CIRRELT

Soutenance de thèse de doctorat de

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« Integration of production, maintenance and quality: Modelling and solution approaches»

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Abstract:

In the highly competitive business nature of this era, enterprises are seeking for novel approaches to develop their performance, to improve the production quality, or to reduce the operational costs. Production planning, maintenance scheduling, and design of quality systems are three key functions of every manufacturing system. Despite the strong interactions between these functions, they are mostly treated separately in the literature as well as in industries. Incorporation of interrelated decisions in a joint model is an effective approach to handle their mutual interactions and the integrated planning will be a beneficiary of the system as a whole. The main goal of this thesis is to propose joint modeling of production, maintenance and quality decisions, and effective optimization methods for the resulted problems in the context of imperfect production, imperfect maintenance systems.

First, we have considered a single-machine, multi-product system with multiple periods in the planning horizon. The system condition is stated by the effective age of the machine which continuously increases with the time, so the conditions are always deteriorating. Machine failures are self-announcing and a minimal repair will be instantly initiated to bring the machine in operation without influencing on its age. On the other hand, quality degradations will be detected by means of process inspections related to the quality system. A poor inspection process may not signal the quality shifts which results in not only a higher number of defects, but also to an increased machine restoration cost. Imperfect age-based preventive maintenance possibilities with multiple maintenance levels to be performed during each period are available to improve the machine conditions. The cost and the time of the maintenance levels, as well as their effect on the system are different. Determination of optimal maintenance plans taking into account their effects on the system availability and the production quality is a challenging issue. A profit maximization model in the context of time-varying costs and demands is proposed in which the costs are the sum of the processing cost, inventory holding cost, backorder cost, setup cost, preventive and corrective maintenance cost, system restoration cost, and the process inspections cost.

In the next step, the model is extended to take into account a multi-machine capacitated lot-sizing problem, where the objective function minimizes the total cost. With the limitation of the maintenance budget in each period, the model addresses the optimal maintenance level to be performed on each machine before commencing the missions. Moreover, the number of quality inspections for each machine in each period is incorporated in the model. Optimal number of inspections is linked to the production levels and to the maintenance plans. The proposed models are distinguished with a high complexity level, non-linearity of the problems, and huge search space. Exploiting the benefits of joint modeling necessitates the development of effective optimization methods as the third objective of this thesis.

A memetic algorithm with population management and state-of-the-art search strategies is proposed which incorporates the power of Genetic algorithms with the speed of local search methods. The algorithm makes use of a Nelder-Mead method along with using an optimization package in the exact determination of the values of several decision variables in each chromosome evolution. The suggested approach extracts not only the positive knowledge in good solutions, but also the negative knowledge in poor individuals to determine the algorithm transitions.

The models and the proposed solution method are analyzed in terms of the benefits of integration, the sensitivity of the parameters, and the quality and the performance of the algorithm.