International Conference on Computational and Experimental Methods in Mechanical Engineering
G.L. Bajaj Institute of Technology and Management, Greater Noida (U.P) India ICCEMME-2017
8th- 9th December 2017, www.conferenceworld.in ISBN: 978-93-86171-85-6

Design and Optimization of a Reconfigurable manufacturing system

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ABSTRACT

The industrial sector of the twenty-first century faces a highly volatile market in which manufacturing systems must be capable of responding rapidly to the market changes, while fully exploiting resources. The reconfigurable manufacturing system (RMS) is a state of the art technology offering the exact functionality and capacity needed, which is built around a part family. The configuration of an RMS evolves over a period to justify the needs of upcoming part families. The foundation for the success of an RMS, therefore, lies in the recognition of appropriate sets of part families. In the present work design and optimization of an RMS will investigate. Design will be based on machine Reconfigurability, responsive index, operational capability and quality. Computations will be done on MATLAB. Reconfigurable manufacturing systems (RMSs) have been introduced to react quickly and effectively to such competitive market demands through modular and scalable design of the manufacturing system on the system level, as well as on the machine components' level.

Keywords: RMS, MATLAB, Machine Reconfigurability, Responsive index.

I INTRODUCTION

The industrial sector of the twenty-first century faces a highly volatile market in which manufacturing systems must be capable of responding rapidly to the market changes, while fully exploiting resources. Reconfigurable manufacturing systems (RMSs) have been introduced to react quickly and effectively to such competitive market demands through modular and scalable design of the manufacturing system on the system level, as well as on the machine components' level. The most significant feature of the RMS is that the configuration of these systems evolves over the period of time in order to provide the functionality and capacity that is needed, and when it is needed.A cost-effective response to market changes requires a new manufacturing approach that not only combines the high throughput of Dedicated Manufacturing Lines (DML) with the flexibility of FMS, but also is able to react to changes quickly and efficiently. A new manufacturing system which can fulfill the objectives mentioned above was proposed in 1999 in the Engineering Research Center for Reconfigurable Manufacturing Systems (ERC/RMS)

at the University of Michigan, College of Engineering, and named it as Reconfigurable Manufacturing System (RMS), and can be defined as "Areconfigurable manufacturing system(RMS) is designed at the outset for rapidchange in its structure, as well as in its hardware and software components, in order to quicklyadjust its production capacity and functionality within a part family in response to sudden marketchanges or intrinsic system change".The RMS goal is summarized by the statement – Exactly the capacity and functionality needed, exactly when needed.

Reconfigurable manufacturing system, will allow flexibility not only in producing a variety of parts, but also in changing the system itself. Reconfigurable manufacturing system can be created by using basic process modules hardware and software that will be rearranged quickly and reliably. Reconfigurable manufacturing system which is cost effective and quick response to market changes, where DMS and FMS are more expensive than reconfigurable manufacturing system because the RMS aims to be installed with the exact production capacity and functionality needed, and may be upgraded (in terms of both capacity and functionality) in the future, when needed. Expanded functionality enables the production of more complex part types and the production of a variety of part types on the same system; it will be associated with adding process capabilities, auxiliary devices, more axis motions, larger tool magazines, and expensive controllers. An RMS may lie between a DMS and an FMS in terms of capacity and functionality. The key feature of RMS is that, unlike a DMS and an FMS, its capacity and functionality are not fixed. The RMS will be designed through the use of reconfigurable hardware and software, such that its capacity and/or functionality can be changed over time and unlike the other manufacturing systems, it does not have a fixed hardware/software.

Design Principles of RMS- The cost effective and quick responsive RMS achieves its characteristics by designing system according to two principles: Design of system and its machines for adjustable structurethat enable system scalability in response to market demands and system/machine adaptability to new products. Structure is adjusted at the system level (e.g., adding machines) and at the machine level (changing machine hardware and control software).Design of a manufacturing system around the part family, with the customized flexibility required for producing all parts of this part family. (This reduces the system cost.).In the present work design and optimization of an RMS will investigate. Design will be based on machine Reconfigurability, responsive index, and operational capability. Computations will be done on MATLAB.

