



**KOLEJ UNIVERSITI TEKNIKAL KEBANGSAAN
MALAYSIA**

**SIMULATION MODELING AND
OPTIMIZATION IN
MANUFACTURING: CASE STUDY
SHOP FLOOR**

Thesis submitted in accordance with the requirements of the
Kolej Universiti Teknikal Kebangsaan Malaysia for the Degree of
Bachelor of Manufacturing Engineering (Honours) (Manufacturing Process)

By

Irwan bin Mohamad Halim

Faculty of Manufacturing Engineering

May 2006


KOLEJ UNIVERSITI TEKNIKAL KEBANGSAAN MALAYSIA
BORANG PENGESAHAN STATUS TESIS*
JUDUL: SIMULATION MODELING AND OPTIMIZATION IN MANUFACTURING: CASE STUDY SHOP FLOOR
SESI PENGAJIAN: 2005-2006

 Saya IRWAN BIN MOHAMAD HALIM

mengaku membenarkan tesis (PSM/Sarjana/Doktor Falsafah) ini disimpan di Perpustakaan Kolej Universiti Teknikal Kebangsaan Malaysia (KUTKM) dengan syarat-syarat kegunaan seperti berikut:

1. Tesis adalah hak milik Kolej Universiti Teknikal Kebangsaan Malaysia.
2. Perpustakaan Kolej Universiti Teknikal Kebangsaan Malaysia dibenarkan membuat salinan untuk tujuan pengajian sahaja.
3. Perpustakaan dibenarkan membuat salinan tesis ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. **Sila tandakan (√)

 SULIT

(Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia yang termaktub di dalam AKTA RAHSIA RASMI 1972)

 TERHAD

(Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan)

 TIDAK TERHAD

Disahkan oleh:

(TANDATANGAN PENULIS)

(TANDATANGAN PENYELIA)

 Alamat Tetap:
12184 TAMAN DESA PERMAI, PADANG
NENAS, 21030 KUALA TERENGGANU,
TERENGGANU DARUL IMAN.

 Cop Rasmi: **TAUFIK**
Pensyarah
 Fakulti Kejuruteraan Pembuatan
 Kolej Universiti Teknikal Kebangsaan Malaysia
 Karung Berkunci 1200, Ayer Keroh
 75450 Melaka

 Tarikh: 29 MAY 2006

 Tarikh: 29 MAY 2006

* Tesis dimaksudkan sebagai tesis bagi Ijazah Doktor Falsafah dan Sarjana secara penyelidikan, atau disertasi bagi pengajian secara kerja kursus dan penyelidikan, atau Laporan Projek Sarjana Muda (PSM).
 ** Jika tesis ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali sebab dan tempoh tesis ini perlu dikelaskan sebagai SULIT atau TERHAD.



FAKULTI KEJURUTERAAN PEMBUATAN

Rujukan Kami (Our Ref) :
Rujukan Tuan (Your Ref):

19 May 2006

Pustakawan
Perpustakaan Kolej Universiti Teknikal Kebangsaan Malaysia
KUTKM, Ayer Keroh
MELAKA.

Saudara,

PENKELASAN TESIS SEBAGAI SULIT/TERHAD
- TESIS SARJANA MUDA KEJURUTERAAN PEMBUATAN (PROSES PEMBUATAN):
IRWAN BIN MOHAMAD HALIM
TAJUK: SIMULATION MODELING AND OPTIMIZATION IN
MANUFACTURING: CASE STUDY SHOP FLOOR

Sukacita dimaklumkan bahawa tesis yang tersebut di atas bertajuk
“**SIMULATION MODELING AND OPTIMIZATION IN MANUFACTURING:**
CASE STUDY SHOP FLOOR” mohon dikelaskan sebagai terhad untuk tempoh
lima (5) tahun dari tarikh surat ini memandangkan ia mempunyai nilai dan
potensi untuk dikomersialkan di masa hadapan.

Sekian dimaklumkan. Terima kasih.


“BERKHIDMAT UNTUK NEGARA KERANA ALLAH”

Yang benar,

EN TAUFIK BIN SYAHRONI
Pensyarah,
Fakulti Kejuruteraan Pembuatan
(Penyelia)
☎06-2332375

DECLARATION

I hereby, declare this thesis entitled “Simulation Modeling and Optimization in Manufacturing: Case Study Shop Floor” is the results of my own research except as cited in the reference.

