

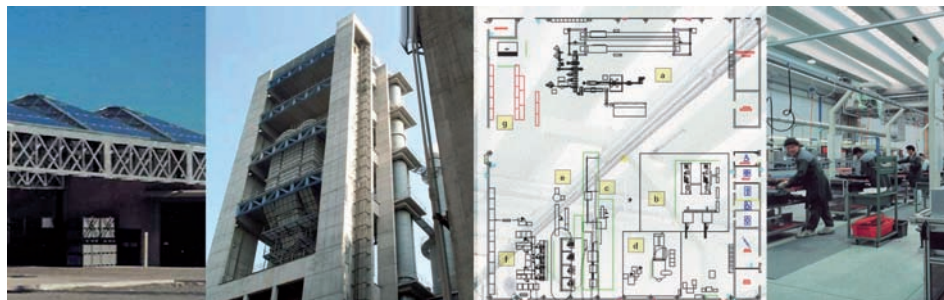
Marco Garetti



Design and Management of Production Systems: Tutorials and Case Studies

with the collaboration of
Natalia Duque Ciceri and Giacomo Tavola

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of Production Systems:
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Table of contents

Foreword	pag. 11
Premessa	» 13

Section 1 Industrial Reference Companies

1. Reference Company for Process Production: the NylPro Group	» 17
1. Introduction	» 17
2. The product	» 17
3. Production processes for nylon	» 18
4. Plant layout	» 23
2. Reference company for Discrete Production: the Wall Boiler Co.	» 24
1. Introduction	» 24
2. The Product	» 24
3. Production Processes for Wall Boilers	» 29
4. The Plant Layout	» 32
5. Enterprise Organization	» 39
6. Production Management	» 46

Section 2 Tutorials

Tutorial 1. Design of a process production plant	pag. 55
1. Introduction and covered topics	» 55
2. Tutorial description	» 55
3. Tutorial development	» 57
Case 1.1 – Continuous flow line design	» 57
Case 1.2 – Batch line design	» 61
Case 1.3 – Definition of overall plant renewal solution	» 64
4. Tutorial conclusions and results	» 64
Tutorial 2. Design of a job-shop manufacturing solution	» 65
1. Introduction and covered topics	» 65
2. Tutorial description	» 65
3. Tutorial development	» 66
Case 2.1 – Job shop design	» 67
4. Tutorial conclusions and results	» 72
Tutorial 3. Using Little’s law	» 73
1. Introduction and covered topics	» 73
2. Tutorial description	» 73
3. Tutorial development	» 73
Case 3.1 – Performance of job-shop producing DI1 code	» 74
Case 3.2 – Performance evaluation of job-shop producing the “Benessere” Hydraulic group	» 75
4. Tutorial conclusions and results	» 76
Tutorial 4. Design of a cellular manufacturing solution	» 77
1. Introduction and covered topics	» 77
2. Tutorial description	» 77
3. Tutorial development	» 79
Case 4.1 – Design of a cell production system	» 79
4. Tutorial conclusions and results	» 85

Tutorial 5. Design of a manual assembly shop	pag. 86
1. Introduction and covered topics	» 86
2. Tutorial description	» 86
3. Tutorial development	» 88
Case 5.1 – Design of assembly workstations	» 88
4. Tutorial conclusions and results	» 89
Tutorial 6. Design of a manual assembly line (part 1)	» 90
1. Introduction and covered topics	» 90
2. Tutorial description	» 90
3. Tutorial development	» 95
Case 6.1 – Analysis of the assembly cycle of the Blue Wind boiler	» 95
4. Tutorial conclusions and results	» 97
Tutorial 7. Design of a manual assembly line (part 2)	» 98
1. Introduction and covered topics	» 98
2. Tutorial description	» 98
3. Tutorial development	» 100
Case 7.1 – Planning of assembly stations and assem- bly cost	» 100
4. Tutorial conclusions and results	» 102
Tutorial 8. Production costs	» 103
1. Introduction and covered topics	» 103
2. Tutorial description	» 103
3. Tutorial development	» 104
Case 8.1 – Cost for the introduction of marginal product N66W	» 104
4. Tutorial conclusions and results	» 107
Tutorial 9. Inventory management in process plants	» 108
1. Introduction and covered topics	» 108
2. Tutorial description	» 108
3. Tutorial development	» 108

Case 9.1 – Inventory management of the raw materials	pag. 108
Case 9.2 – Inventory management for finished product N66Y	» 110
Case 9.3 – Stock level of filters for rotary driers	» 111
4. Tutorial conclusions and results	» 112
Tutorial 10. Stock management of screw like parts	» 113
1. Introduction and covered topics	» 113
2. Tutorial description	» 113
3. Tutorial development	» 113
Case 10.1 – Stock management of screws like parts	» 113
4. Tutorial conclusions and results	» 115
Tutorial 11. Aggregate production planning	» 116
1. Introduction and covered topics	» 116
2. Tutorial description	» 116
3. Tutorial development	» 117
Case 11.1 – Aggregate production plans	» 117
4. Tutorial conclusions and results	» 119
Tutorial 12. Generating MRP plan for Blue Wind boiler	» 120
1. Introduction and covered topics	» 120
2. Tutorial description	» 120
3. Tutorial development	» 121
Case 12.1 – MRP Plan for Blue Wind boiler	» 121
4. Tutorial conclusions and results	» 122
Tutorial 13. Kanban production management	» 123
1. Introduction and covered topics	» 123
2. Tutorial description	» 123
3. Tutorial development	» 124
Case 13.1 – Kanban production management	» 130
4. Tutorial conclusions and results	» 135

