to meet fluctuating demand volume and different types of products by combining the merits of DMS and RMS [5]. Koren et al. [6] defined RMS as “A Reconfigurable Manufacturing System (RMS) is designed at the outset for rapid change in structure, as well as in hardware and software components, in order to quickly adjust production capacity and functionality within a part family in responseto sudden changes in market or in regulatory requirement”. According to Mehrabi et al. [7] there are several characteristics of RMS, such as manufacturing system communication software, new machine controllers, configuration of flexible machines, flexible processes and system configurations for product flow as shown in Fig. 1. The main focus of this paper is on the performance evaluation measures adopted to select an efficient system configuration.

NEED OF PERFORMANCE MEASURES

At the point when there is a variation in the product demand volume or design,

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configuration arrangement is to be redesigned to meet new product demand volume and design. Hence, it becomes necessary for the maker to choose themost productive configuration among the alternates by some performance criterion. However, current approaches are mainly focused on the single performance measure, namely the initial capital cost of the manufacturing system, ignoring other important aspects. This paper reviews the performance measures adopted for the analysis of system configurations and comparing alternate configurations in a RMS. These performance measures enable the manufacturers to choose a configuration from an aggregate system point of view. The next section reviews the performance measures for system configuration selection approaches. In section IV the paper concludes with a summary of the literature review and an outlook on future research issues.

Methodology

II. ANALYSIS OF SYSTEM CONFIGURATION

A. Review System Configuration of RMSGenerally, manufacturing system configuration has threemain models: series configuration model, parallelconfiguration model and hybrid configuration model (seriesparallelor parallel-series). Serial configuration is notredundancy system; parallel configuration is high redundancysystem due to parallel structure. The traditional linear seriessystem is low cost and poor stability. Parallel system is goodstability; however, high cost baffled its development. Practicehas proved that series and parallel configuration are notsuitable for manufacturing system application. To solve thisproblem, a hybrid configuration was proposed, however, theliterature shows that there is still a lack of summing uprelevant theories to improve the application and developmentof manufacturing system configuration [3].

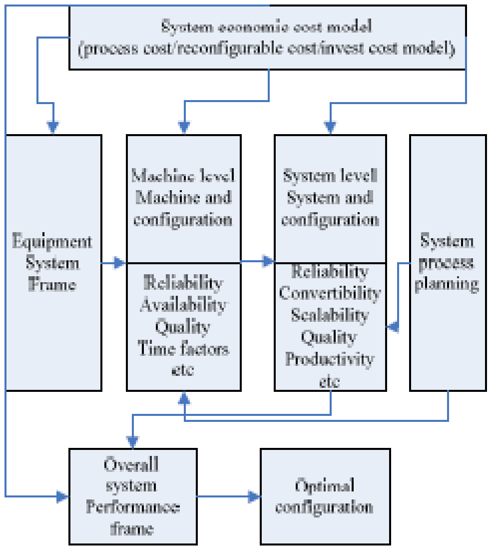

Fig. 1 System level structure.

The relevant field of reconfigurable manufacturing systemconfiguration has been studied at home and abroad. In 2000,Professor Koren and some scholars of Michigan Universityresearched the impact of manufacturing system configurationon performance; a series-parallel hybrid system configurationhas been presented as a basic RMS configuration model.

Japanese scholars have proposed a holonic manufacturingsystem configuration of RMS based on the series-parallelhybrid model [4]. In China, some scholars of Machine ToolResearch Institute of Beijing and Qinghua University havepresented the principle of RMS layout configuration based onthe foundation theory, and the array of RMS configurationhave been presented based on the series-parallel hybridconfiguration.

In sum, there are two primary RMS configuration models,one is series-parallel hybrid configuration and the other isparallel-series hybrid configuration, therefore, the two hybridconfigurations is studied basically, the main configurationmodels are shown in Fig.2. Configuration (a) is series-parallelhybrid configuration; configuration (b) and (c) are parallelserieshybrid configuration. Configuration (b) is awaitingsystem, which all elements of this configuration have not beenoperated at the same time; therefore, flexibility andredundancy of this model are better than others.

5) Material transmission ratio.

In Fig.1, there are two material transmission paths asindicated by the arrows of configuration (a) and configuration(b). Configuration (b) is material branch-line transmissionstage by stage. This material transmission efficiency can beachieved to 96% and is higher compare with configuration (a),in 2003, Ford Motor Company has optimized the engineproduct line with this path, and the economic income has beenincreased sharply [9]. A simulation has been implemented forcomparing the ratio of two configurations; the EMPLANTsoftware has been used for this simulation. The clamp andrelevant assistant tools have been integrated in machine,otherwise, and the buffer allocation, working procedure andworking crafts are same to two configurations.The simulation project is from [10], which is the KeyScience-Technology Project of Shanghai City Tenth Five-Year-Plan by Modern Manufacturing Technology Institute ofTongji University. The relevant machine and every levelperformance data can be used and arranged according to theproduct line from this project, and the product lineconfiguration is designed according to configuration (a) and(b) and path of Fig.1 for studying the transmission ratio. Thetransmission ratio is divided into three factors (available ratio,awaiting ratio and block ratio) and the simulation stepsincluded three aspects: the ability of adapting to identicalmachining order form (small volume); the ability of adaptingto different machining order form (medium volume); theability of adapting to urgent machining order form.The result from simulation test indicates that thetransmission ratio of hybrid parallel-series configuration (b) isbetter in two aspects, and the available ratio is obvious [10].

