Chapter 3

Fuzzy Parallel Machine Scheduling Problem Under Fuzzy Job Deterioration and Learning Effects With Fuzzy Processing Times

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ABSTRACT

This chapter presents a mixed integer non-linear programming (MINLP) model for a fuzzy parallel machine scheduling problem under fuzzy job deterioration and learning effects with fuzzy processing times in order to minimize fuzzy makespan. The uncertainty of parameters such as learning/deterioration effects and processing times in a scheduling problem makes the solution of the problem uncertain. Fuzzy sets can be used to encode uncertainty in parameters. In this chapter, possibilistic distributions of fuzzy parameters and possibilistic linear programming approaches are used in order to create a solution method for MINLP model of fuzzy parallel machine scheduling problem.

INTRODUCTION

This chapter proposes a mixed integer non-linear programming (MINLP) model for a parallel machine scheduling problem under fuzzy learning and deterioration effects with fuzzy processing times. The real life is full of uncertainty and a decision maker (DM) cannot always define a deterministic domain for scheduling parameters and even decision variables. With a practical view for scheduling problems, DM may not always determine exact scheduling parameters such as processing times and due dates because

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of lack of knowledge, DM’s experience and judgment, vagueness and imprecision in scheduling environment for measuring parameters and uncertainty of problem’s own characteristics (Arık & Toksar, 2017). Learning and deterioration effects have been hot-topics for scheduling problems for 20 years. The expression of learning effect denotes that repeats of similar tasks by a worker or on a machine can lead the current task duration to be faster than previous tasks’ durations. This effect can be dependent on job position or the cumulative sum of previous jobs’ durations. On the contrary, deterioration effect implies that while jobs are waiting in the queue or being processed by workers or on a machine, their duration can be slower than previous jobs’ durations. Both of these effects have been accepted as deterministic scheduling parameters. Some recent papers (Arık & Toksar, 2017; Toksar, & Arık, 2017) investigates one or both of these effects in scheduling problems as fuzzy numbers. Fuzzy set theory can be applied to mathematical models in order to encode uncertainty of model parameters such as processing times, learning and deterioration effects. Applications of fuzzy set theory to optimization problems have been studied since the 1980s. This chapter investigates a possibilistic linear programming technique to the proposed problem. Possibilistic linear programming techniques are dependent on the possibility theory that was introduced by Zadeh (1978). Possibility theory uses possibility distribution for a fuzzy event to help DM deduce this fuzzy event’s plausibility. Possibility distributions of parameters in form of fuzzy numbers in the objective function, constraints and right-hand side values of a mathematical model can be used to generate a joint possibility distribution for all parameters. Then, this joint possibility distribution can be used for finding the most plausible solution among alternative solutions in the problem space.

**Literature Review**

Scheduling problems with fuzziness have been interested in researchers for a long time. Behnamian’s survey (2016) and Abdullah and Abdolrazzagh’s (2014) literature review are a good guidance for the readers. Fuzziness in scheduling problems was started with processing times by McCallon and Lee (1990). Processing times and due-dates are the most preferred fuzzy parameters in scheduling problems. Furthermore, precedence relations and batch sizes are preferred as fuzzy parameters by researchers. Table 1 shows some of fuzzy parameters in the literature. Some of pioneer studies about fuzziness in scheduling problems are Tsujimura et al. (1993), Ishibuchi et al. (1994), Han et al. (1994), Dubois et al.(1995), Ishii and Tada (1995), and Kuroda and Wang (1996).

For solving fuzzy scheduling problems, different solution techniques such as genetic algorithms, simulated annealing, particle swarm optimization algorithms, chance-constrained programming and possibility theory have been developed and used by researchers. Table 2 gives some of these solution techniques in the literature. Furthermore, more recently published papers belongs to Bentrcia et al.

**Table 1. Fuzzy Parameters in Scheduling Problems**

<table>
<thead>
<tr>
<th>Fuzzy Parameters</th>
<th>Researchers</th>
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</thead>
<tbody>
<tr>
<td>Due-dates</td>
<td>Ishii et al. (1992), Ishibuchi et al. (1994), Han et al. (1994), Li et al. (2015)</td>
</tr>
<tr>
<td>Precedence relations</td>
<td>Li et al. (2015), Li et al. (2012), Xie et al. (2005)</td>
</tr>
<tr>
<td>Batch sizes</td>
<td>Li et al. (2012)</td>
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