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Developing the dynamic cell formation and production planning considering the inter/intra-cell material handling equipment

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Abstract: In this paper, a new integrated mathematical model of the production planning and dynamic cellular manufacturing system (DCMS) wherein the product mix and/or volume is different from one period to another has been developed. So far, literature review indicates that the key role of Material Handling Equipment (MHE) has not been considered in the developed model, while ignoring such role will lead to wrong results. In other words, ignoring characteristics such as MHE capacity and inter and intra-cell movement times cannot be justifiable especially in shops in which, the movement times for parts are considerable compared to their processing times. The proposed model covers concepts such as inter/intra-cell movement, reconfiguration, subcontracting, inventory and backorder, lead time for subcontracted parts, optimal lot sizing in each period, number of inter/intra-cell MHE assigned to manufacturing system, number of MHE purchased and sold in each period and price of purchasing/selling for each inter/intra-cell MHE. A numerical example and sensitivity analysis have been used to verify the proposed mathematical model.

Keywords: Dynamic Cellular Manufacturing System, Dynamic Cell Formation Problem, Material Handling Equipment, Production Planning

Introduction: Due to the global market competition, the manufacturing systems are changing from traditional configurations such as flow shop and job shop toward structures such as Cellular Manufacturing System (CMS). On the other hand, customer demands are different from one period to another. In such conditions, companies that use CMS should change their cell configurations every period. In other words, a new Dynamic Cell Formation Problem (DCFP) is needed to be performed for each period. The objective is to handle a DCFP together with a production planning policy by manufacturers. This integrated problem was proposed by Bulgak and Bektas (2009) for the first time. They developed a mixed integer nonlinear mathematical model and solved several computational examples by CPLEX. In another study, Safaee and Tavakkoli Moghaddam (2009) studied an integrated model of DCFP and production planning. Their model included the outsourcing and lead time concepts together. Then, other studies proposed DCFP and production planning together with others subjects such as worker assignment, machine breakdown, company layout, etc. In this paper, the roles of inter/intra cell Material Handling Equipment (MHE) and DCFP and production planning are studied, simultaneously.

Mehodology/Approach: First, a new mixed integer nonlinear mathematical model is proposed considering DCFP, production planning and the role of inter/intra cell MHE. Due to the complexity of nonlinear models, a transformation is occurred from the nonlinear developed model to a linear one. Then, the linear model is coded in commercial software named 'GAMS'. Several examples are run on GAMS to validate the proposed model. Finally, the sensitivity analysis is performed on a number of important parameters.

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Findings and Discussion: In order to illustrate the effect of MHE on the DCFP and production planning, two numerical examples were investigated with and without MHE. The first difference between these two examples was in objective function value as represented in Table 3 regardless of MHE and in Table 5 regarding MHE. The second difference was in production planning as it addressed in Table 4 regardless of MHE and Table 6 regarding MHE. The third difference was in cell configuration as represented in Figure 2. Finally the forth difference was in the number of MHE used in manufacturing system regardless and regarding MHE as addressed in Tables 7 and 8, respectively. All Tables and Figures proved that MHE management can play an effective role in a manufacturing system.

Conclusion: In this paper, the integrated model of DCFP, production planning and MHE was investigated. A mixed integer nonlinear mathematical model was developed and then transformed into a linear one. To validate the proposed model, a numerical example was presented and this example was solved without and with MHE. Finally, a sensitivity analysis was performed on a number of important parameters.

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