

**OPTIMISATION OF DYNAMIC AND STOCHASTIC PRODUCTION
SCHEDULING SYSTEMS AFTER RANDOM DISRUPTIONS**

by

Johannes Bekane Mapokgole

A dissertation submitted in fulfillment of the requirements for the degree
Magister Technologiae: Engineering: Industrial, in the
Faculty of Engineering and Technology

Department of Industrial Engineering and Operations Management

Faculty of Engineering



VAAL UNIVERSITY OF TECHNOLOGY

Supervisor/Promoter: Dr. TB Tengen

Date: May 20th, 2013

CONFIDENTIALITY CLAUSE

Date

TO WHOM IT MAY CONCERN

RE: CONFIDENTIALITY CLAUSE

This work is of strategic importance.

The contents of this dissertation are to remain confidential and are not to be circulated for a period of 5 years.

Sincerely,

.....

J.B. Mapokgole

DECLARATION

This work has not previously been accepted for any degree and is not concurrently being submitted in candidature for any degree.

Signed

Date

STATEMENT 1

This dissertation is being submitted in fulfillment of the requirements for the degree of Magister Technologiae: Industrial Engineering.

Signed

Date

STATEMENT 2

The dissertation is the results of my own independent work/investigation, except where otherwise stated. Other sources are acknowledged by giving explicit references. A bibliography is appended.

Signed

Date

STATEMENT 3

I hereby give consent for my dissertation, if accepted, to be available for photocopying and for interlibrary loans after expiry of a bar on access approved by the Vaal University of Technology.

Signed

Date

ACKNOWLEDGEMENTS

I hereby wish to express my hearty gratitude to Dr. Tengen Thomas Bobga for giving me the opportunity to work under his very well-versed guidance. His support and trust helped me in developing ideas and models and testing them successfully in selected companies based in Gauteng (South Africa).

DEDICATION

This dissertation is dedicated to my mother (Mmatlala Annah Mapokgole).

ABSTRACT

The current business environments in many companies are characterized by markets facing tough competitions, from which customer requirements and expectations are becoming increasingly high in terms of quality, cost and delivery dates, etc. These emerging expectations are even getting stronger due to rapid development of new information and communication technologies that provide direct connections between companies and their clients. As a result, companies should have powerful control mechanisms at their disposal. To achieve this, companies rely on a number of functions including production scheduling. This function has always been present within companies, but today, it is facing increasing complexities because of the large number of jobs that must be executed simultaneously. Amongst many factors, it is time driven.

This study demonstrates that several disciplines can be married into one model (i.e. a unified model) to solve scheduling problems after disruptions, and clears the way for future multi-disciplinary research efforts. Scheduling problem is modeled as follows: Ito's stochastic differential rule is used to analyse the time evolution of random or stochastic processes. Multifactor productivity is used to unify various disruption factors. Theory of line balancing is also employed to determine the required number of resources to minimize bottleneck. Reliability: disruptions are considered to be equivalent to system failure. The failure rate of the system is translated to the reliability of the system mathematically. The probabilities of failure are used as indicators of disruptions, and the theory of reliability is then applied. Bernoulli's principle is also employed to relate pressure to production flow and aid in managing bottleneck situations.

Results indicate that the amount of resources needed after disruption depends on the nature of disruption, and that the scheduler should plan to increase number of facilities following a trend that is only predicted by the nature of disruptions. It is also shown that disruption of one type may not greatly affect productivity of a certain company layout, whilst similar disruptions can have devastating effect on another type. It is further concluded that impacts of disruption are dependent on the type of company layouts.

Keywords:

Production Scheduling, Reliability, Disruptions, Multifactor Productivity, Line Balancing, Ito's Stochastic Differential Rule, Bernoulli's theory, Company-Layouts.

TABLE OF CONTENTS

	Page
CHAPTER 1	
INTRODUCTION AND OVERVIEW	1
1.1. BACKGROUND AND INTRODUCTION	1
1.1.1. Scheduling	1
1.1.2. Production Scheduling	2
1.2. PROBLEM STATEMENT AND DEFINITION	3
1.2.1. Dispatching Rules	4
1.2.2. Enterprise Resource Planning (ERP) Systems	4
1.2.3. Capacity Requirement Planning	5
1.3. RESEARCH QUESTIONS, MOTIVATIONS, OBJECTIVES AND METHOD	7
1.3.1. Research Questions	7
1.3.2. Motivation of Research	7
1.3.3. Research Objectives	8
1.3.4. Research Method Summary	8
CHAPTER 2	
LITERATURE REVIEW	11
2.1. PRELIMINARY LITERATURE REVIEW	11
2.1.1. Production Scheduling Origins	11
2.2. PRODUCTION PLANNING AND CONTROL	14
2.2.1. Rescheduling and Impact of Disruptions	14
2.2.2. Disruptions Classification	16
2.2.3. Supply Chain Value System	18
2.3. RESCHEDULING ENVIRONMENT	19
2.3.1. Static and Dynamic Environment	19
2.3.2. Manufacturing Process, Planning and Control	20
2.3.3. Production Scheduling Environment	21