II LITERATURE REVIEW

Mehrabi, M.G. et al. presented a review of manufacturing techniques and introduction of reconfigurable manufacturing systems; a new paradigm in manufacturing which is designed for rapid adjustment of production capacity and functionality, in response to new market conditions. In the process of designing and operating reconfigurable manufacturing systems distinguish from among system-level issues, component-level (i.e., machine

and controls) issues, and ramp-up time reduction issues are sorted out. Role of RMS in any production is described.Koren, Y. et al. discussed about a new type of manufacturing system that is very responsive to global markets; a system whose production capacity is adjustable to fluctuations in product demand, and which is designed to be upgradable with new process technology needed to accommodate tighter product specifications. Current systems, even so called flexible manufacturing systems, do not have these characteristics. They stated that RMS will change the relationship between suppliers of production equipment and the end-users. Mehrabi, M.G. et al. presented a review of manufacturing techniques and introduction of reconfigurable manufacturing systems; a new paradigm in manufacturing which is designed for rapid adjustment of production capacity and functionality, in response to new market conditions. In the process of designing and operating reconfigurable manufacturing systems distinguish from among system-level issues, component-level (i.e., machine and controls) issues, and ramp-up time reduction issues are sorted out. Role of RMS in any production is described.Koren, Y. et al.discussed about a new type of manufacturing system that is very responsive to global markets; a system whose production capacity is adjustable to fluctuations in product demand, and which is designed to be upgradable with new process technology needed to accommodate tighter product specifications. Current systems, even so called flexible manufacturing systems, do not have these characteristics.They stated that RMS will change the relationship between suppliers of production equipment and the end-users.

ElMaraghy, H. compared the characteristics of the two paradigms i.e. RMS and FMS. The concept of manufacturing system life cycle is presented. The highlights of recent research on manufacturing system flexibility and its measurement and impact are reviewed. A theoretical review of aspects of RMS and FMS is focused. Further, views of a panel of experts from academic and industry on the comparisons between flexible and reconfigurable manufacturing are presented. Abdi M. et al. Presented different RMS characteristics to address design strategy which considered as a part of a RMS design loop to achieve a reconfigurable strategy over its implementation period. As another part of the design loop, a reconfiguration link between market and manufacturing is presented in order to group products into families. In particular, the Analytical Hierarchical Process (AHP) is used while considering both market and manufacturing requirements. Oke, A. O. et al.developed a manufacturing system is easily reconfigurable. Authors proposed a design of dedicated manufacturing system that is made reconfigurable by the provision of some extra material-handling system, between all the workstations, and an auxiliary buffer within which a reconfigurable control system is incorporated. Researchers suggested that further work should be done on the control at the auxiliary buffer. Gumasta, K. et al. developed an index to measure the reconfigurability of RMSs keeping in mind their various core characteristics such as modularity, scalability, convertibility and diagnosability. These characteristics have been mapped together using multi-attribute utility theory. They suggested that, this index can be used to find the reconfigurability of a system possessing different characteristics. Degree of Reconfigurability obtained for random data generated using MATLAB.

 ISBN: 978-93-86171-85-6

III RESEARCH PROCEDURE

It is a mathematical and computational modeling. Computations will be done using MATLAB. A random allocation matrix is generated using MATLAB. Validation will be done on the basis of 'A novel methodology to measure the responsiveness of RMTs in reconfigurable manufacturing system' by kapil k goyal et al.

Notation

Notations

mc_i^j	machine i $(1 < i < I)$ in its jth $(1 < j < J_i)$ configuration
nc_i^j	number of machines needed to satisfy the required demand rate
$\delta_{i,k}^j$	1 if operation k can be performed with machine i having its jth configuration, otherwise 0
AM_i^j	a set of auxiliary modules required in machine i with its jth configuration
$OC_{p,q}$	operational capability of pth RMT with its qth configuration from the feasible alternative set of machine configurations to perform an operation
$MR_{p,q}$	machine reconfigurability of pth RMT with its qth configuration from the feasible alternative set of machine configurations to perform an operation
$RI_{p,q}$	responsiveness index of pth RMT with its qth configuration from the feasible alternative set of machine configurations to perform an operation

Table No 1 Validation Reconfigurable Tool and cost-

ISBN: 978-93-86171-85-6

RMT configuration and cost.