Signature : 

Author's Name : Irwan bin Mohamad Halim

Date : 14 JUNE 2006

APPROVAL

This thesis submitted to the senate of KUTKM and has been accepted as fulfillment of the requirement for the degree of Bachelor of Manufacturing Engineering (Honours) (Manufacturing Process). The members of the supervisory committee are as follows:

Signature : 

Supervisor's Name : Encik Taufik bin Syahroni

Date : 14 June 2006

DEDICATION

For my family; Allahyarham Mohamad Halim bin Sepaie,

Mrs. Faridah binti Awang,

Miss Munirah binti Mohamad Halim,

Miss Wahida binti Mohamad Halim,

Miss Adilah binti Mohamad Halim,

Mr. Aminuddin bin Mohamad Halim,

Miss Norazmany binti Awang,

Mr. Khalid bin Mohammad,

Mrs. Latifah binti Awang,

Mr. Awang bin Hussin,

Mr. Taufik bin Syahroni,

Mr. Nor Akramin,

Assoc. Prof. Jasmin binti Baba

ACKNOWLEDGEMENT

First of all, I would like to thanks to Allah for His bless and let my Final Year Project (Part 1) successfully done. Then, I would like to appreciate my parents for their encouragement in my life besides full support in my project.

I would like to thanks to En. Taufik bin Syahroni as my PSM's project supervisor in giving me guidance to complete this report and spend your time for me during my project term. It is something to encourage me because without his guidance, it difficult and impossible to prepare my report and believe in me which giving me many point in doing research work.

Lastly, I would like to thanks to En. Akramin for his skills and knowledge in taught about using the Witness simulation whereby he helps me to understand the software. Thanks again to everyone.

ABSTRACT

This PSM Project report is about the simulation model that applied in the manufacturing system. This simulation model will showed the process that included in the factory. From here also, we can see the process of producing a product from beginning until finishing. Firstly, before starting this project, an objectives and scope of project should be defined before. This is a guideline for me to complete this project. Then, the literature review or studying this title is done by referring to the journal, books, and articles. This process is important because to generate some ideas until know completely about the simulation model. Beside that, this is purpose to study about the definition of shop floor in factory and to know about the application of shop floor. Some of the generate ideas and practices have been described in this report. The limitation and problem occurred also have been stated in this reports. The topics will be discussed in this report included manufacturing issues that will be addressed using simulation, simulation software that will be using in manufacturing applications, technique to developed a simulation model and result from the simulation model. Comparison for each alternative and propose layout also will be discussed. For this PSM project, the project is more focused on Witness simulation software. This software acted as tool to create a simulation modeling in manufacturing system. This simulation software have been selected because it is easy and capable to simulate the activities, and also capable to simulate the arrival entities for each station of process. The process also can be set up for one shift duty that is 8 hours for working hours. Time that used in this process is in seconds. Process planning and the methodology in completing this process also have been described in this report completely.

Keywords: productivity, cycle time, Work In Progress (W.I.P), tolerance, modeling.

ABSTRAK

Projek PSM ini adalah berkenaan dengan model yang telah disimulasikan dan diaplikasikan didalam sistem proses pembuatan. Model yang telah disimulasikan ini menunjukkan proses yang berlaku dalam kilang. Dari sini juga, kita dapat lihat proses untuk penghasilan produk dari permulaan hingga ke akhir proses. Pada mulanya, sebelum memulakan projek ini, objektif dan skop projek perlulah dikenalpasti dahulu. Ini merupakan satu panduan kepada saya untuk menyiapkan projek tersebut. Kemudian, kajian ilmiah atau proses mempelajari secara mendalam tentang tajuk ini telah dilakukan dengan membuat rujukan melalui jurnal-jurnal, buku-buku rujukan dan rencana-rencana. Rujukan-rujukan ini adalah penting kerana ia bertujuan untuk mendapatkan idea-idea sehingga mengetahui secara mendalam proses untuk membuat suatu model yang ingin disimulasikan. Selain itu juga, ia bertujuan untuk mempelajari tentang definisi “Shop Floor” di kilang dan untuk mengetahui tentang aplikasinya. Sesetengah idea yang diperolehi akan dihuraikan secara mendalam dalam tesis ini. Kekurangan dan masalah timbul sewaktu menjalankan projek ini juga akan diterangkan didalam tesis ini. Antara topik-topik yang akan dibincangkan termasuklah isu sistem pembuatan yang akan ditunjukkan didalam bentuk model yang telah disimulasikan, perisian simulasi yang akan digunakan dalam aplikasi sistem pembuatan, teknik-teknik untuk membangunkan simulasi model dan keputusan yang diperolehi dari simulasi model. Perbandingan bagi setiap alternatif dan cadangan bentuk susunan mesin juga akan dibincangkan. Untuk projek PSM ini, ia lebih tertumpu pada perisian simulasi Witness. Perisian ini telah dipilih kerana ianya mudah dan mampu untuk membangunkan aktiviti dan juga boleh menunjukkan bentuk proses yang berlaku didalam kilang bermula dari proses awal hingga akhir untuk setiap seksyen. Proses yang dijalankan juga boleh ditetapkan untuk