C. System Configuration Model of RMS

According to the above analysis, in a certain range, hybridparallel-series configuration is superior to series-parallel fromthe structural reliability, productivity and the like, this is vital

factors to RMS configuration has been changed from theinitial hybrid series-parallel to parallel-series. RMS should beautomatically adjusted or added element, therefore, systemconfiguration must be redundant and all the parts of eachbranch should not put into operation at the same time, this canensure a better system flexibility and redundancy, that is,configuration has the characteristic of awaiting system. Theconfiguration of RMS is hybrid parallel-series redundancysystem, which has the

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characteristic of awaiting system andthe material branch-line transmission line stage by stage. Takeadvanced CNC machine tools, perfect reconfigurable machinetools (RMT) and perfect RIM as basic parts element. Theconfiguration reference model of RMS is shown in Fig.4,which these large arrows represented the material path

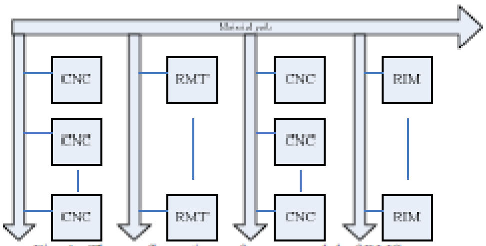

Fig. 4. The configuration reference model of RMS

Results

To satisfy the changing need of increasing order volume,enterprise required optimizing the reconfigurable auto motorproduction line. Enterprise of Shanghai SH automobile motorrequired that the production line will be guaranteed to achievethe original reconfigurable characteristics, there are twoconstraints: workshop equipment storage space constraints andcost constraints (1200,0000 Yuan) [10].

The task of this production line is that finish theseworking procedure of pressure commutator, spot welding,testing and machining commutator. This paper adopted thepresented configuration model of RMS, material transmissionline and production cost formula to optimize it. From the taskand equipment of this production line, the problem can besummarized into five stages hybrid parallel-series systemconfiguration, the redundant equipments number of each stagecan be calculated to guarantee the system's reliability index.The reliability of optimization production line isimproved from original 92.50% to 99.95%, which is beyondthe 98.5% of enterprise proposed. The optimization productionline meets the requirement of the enterprise and improves thereliability of the system and maintains the existing productionlines own reconfigurable characteristics under the conditionsof limited resources, cost-bound. Since the operation of onequarter, by using the presented configuration model, thisupdated production line improved economic efficiency beyondseveral millions Yuan directly and arrived at a better balancerelations between the demand and supply of customizeddemand, the actual effect is significant.

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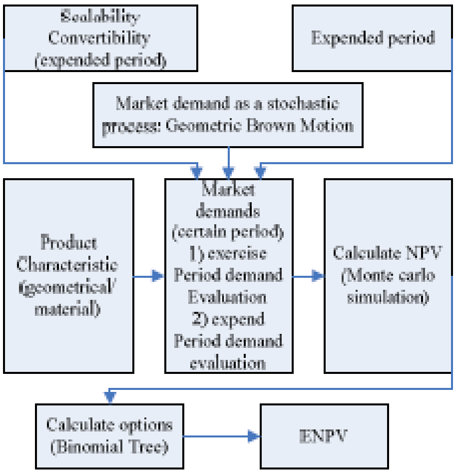

Fig. 5. Invest cost flow model based on ROA

CONCLUSION

The system configuration reference model has beenpresented. The results from studying some relevantperformances with reliability, convertibility and the like,however, there is not any perfect configuration model of RMSdue to complex relationship between performances, therefore,the relevant performance must be integrated to select theoptimal configuration correspondingly. For example,reliability, productivity and convertibility are important toshow characteristics of RMS. Otherwise, from this paper, theimpact of system configuration on performance is useful tostudy system configuration of others advanced manufacturingsystems. Economic cost evaluation has been studied, amathematics model is presented to calculate the productioncost and a method flow is presented to calculate theinvestment cost. The relevant integrated system performanceanalysis model of RMS and economic evaluation calculationmethods of multi-options will be studied in future.The investment model is presented in this paper based onROA theory and economy mathematics. The investmentmodel will be developed in future and as the next focus.

Future scope

It is very difficult to forecast long term trends for manufacturing systems, since the changes are happening at a very fast pace. However, it is possible to extrapolate future trends from the current situation by analysing and specifying the key drivers behind the changes. Certainly, availability and distribution of information plays an important role in this transition and it is considered as one of the key drivers. In this regard, there is a need for improvement and standardization of various components (such as data interfaces, protocols and communication systems) so that data can be transferred to the desired location at a faster rate.

There have been reports of several studies relevant to future manufacturing technologies, processes, and machine tools . They have all agreed that manufacturing should be viewed, designed and optimized as a system (as a whole) to achieve the required responsiveness (i.e. shorter lead-time and ramp -up time). In this regard, there is a need for fundamental understanding of manufacturing processes, equipment, and technologies and their relations to the rapidly changing market. There are many research efforts underway,

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however we are still at the beginning of a new era of modern manufacturing systems and there are many barriers to their advancement [79]. As reported, there is a lack of available tools and methodologies to analyse the trade-off among processes, equipment, life-cycle costs, and initial investment. Also, there is a lack of effective communication among product designers, process designers and machine-tool designers, as needed for the design of an optimized manufacturing system.

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