2.3.3.1.	Flow-Shop Scheduling	21
2.3.3.2.	Predictive Scheduling: “commonly known as Scheduling”	22
2.3.3.3.	Reactive Scheduling: “Rescheduling”	24
2.4.	RESCHEDULING MANUFACTURING SYSTEMS	27
2.5.	DYNAMIC SCHEDULING TECHNIQUES	29
2.5.1.	Completely Reactive Scheduling (CRS)	29
2.5.2.	Predictive-Reactive Scheduling	30
2.5.3.	Robust Predictive-Reactive Scheduling	32
2.5.4.	Robust Proactive Scheduling	33
2.5.	STOCHASTIC OPTIMAL CONTROL	33
2.6.	SUMMARIES OF APPROACHES DEPLOYED	34
2.6.1.	Stochastic Theory	34
2.6.2.	Productivity or Multifactor Productivity	36
2.6.3.	Reliability	37
2.6.4.	Line Balancing	37
2.6.5.	Types of Company-Layouts	37
2.6.6.	Bernoulli’s Principle	39
 CHAPTER 3		
	RESEARCH DESIGN AND RESULTS: Approaches to address the problem	41
3.1.	MULTIFACTOR PRODUCTIVITY, ITO STOCHASTIC THEORY AND LINE BALANCING	42
3.2.	RELIABILITY AND FAILURE	49
3.2.1.	Company Layouts	50
3.2.1.1.	Production Line Department	50
3.2.1.2.	Product Family Layout	51
3.2.1.3.	Process department	51
3.2.1.4.	Fixed Position Layout	51
3.3.	BERNOULLI’S PRINCIPLE	53
3.3.1.	Predictive or Static State	54
3.3.2.	Dynamic or Unsteady State	55

3.3.3. Bottleneck Operation	56
3.4. PROPOSED RESCHEDULING CONCEPTS OR APPROACHES	58
3.4.1. Threshold Concept	58
3.4.2. Rescheduling Interval (RI)	59
3.5. SUPPLY CHAIN DISRUPTIONS	61
3.5.1. Supply Chain: Impact of Disruptions	65
3.5.2. Production Performance: Strike	67
 CHAPTER 4	
SUMMARISED DISCUSSIONS	71
4.1. UNIFIED MODEL	71
4.2. COMPANY-LAYOUTS	71
4.3. SUPPLY CHAIN DISRUPTIONS	73
4.4. BERNOULLI'S THEOREM	73
 CHAPTER 5	
CONCLUSION, RESCHEDULING GUIDE AND FURTHER STUDY	75
5.1. CONCLUSION	75
5.2. RESCHEDULING GUIDE	76
5.3. FUTURE ENDEAVOURS	77
 BIBLIOGRAPHY	79
LIST OF PUBLICATIONS	88

LIST OF FIGURES

	Page
Figure 1: Disrupted Flow	16
Figure 2: Production System Framework	20
Figure 3: Precedence Structure of a Job in a Flow-Shop (Serial Unit Process)	22
Figure 4: Precedence Structure of a Flow-Shop (Generalized Serial/ Parallel Process)	22
Figure 5: Example of Gantt Chart	24
Figure 6: Production Scheduling as a Feedback Control System	25
Figure 7: National Strikes	29
Figure 8: Different Types of Company-Layouts	39
Figure 9: Time Evolution of Input Functions Due to Various Kinds of Disrupting Factors	44
Figure 10: Time Evolution of the (a) Productivity, (a) Production Time, (c) Number of Workstation Required, and (d) Number of Resources to Meet Demand	48
Figure 11: Change (Δ) In Pressure and Production Flow Rates	54
Figure 12: Production Flow Depiction	55
Figure 13: Production Flow Subject to Pressure and Varying Capacities	55
Figure 14: A Bottleneck Operation Flow	56
Figure 15: Proposed Approach for Determining Bottleneck Operation	57
Figure 16: Basic Decision Flowchart Following Disruptions	58
Figure 17: Impact of Disruptions in Manufacturing Operations	60
Figure 18: Impacts of Various Disruptions per Company Layout	63
Figure 19: Disruptions Indices per Company-Layout	67
Figure 20: Impacts of Disruptions per Month	70
Figure 21: Aggregate Impact of Disruptions per Month	70

LIST OF TABLES

	Page
Table 1: Common Disruptions	17
Table 2: Various Disruptive Factors per Company Layouts	51
Table 3: Company-Layout Disruption Indices	62
Table 4: Company-Layouts Loss Breakdown	64
Table 5: Manufacturing Process Industry	66
Table 6: Various Leading Disruption Types per Company Layout	66
Table 7: Production Throughput per Week	68
Table 8: Monthly Actual Performances	69
Table 9: Production Rates	69