masa satu shif iaitu 8 jam waktu bekerja. Masa yang telah ditetapkan dalam model ini adalah dalam bentuk saat. Perancangan dan juga kaedah-kaedah untuk projek ini juga akan diterangkan dalam tesis ini dengan selengkapnya.

TABLE OF CONTENTS

| | |
|-------------------------------------------------|----------|
| Acknowledgement | i |
| Abstract | ii |
| Abstrak | iii |
| Table of Contents | v |
| List of Figures | x |
| List of Tables | xii |
| List of Abbreviations, Specialized Nomenclature | xiv |
| | |
| 1. INTRODUCTION | 1 |
| 1.1 Background | 1 |
| 1.2 Situation in industry | 2 |
| 1.3 Problem statement | 4 |
| 1.4 Objectives | 5 |
| 1.5 Scope of the study | 5 |
| 1.6 Definition for shop floor | 6 |
| 1.7 Benefit of shop floor | 7 |
| | |
| 2. LITERATURES REVIEW | 8 |
| 2.1 Introductions | 8 |
| 2.2 Definition of manufacturing systems | 9 |
| 2.3 Integrated manufacturing systems | 12 |
| 2.4 Definition of production manufacturing | 14 |
| 2.5 Definition of systems | 14 |
| 2.6 Structure of manufacturing systems | 15 |
| 2.6.1 Plant layout | 15 |
| 2.7 Introduction to modeling and simulation | 18 |
| 2.7.1 Types of simulation | 19 |
| 2.7.1.1 Static simulation | 19 |

| | |
|-------------------------------------------------|-----------|
| 2.7.1.2 Dynamic simulation | 21 |
| 2.7.2 Application manufacturing simulation | 23 |
| 2.8 Manufacturing modeling features | 23 |
| 2.8.1 Resources | 24 |
| 2.8.2 Material handling | 24 |
| 2.8.3 Workstation logic | 24 |
| 2.8.4 Buffers | 24 |
| 2.8.5 Order / process plan | 25 |
| 2.9 Use of simulation in manufacturing | 25 |
| 2.10 Application of simulation in manufacturing | 28 |
| 2.10.1 Method analysis | 29 |
| 2.10.2 Plant layout | 30 |
| 2.10.3 Batch sizing | 34 |
| 2.10.4 Production control | 34 |
| 2.10.5 Inventory control | 35 |
| 2.10.6 Real time control | 36 |
| 2.10.7 Emulation | 37 |
| 2.11 The important of modeling and simulation | 38 |
| 2.12 Why simulation | 38 |
| 2.13 Simulation optimization | 39 |
| 2.14 Chapter Summary | 39 |
| 3. METHODOLOGY | 40 |
| 3.1 Introduction | 40 |
| 3.2 Research methodology | 41 |
| 3.2.1 Defining an objectives | 46 |
| 3.3 Research design | 47 |
| 3.4 Research tool | 47 |
| 3.4.1 Data collecting | 47 |
| 3.4.2 Data storage | 49 |