Machine	Machine Configuration	Basic Modules	Auxiliary Modules	Cost (in 10^3 of USD)
M_1	mc_1^1	{01, 05}	{13, 17, 21, 22}	750
	mc_1^2	{01, 05}	{12, 13, 15, 20, 21}	955
	mc_1^3	{01, 05}	{11, 17, 18, 20, 21}	1025
	mc_1^4	{01, 05}	{15, 17, 18}	840
M_2	mc_2^1	{02, 04, 08}	{11, 13, 16, 22, 24}	1215
	mc_2^2	{02, 04, 08}	{14, 16,19}	910
	mc_2^3	{02, 04, 08}	{13, 19, 24}	1140
	mc_2^4	{02, 04, 08}	{11, 13, 15, 18, 24}	1350
	mc_2^5	{02, 04, 08}	{11, 14, 18}	1050
M_3	mc_3^1	{03, 05, 07}	{11, 12, 14, 16, 18}	780
	mc_3^2	{03, 05, 07}	{12, 13, 14, 17, 19, 20}	1825
M_4	mc_4^1	{04, 09}	{18, 23}	1350
	mc_4^2	{04, 09}	{11, 15, 18, 20, 21}	1500
	mc_4^3	{04, 09}	{13, 14, 17, 18}	1400
M_5	mc_5^1	{03, 06, 10}	{20, 22}	900
	mc_5^2	{03, 06, 10}	{16, 17, 19, 20, 25}	1175
	mc_5^3	{03, 06, 10}	{11, 12, 13, 15, 22}	1230
	mc_5^4	{03, 06, 10}	{20, 22, 24}	1175

Table No. 2 Production

RMT operational capability chart.

Operation $(k) \rightarrow mc_i^j \downarrow$	RMT production rate in parts/hour for performing various operations																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
mc_1^1	–	–	–	14	–	–	–	12	–	–	–	8	–	–	–	18	–	–	–	–
mc_1^2	–	–	–	–	15	–	–	–	20	–	–	–	–	–	–	–	–	16	–	–
mc_1^3	–	–	20	–	–	–	15	–	–	–	–	–	–	–	–	25	–	–	–	–
mc_1^4	–	–	–	–	–	–	–	–	–	15	–	–	–	–	–	–	–	–	12	–
mc_2^1	14	–	–	–	–	15	–	–	–	–	–	12	–	–	–	–	–	–	–	20
mc_2^2	–	15	–	–	–	–	–	–	–	–	–	–	14	–	15	–	–	–	–	–
mc_2^3	–	–	25	–	–	–	–	18	–	–	25	–	–	–	–	–	20	–	–	–
mc_2^4	–	20	–	–	20	–	18	–	–	–	–	–	–	24	–	–	–	–	–	–
mc_2^5	–	–	–	18	–	–	–	–	–	–	–	–	20	–	–	–	–	14	–	15
mc_3^1	–	12	–	–	–	–	–	–	15	–	–	10	–	–	–	–	10	–	–	–
mc_3^2	30	–	–	26	–	–	–	24	–	–	24	–	–	–	20	–	35	–	15	–
mc_4^1	–	–	–	–	–	25	–	–	–	30	–	–	–	–	–	–	–	25	–	–
mc_4^2	25	–	–	–	–	–	–	–	–	–	–	22	–	–	–	–	30	–	–	26
mc_4^3	–	18	–	25	–	–	–	16	–	–	–	–	22	–	–	28	–	–	20	–
mc_5^1	16	–	–	–	–	–	15	–	–	–	15	–	–	18	–	–	–	18	–	–
mc_5^2	–	–	24	–	20	–	–	–	–	25	–	–	–	–	–	–	24	–	–	20
mc_5^3	–	–	–	24	–	–	–	–	30	–	–	–	–	–	18	–	–	–	–	–
mc_5^4	20	–	–	–	–	22	14	–	–	–	–	–	–	20	–	16	–	–	18	–

Table No 3 KKgoyal et al vs Present study

 ISBN: 978-93-86171-85-6

Operation	feasible configuration	MR kkgoyal et al	MR present study
4	mc11	1.64	1.6399
	mc25	2.51	2.50
	mc23	0.91	0.90
	mc43	1.73	1.729
	mc53	2.49	2.49
8	mc11	1.64	1.6399
	mc23	2.61	2.62
	mc32	0.91	0.90
	mc43	1.29	1.28
16	mc11	2.05	2.05
	mc13	2.94	2.939
	mc43	1.73	1.729
	mc54	2.19	2.19

Machine Reconfigurability of two different periods without change in machine and module for different Parts and Demands-

Table No 4 Production Plan for Period 1 and Part 1 and Demand 1

RMT operational capability chart.

