AIN SHAMS UNIVERSITY

FACULTY OF ENGINEERING

Design and Production Engineering

Production rescheduling optimization model

A Thesis submitted in partial fulfilment of the requirements of the degree of

Master of Science in Mechanical Engineering

(Design and Production Engineering)

by

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Bachelor of Science in Mechanical Engineering

(Design and Production Engineering)

Faculty of Engineering, Ain Shams University, 2013

Supervised By

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Cairo - (2019)

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Statement

This thesis is submitted as a partial fulfilment of Master of Science in Mechanical Engineering, Faculty of Engineering, Ain shams University.

The author carried out the work included in this thesis, and no part of it has been submitted for a degree or a qualification at any other scientific entity.

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Thesis Summary

Production rescheduling optimization model

In the dynamic environment of production, the task of managing and controlling production systems becomes more difficult as a result of internal disruptions like machine breakdowns, and external disruptions (such as urgent jobs). Once the initial production schedule is disrupted, a corrective action should be taken to minimize the negative effects of disruption on the overall performance. Some of the practical strategies to handle disruptions are: working for overtime, outsourcing some of the production tasks and production rescheduling. Rescheduling refers to the process of updating an existing production schedule in response to disruptions or other changes to maintain schedule performance.

Production rescheduling studies considered the rescheduling problem from different perspectives. Some studies are focused on the nature of the scheduling environment which is static or dynamic scheduling. Some are concerned with the strategy of considering the uncertainty in the production system. Some are concerned with the policy that should to be followed to respond to disruptions whenever occur. Some are concerned with the method by which the disrupted schedule would be updated. Some are dedicated to find a solution for a specific machine environment problem under a specific set of assumptions. Some are concerned with finding appropriate performance measures for the rescheduling problem. Others are concerned with the optimization tool that is used to find an optimal or near-optimal solution.

Most of rescheduling studies consider static set of jobs to be rescheduled upon disruption occurrence. Two alternative policies are mostly followed to respond to disruptions either upon occurrence, event-driven policy, or periodic policy to be performed at equally spaced time intervals. The method of updating a disrupted schedule by generating a completely new schedule has been proven to be superior to other methods by computational results. The disruption of urgent job arrival has been considered in most of rescheduling studies. Despite its importance, the single machine environment was rarely considered in the rescheduling studies.

The objective of this study is to answer the following questions: Is rescheduling needed when disruptions occur? If yes, when to reschedule? and how often?

This study followed a reactive strategy to handle unexpected disruptions in a single machine environment such that the unexpected disruptions are not accounted for while generating the initial schedule. Instead, the schedule is revised when unexpected disruptions occur according to the followed rescheduling policy. The performance of different rescheduling policies is compared in terms of the total tardiness and total cost at different disruption parameters. The disruption parameters considered in this study are: disruption duration, time of disruption occurrence and the number of disruptions.

In this study, a genetic algorithm is used to generate the initial schedule and the updated schedules.

Since production rescheduling may be affected by many factors and our concern is to estimate the effect of these factors on the rescheduling decision, as well as the effect of possible interactions between these factors. Using Minitab® statistical software, a general factorial experiment, in which more than two factors are considered and each factor has different number of levels, is designed to study the performance of different rescheduling policies. In each complete trial of the experiment, all possible combinations of all levels of the factors are investigated. The experiment includes the following factors: 1) rescheduling policy. 2) time of disruption occurrence. 3) Number of disruptions during the planning period. 4) Disruption duration. 5) jobs' processing time represented by different number of jobs to be scheduled in the same planning horizon. and 6) the optimization objective (minimum total tardiness or minimum total cost).

The results are first analyzed using ANOVA to identify parameters with statistically significant variation. Then the results are further analyzed and discussed using different graphical methods.

The computational results showed that the timing of the occurrence of disruption as related to scheduling horizon has a major effect on determining the best rescheduling policy. Event-driven policy is found to be superior to other policies for short infrequent disruptions. On the other hand, the periodic rescheduling policy is found to be superior to other policies for long and/or frequent disruptions.

Key words: Single machine, rescheduling, event-driven rescheduling, periodic rescheduling, rescheduling frequency.

Acknowledgment

I would like to express my gratitude to the supervision team, Prof. Amin El-Kharbotly, with his experience, support, motivation, and guidance to this interesting point, and throughout the work, and Dr. Yomna, with her sincere support, accurate comments, close supervision and useful advices in the research and in many other things as well.

February 2019

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List of Abbreviations

AWI-J	Active Wilkerson Irwin – Job
AWI-O	Active Wilkerson Irwin – Operation
AOR	Affected Operations Rescheduling
ATC	Apparent Tardiness Cost
ACO	Ant Colony Optimization
ANOVA	Analysis of Variance
BB	Branch and Bound
BS	Beam Search
CFJIT	Critical First Job Idle Time
CPU	Central Processing Unit
DHS	Discrete Harmony Search
DOE	Design of Experiments
ED	Event-Driven
EDD	Earliest Due Date
FMS	Flexible Manufacturing System
FJR	Fit Job Repair
FBS	Filtered Beam Search
GA	Genetic Algorithms
GDP	Ground Delay Program
HFBS	Heuristic Filtered Beam Search
IG	Iterated Greedy
LP	Linear Programming

LTL	Less than Truck Load
LEPST	Longest Expected Processing with Setup Time
MCR	Minimum Critical Ratio
MLEPST	Modified Longest Expected Processing with Setup Time
MDD	Modified Due Dates
MAIT	Maximum Allowable Idle Time
MWCTD	Minimum Weighted Completion Time Difference
MSB	Modified Shifting Bottleneck
MTBF	Mean Time Between Failures
MTTR	Mean Time to Repair
MPS	Master Production Schedule
NP	Non-Polynomial
PR	Periodic Rescheduling
RSR	Right Shift Repair
RS	Right Shifting
SPT	Shortest Processing Time
SOPT	Shortest Operation Processing Time
TR	Total Rescheduling
TWK	Total Work content
VNS	Variable Neighborhood Search
WSPT	Weighted Shortest Processing Time
WIP	Work-In-Process
WSPT	Weighted Shortest Processing Time

List of Symbols

a	The lower bound of time of disruption occurrence.
b	The upper bound of time of disruption occurrence.
C_j	Completion time of job (j) [in hrs.].
$C_{[k]}(\upsilon)$	Completion time of job k in schedule υ [in hrs.].
$C_{tardiness}$	Total tardiness cost.
C_{WIP}	Total WIP holding cost.
$C_{expediting}$	Total material expediting cost.
$C_{sch/res}$	Total computational cost of scheduling/rescheduling.
$C_{earliness}$	Total earliness cost.
d_j	Due date of job (j) [in hrs.].
DS_d	Start time of disruption (d) [in hrs.].
DE_d	End time of disruption (d) [in hrs.].
DL_d	Duration of disruption (d) [in hrs.].
e	The lower bound of disruption duration.
h	Upper bound of jobs' processing time.
j	The job number, where j = 1, …, N.
J_o	Set of jobs to be initially scheduled, where $J_o = \{1, \ldots, N\}$.
k	The disrupted job.
l	Lower bound of jobs' processing time.
M	The makespan of the initial schedule [in hrs.].
M'	The makespan of the actually realized schedule [in hrs.].
P_j	Processing time of job (j) [in hrs.].