| | |
|--------------------------------------------|-----------|
| 3.4.3 Simulation software | 49 |
| 3.4.3.1 Witness Simulation Software | 50 |
| 3.4.3.2 Witness Modeling Element | 50 |
| 3.4.3.3 Advantages of Witness Simulation | 50 |
| 3.4.3.4 Disadvantage of Witness Simulation | 51 |
| 3.4.3.5 Basic Discrete Elements | 51 |
| 3.5 Research planning | 53 |
| 3.6 Whole Planning For PSM Project | 53 |
| 4. DATA COLLECTION | 54 |
| 4.1 Introduction | 54 |
| 4.2 Data Collection | 56 |
| 4.3 General Data | 56 |
| 4.4 Actual Layout | 59 |
| 4.5 Project Activities | 59 |
| 4.6 Chapter Summary | 61 |
| 5. DEVELOPMENT OF SIMULATION MODEL | 62 |
| 5.1 Introduction | 62 |
| 5.2 Model Development | 62 |
| 5.3 Model Definition | 63 |
| 5.4 Simulation Model on Actual Process | 64 |
| 5.5 Structural Model (Early) | 66 |
| 5.6 Assumption | 66 |
| 5.7 Verification and Validation Process | 67 |
| 5.7.1 Definition for Verification | 67 |
| 5.7.2 Verification Process | 67 |
| 5.7.3 Definition for Validation | 68 |
| 5.7.4 Validation Process | 68 |
| 5.8 Run Time | 70 |

| | |
|------------------------------------------------------------------------|-----------|
| 5.9 Chapter Summary | 70 |
| 6. ALTERNATIVES SUGGESTION | 71 |
| 6.1 Introduction | 71 |
| 6.2 Explanation for Each Model | 71 |
| 6.3 Alternative Overcome | 73 |
| 6.3.1 Alternative 1 | 73 |
| 6.3.2 Alternative 2 | 76 |
| 6.4 Chapter Summary | 78 |
| 7. RESULT | 79 |
| 7.1 Introduction | 79 |
| 7.2 Simulation Analysis Result | 79 |
| 7.3 Model for Actual Process | 80 |
| 7.3.1 Result for Actual Process | 80 |
| 7.3.2 Machine Utilization | 80 |
| 7.4 Alternative 1 Model | 84 |
| 7.4.1 Result for Alternative 1 | 84 |
| 7.4.2 Machine Utilization | 84 |
| 7.5 Alternative 2 Model | 88 |
| 7.5.1 Result for Alternative 2 | 88 |
| 7.5.2 Machine Utilization | 88 |
| 7.6 Comparison between Actual Process, Alternative 1 and Alternative 2 | 92 |
| 7.6.1 Busy Value | 92 |
| 7.6.2 Idle Time | 94 |
| 7.6.3 PCB Product | 96 |
| 7.7 Chapter Summary | 96 |

| | |
|--------------------------------------------------------------------------------------------|-----|
| 8. DISCUSSION | 97 |
| 8.1 Introduction | 97 |
| 8.2 Pro Model Software | 97 |
| 8.3 Witness Software | 98 |
| 8.4 Simulation Result Analysis | 99 |
| 8.5 Comparison with actual simulation model, alternative 1 and alternative 2 | 99 |
| 8.6 Comparison on Output rate for an actual model with alternative 1 and alternative 2. | 101 |
| 8.7 Chapter Summary | 102 |
| 9. CONCLUSION | 103 |
| 10. REFERENCES | 104 |

LIST OF FIGURES

| | | |
|-----|--------------------------------------------------------------------------------------------------------------------|----|
| 2.1 | Three flows concerning manufacturing: flow of materials, flow of information and flow of costs. | 11 |
| 2.2 | Procedure of integrated manufacturing systems. | 13 |
| 2.3 | A modified SLP procedure. | 17 |
| 2.4 | Activity model of static simulation. | 20 |
| 2.5 | Activity model of dynamic simulation. | 22 |
| 2.6 | Decision range in manufacturing simulation. | 26 |
| 2.7 | Material Flow System. | 31 |
| 2.8 | Comparison between (a) process layout, (b) product layout and (c) cell layout. | 33 |
| 3.1 | Flowchart process of the Research Methodology | 42 |
| 3.2 | Steps in time study. | 44 |
| 3.3 | Time Study Board. | 48 |
| 3.4 | Stop Watch. | 48 |
| 4.1 | Role of Theoretical probability distribution in simulation. | 55 |
| 4.2 | The sketch for actual layout | 60 |
| 5.1 | Layout of actual process in simulation model using Witness Software | 64 |
| 5.2 | Figure above show the process for producing a PCB product. | 69 |
| 6.1 | Layout for alternative 1 and show the location of the adding machine at Edge Tapping Machine. | 72 |
| 6.2 | Layout for alternative 2 and show the location of the adding machine at Edge Tapping machine and OL Transfer Image | 73 |