Operation $(k) \rightarrow mc_i^j \downarrow$	RMT production rate in parts/hour for performing various operations																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
mc_1^1	–	–	–	14	–	–	–	12	–	–	–	8	–	–	–	18	–	–	–	–
mc_2^1	–	–	–	–	15	–	–	–	20	–	–	–	–	–	–	–	–	16	–	–
mc_3^1	–	–	20	–	–	–	15	–	–	–	–	–	–	–	–	25	–	–	–	–
mc_4^1	–	–	–	–	–	–	–	–	–	15	–	–	–	–	–	–	–	–	12	–
mc_1^2	14	–	–	–	–	15	–	–	–	–	–	12	–	–	–	–	–	–	–	20
mc_2^2	–	15	–	–	–	–	–	–	–	–	–	–	14	–	15	–	–	–	–	–
mc_3^2	–	–	25	–	–	–	–	18	–	–	25	–	–	–	–	–	20	–	–	–
mc_4^2	–	20	–	–	20	–	18	–	–	–	–	–	–	24	–	–	–	–	–	–
mc_5^2	–	–	–	18	–	–	–	–	–	–	–	–	20	–	–	–	–	14	–	15
mc_1^3	–	12	–	–	–	–	–	–	15	–	–	10	–	–	–	–	10	–	–	–
mc_2^3	30	–	–	26	–	–	–	24	–	–	24	–	–	–	20	–	35	–	15	–
mc_4^3	–	–	–	–	–	25	–	–	–	30	–	–	–	–	–	–	–	25	–	–
mc_1^4	25	–	–	–	–	–	–	–	–	–	–	22	–	–	–	–	30	–	–	26
mc_3^4	–	18	–	25	–	–	–	16	–	–	–	–	22	–	–	28	–	–	20	–
mc_4^4	16	–	–	–	–	–	15	–	–	–	15	–	–	18	–	–	–	18	–	–
mc_2^5	–	–	24	–	20	–	–	–	–	25	–	–	–	–	–	–	24	–	–	20
mc_3^5	–	–	–	24	–	–	–	–	30	–	–	–	–	–	18	–	–	–	–	–
mc_5^5	20	–	–	–	–	22	14	–	–	–	–	–	–	20	–	16	–	–	18	–

Table No 5 Production Plan for Period 2 and Part 2 and Demand 1

 ISBN: 978-93-86171-85-6

MC	Production Plan for PLANING HORIZONE																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
mc11	10			15				30				15				8			15	
mc12		15			12						20									
mc13									18							30		15		
mc14	20				17							30								18
mc21		17									18								20	
mc22			18			15			19				20			15				
mc23								16					20							
mc24						30														
mc25				21			12								30				15	
mc31										17								18		
mc32		22		14		18		19									16			
mc41															30					
mc42							20													
mc43			12	17				21								20	16			
mc51	15										12									30
mc52					16									20						
mc53				17			15						18					20		
mc54		16										19				10				

Table No 6 Machine Reconfigurability for Period 1 and 2 and Part 1 and Demand 1

IV RESULTS

Operation	feasible configuration	Period 1	Period 2
4	mc11	1.6399	2.04
	mc25	2.50	3.33
	mc32	0.90	.54
	mc43	1.729	1.29
	mc53	2.49	1.86
8	mc11	1.6399	2.04
	mc23	2.62	2.62
	mc32	0.90	.675
	mc43	1.28	1.70
16	mc11	2.05	1.025
	mc13	**2.939**	**4.4**
	mc43	1.729	1.729
	Mc54	2.19	1.46