| | | |
|-----|------------------------------------------------------------------------------------|----|
| 6.3 | Layout and path for alternative 1 | 74 |
| 6.4 | Layout and path for alternative 2 | 76 |
| 7.1 | Graph for idle time, busy and blocked for actual simulation Model. | 83 |
| 7.2 | Graph for busy, idle time and blocked for Alternative 1 simulation model. | 87 |
| 7.3 | Graph for busy and idle time simulation model for alternative 2 | 91 |
| 7.4 | Graph for combining the busy value data in actual, Alternative 1 and alternative 2 | 93 |
| 7.5 | Graph for idle time in actual, alternative 1 and alternative 2 | 95 |

LIST OF TABLES

| | | |
|-----|---------------------------------------------------------------------------------------------------------|----|
| 4.1 | Cycle time for each machine and areas. | 58 |
| 5.1 | Explanation each elements that using in the simulation model. | 64 |
| 5.2 | Command used for each elements in the simulation model | 65 |
| 5.3 | Comparison actual and simulation model | 69 |
| 6.1 | Table shows the alternative, changes and purpose of each Alternative. | 72 |
| 6.2 | Throughput PCB products after running the simulation (alternative 1) for 1 shift duty or 28800 seconds. | 75 |
| 6.3 | Throughput PCB products after running the simulation (alternative 2) for 1 shift duty or 28800 seconds. | 77 |
| 7.1 | Result for idle, busy, blocked and no of operation for actual process in simulation model. | 81 |
| 7.2 | Result for PCB products for actual process after running the Simulation model. | 82 |
| 7.3 | Result for idle, busy, blocked and no of operation for 1 st alternative. | 85 |
| 7.4 | Result for PCB products for 1 st alternative after running the model. | 86 |
| 7.5 | Result for idle, busy, blocked and no of operation for 2 nd alternative. | 89 |
| 7.4 | Result busy for Actual, Alternative 1 and Alternative 2. | 86 |
| 7.5 | Result for idle, busy, blocked and no. of operation for 2 nd alternative. | 89 |

| | | |
|-----|--------------------------------------------------------------------------------------------------|-----|
| 7.6 | Result for PCB product for 2 nd alternative after running the simulation model. | 90 |
| 7.7 | Result busy for actual, alternative 1 and alternative 2 | 92 |
| 7.8 | Result an idle time for actual, alternative 1 and alternative 2. | 94 |
| 7.9 | Result for PCB product after running the simulation for Actual, alternative 1 and alternative 2. | 96 |
| 8.1 | Percentage increments of busy value for each alternative model refer to the actual model. | 100 |
| 8.2 | Comparison on input rate, output rate and productivity for each model. | 101 |

LIST OF ABBREVIATIONS, SPECIALIZED NOMENCLATURE

| | | |
|-----------|---|------------------------------------------------|
| PSM | - | Projek Sarjana Muda. |
| KUTKM | - | Kolej Universiti Teknikal Kebangsaan Malaysia. |
| OR | - | Operation Research. |
| IE | - | Industrial Engineering. |
| M | - | Malaysia. |
| FMS | - | Flexible Manufacturing Systems. |
| CIM | - | Computer Integrated Manufacturing. |
| R & D | - | Research and Control. |
| Q | - | Quantity. |
| P | - | Production. |
| GT | - | Group Technology. |
| SLP | - | System Layout Planning. |
| R | - | Routing. |
| S | - | Supporting Service. |
| T | - | Time. |
| CAD | - | Computer Added Design. |
| DBR | - | Drum Buffer Rope |
| TCO | - | Total Lost Of Ownership. |
| PCB | - | Printed Circuit Board |
| DBR | - | Drum Buffer Rope. |
| QC | - | Quality Control. |
| QA | - | Quality Assurance |
| OL | - | Outer Layer. |
| W.I.P | - | Work In Progress. |
| Avg W.I.P | - | Average Work in Progress. |

CHAPTER 1

INTRODUCTION

1.1 Background

In this PSM project, I had chosen the title of Simulation Modeling and Optimization in Manufacturing: Case Study Shop Floor to fulfill my study in KUTKM. This case study focuses on the simulation for shop floor in industry. For this case study, to complete this project, I have chosen Company X Sdn. Bhd. that is locating at Batu Berendam area. This company produces a PCB product for Communication Company for Malaysia and Singapore. In this project, my case study will focus on the problem occurred at the production line for producing this product. Here, I also will determine the capacity output for this product and using Witness simulation I will show the process that is used in actual factory.

Firstly, I will go through for time study at this production line. For this part, I will go to Company X Sdn. Bhd. to take all the data in this factory. The data including all the time needed for the machine to produce a PCB product. These time studies are important for me because all this time will be using to put into the simulation using Witness simulation.

When the simulation is complete, we can see the operation after running the simulation. This simulation will show us the location all the machine and the plant layout that has in the factory and on how the product produces from raw material until

finish product. From this simulation, I can make analysis after the data print out from this simulation.

During this simulation model, I can observe what the problems are during the process. The problems that may be occur such as machine stop during the process of buffer. All this problems will affect the productivity. So that, it is my job to solve the problems in order to increase production line or reduce cost.

From here, I can say that this simulation is important for industry because we can make observation and detect the problem occur in the production line. After that, the improvement process will be done easily and faster.

1.2 Situation in industry

Now a day, we can see that manufacturing industries are facing a growing and rapid change. Major trend like globalization, customer orientation and increasing market dynamic lead to a shift in managerial principles: enterprises have to become more flexible, open, fast, effective, self organized, decentralized, to sum it up, agile. On enterprise level this lead to a *“shift from manufacturing to innovative, knowledge-based information and service application of products.”*

Still manufacturing serves as a basic function for any agile enterprise. Manufacturing faces the same challenges as the enterprise as a whole. For the future, manufacturing can not only rely on technical excellence in machining, technologies and methods but has to achieve organizational excellence in knowledge, experience and motivation as well. The shop floor as provider of physical goods has to become an agile entity within the enterprise and within a network or enterprises forming a virtual organization.

The call for agility challenges the shop floor with several problems. With an increasing occurrence of changes and dominating customer demand, management of manufacturing processes and the coordination of the various resources, i.e. machines materials, information, information, knowledge and humans, becomes a core task for shop floor control. Besides not only an optimal management of the current situation is necessary but a continuous improvement of practices and performance.

This lead to the question of adequate design concepts for shop floor control. Assessing industry, global leaders, best practices and hidden champions can be found. But in industrial reality at large, “the shop floor is not under control”. Even though various solutions ranging from organizational strategies like group technology, knowledge based scheduling and genetic algorithm do exist, the problem of inadequate performance of shop floor control tends to remain omnipresent in most industrial enterprises until today.

The situation can be summarized by the following observations:

- a. Most current managerial concepts tend to address the overall enterprise and usually are very general and not focused on manufacturing industry or the shop floor respectively.
- b. The shift towards the entrepreneurial function of management tends to leave manufacturing out of sight and often leads to the impression among practitioners that manufacturing is of no further importance.
- c. While managerial literature deals with organizations, classic industrial engineering research still tends to neglect the organizational issues of shop floor control while simultaneously producing an immense number of highly theoretical and hypothetical solutions every year.

- d. In industry shop floor control is overshadowed by the paradigm of “command and control” leaving management to rely on power as means of ensuring effective control rather than any kind of conceptual approach. Therefore any conceptual approach as a means of altering the command structure is opposed. As a result, operators and workers are left with an increasing pressure replacing an empty prophecy of self control.

1.3 Problem statement

Research on shop floor has long concentrate on the scheduling problem and its solution. Solving an organizational problem underwent reduction to a mathematical model. Traditional approaches, such as those in Operations Research (OR). Industrial Engineering (IE) and some commercial software development try to achieve ideal scheduling systems by focusing on the scheduling process itself. The modeling techniques applied thus result in a simplification of the original problem. In contrast, most practical engineering approaches try to avoid any sophisticated scheduling as such and focus upon stable design of the manufacturing system and the requirements of systems control and controllability. The neglect of scheduling and control is omnipresent in most commercial software packages which usually do feature no sophisticated scheduling solution. All these approaches still maintain the fiction of a deterministic world where one cause determines one result.

Shop floor control is an object for various disciplines from engineering, management to the social sciences. No comprehensive framework or even overview on shop floor control research currently exists. As a result, many problems of the real world remain unsolved, because deterministic approaches from research and practice have significant drawbacks. Due to the fixation on mathematical solutions in traditional research, many potentials present of real world production are not considered, e.g. operator experience, motivation and qualifications, are not taken into account. The