Table No 7 Machine Reconfigurability for Period 1 and 2 and Part 1 and Demand 2

 ISBN: 978-93-86171-85-6

Operation	feasible configuration	Period 1	Period 2
4	mc11	1.6399	1.632
	mc25	2.50	2.49
	mc32	0.90	.54
	mc43	1.729	1.032
	mc53	2.49	1.488
8	mc11	1.36	1.36
	mc23	2.62	2.09
	mc32	0.90	.675
	mc43	1.024	1.275
16	mc11	2.05	.911
	mc13	**2.939**	**2.93**
	mc43	1.729	1.29
	mc54	1.752	1.25

V CONCLUSION

In the present study a novel approach has been proposed for measuring the responsiveness of the RMTs based on machine re-configurability. The machine re-configurability is proposed as the ratio of number of configurations into which an RMT can be reconfigured and the required reconfiguration efforts in the change of modules. Higher values of the machine re-configurability decreases the response time to handle the fluctuating demands and lowers the associated reconfiguration costs. As in table no. 5.1 and 5.2 there is different part, different demand, here machine configurability mc_1^3 shows the higher reconfigurabilty for both demand 60 and 70. So we can say this is the best configuration to use here. So Using RMS the decision-maker can decide if he would Rather choose a fast production system with a relatively high cost, or the opposite, i.e. a low cost system with an average speed. It is clear that the more machines are used, the faster is the system, and the higher are the costs. As we have taken the different cases for N no. of machines for different operation and analyzed the result if we have to choose from n no. of machines and then done the optimization then we found the best configuration. RMS are designed to be fast enough and to produce with an sufficient flexibility to react to the market changes, thus, we plan to extend this work to be not only suitable for the current products, but also reactive for the arrival for new product.

REFERENCES

[1] Koren, Y., Ulsoy, A.G., (1997), "Reconfigurable Manufacturing Systems", Technical report, ERC/RMS-TR-001, University of Michigan, Ann Arbor.

[2] Mehrabi, M.G., Ulsoy, A.G., Koren, Y., (2000), "Reconfigurable manufacturing system a key to future manufacturing", Journal of Intelligent Manufacturing, Vol.11, No.4 pp. 403-414.

[3] Koren, Y., (1998) "Reconfigurable Manufacturing Systems and Transformable Factories", Part1, chapter3, pp: 27-45.

[4] Rossitza, M., Setchi, M.R., Lagos N., (2004), "Reconfigurability and Reconfigurable Manufacturing Systems-State of the Art Review", INDIAN-04, 2nd IEEE International Conference on Industrial Informatics, 24-26 June, pp. 529-535.

[5] Oke1, A.O., Abou-El-Hossein K., Theron, N. J., (2011), "The Design and development of a reconfigurable manufacturing system", South African Journal of Industrial Engineering, Vol.22, No.2, pp. 121–132

[6] ElMaraghy H., (2006) "Flexible and reconfigurable manufacturing systems paradigms", International Journal of Flexible Manufacturing Systems, Vol.17, No.4, pp. 261–276

[7] Pattanaik L. N., Jain P. K., Mehta, N. K., (2007) "Cell formation in the presence of reconfigurable machines", International Journal of Advance Production Technology Vol.34, pp. 335–345.

[8] Rakesh K., Jain, P.K., Metha, N.K., (2008) "A framework for simultaneous recognition of part families and operation groups for driving a reconfigurable manufacturing system ", Proceedings of CARS & FOF 2008, 29-31 July, Koriyama Japan.

[9] Koren, Y., Heisel, U., Jovance, F., Moriwaki, T., Pritschow, G., Ulsoy, G., Vanbrussel, H., (1999), "Reconfigurable manufacturing system-keynotes", Annals of the CIRP, Vol.48, No.2 pp.527-540

[10] Abdi, M.R., Labib, A.W., (2003), "A design strategy for reconfigurable manufacturing systems (RMSs) using an analytical hierarchical process (AHP): a case study", International Journal of Production Research,Vol.41, No.10, pp. 2273 — 2299

[11] Gumasta, K., Gupta, S.K., Benyoucef, L., Tiwari, M.K.,(2011), "Developing a reconfigurability index using multi-attribute utility theory",International Journal of Production Research, Vol.49,No6, pp: 1669-1683.

[12] Katz, R., (2007), "Design Principles of Reconfigurable Machines", International journal of advanced manufacturing technology, Vol.34, No.5-4. pp. 430-439.