Tutorial 14. Real-time production scheduling of a flexible manufacturing system	pag. 137
1. Introduction and covered topics	» 137
2. Tutorial description	» 137
3. Tutorial development	» 139
Case 14.1 – Real Time Scheduling of WBC FMS	» 139
4. Tutorial conclusions and results	» 142

Glossary	» 143
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Tutorial List

Tutorial 1. Design of a process production plant	» 55
Tutorial 2. Design of a job-shop manufacturing solution	» 65
Tutorial 3. Using Little's law	» 73
Tutorial 4. Design of a cellular manufacturing solution	» 77
Tutorial 5. Design of a manual assembly shop	» 86
Tutorial 6. Design of a manual assembly line (part 1)	» 90
Tutorial 7. Design of a manual assembly line (part 2)	» 98
Tutorial 8. Production costs	» 103
Tutorial 9. Inventory management in process plants	» 108
Tutorial 10. Stock management of screw like parts	» 113
Tutorial 11. Aggregate production planning	» 116
Tutorial 12. Generating MRP plan for Blue Wind boiler	» 120
Tutorial 13. Kanban production management	» 123
Tutorial 14. Real-time production scheduling of a flexible manufacturing system	» 137

Cases List

Case 1.1 – Continuous flow line design	» 57
Case 1.2 – Batch line design	» 61

Case 1.3 – Definition of overall plant renewal solution	pag. 64
Case 2.1 – Job shop design	» 67
Case 3.1 – Performance of job-shop producing DI1 code	» 74
Case 3.2 – Performance evaluation of job-shop producing “Benessere” Hydraulic group	» 75
Case 4.1 – Design of a cell production system	» 79
Case 5.1 – Design of assembly workstations	» 88
Case 6.1 – Analysis of the assembly cycle of Blue Wind boiler	» 95
Case 7.1 – Planning of assembly stations and assembly cost	» 100
Case 8.1 – Cost for the introduction of marginal product N66W	» 104
Case 9.1 – Inventory management of raw materials	» 108
Case 9.2 – Inventory management for finished product N66Y	» 110
Case 9.3 – Stock level of filters for rotary driers	» 111
Case 10.1 – Stock management of screws like parts	» 113
Case 11.1 – Aggregate production plans	» 117
Case 12.1 – MRP Plan for Blue Wind boiler	» 121
Case 13.1 – Kanban production management	» 130
Case 14.1 – Real Time Scheduling of WBC FMS	» 139

Foreword*

This book comes from a rethinking of how to organize activities complementary to training courses on the theory of design and management of production systems. In the past, these tutorials were based on individual exercises or case studies that, while allowing to easily build a “proper case” for the specific application of theory, on the other hand they hardly allow the student to “identify himself” in the real production of a real company.

The novelty of this workbook consists in locating all applications of the theory in two reference companies that in the first part of the book are made known to the reader with a number of details about their products, technologies, facilities, organization, production management system, etc. The two companies are part of the two major classes to which industrial production systems belong, namely the class of process production and that of discrete manufacturing. The purpose of the first part of the book is to let each of these two companies to “belong to the reader”, thus enabling him to understand the company production mission, its strengths, operational constraints, configuration data, and the production management rules in place.

The second part of the book presents 14 tutorials offering the opportunity for application of theory into the reality of the two reference companies. From the learning perspective, this can give the impressive advantage to operate seamlessly within the same reality by simply going to examine different aspects, but always with a close attachment to the complexity of a real situation. Moreover, this approach lends itself to interesting and logical links between different tutorials, making the student understand well the

* Please note that the data and information contained in the description of the two reference companies, despite coming from industrial, have been appropriately modified in certain parts both for educational purposes and for reasons of confidentiality (this does not detract, however, the narrow realism of the cases treated). Also note that the figures reported in this text are to be considered as general indications and can differ from the data in Excel© spreadsheets.

characteristics of continuity, connection, and complexity that always characterize the problems of design and management of production systems.

The 14 tutorials are divided into two groups. The first 7 cover the most important design problems in production systems, ranging from the sizing of a batch and continuous process production system, to the design of manufacturing systems based on job-shop, cell and line solutions, and to assembly systems of various kinds. The second group of 7 tutorials is dedicated to production management issues, going from the analysis of costs, inventory management, the various production planning horizons (long, medium and short term), to the methods of Just in Time and real time scheduling.

To facilitate the development of tutorials, each tutorial refers to an Excel© file as the guiding and solving tool for each individual application. In this book, the structure of the supporting Excel© files is discussed case by case, while the spreadsheets (complete of work data, but missing the solutions) are freely available, basing on the following information: i) students of Politecnico di Milano, attending the course titled “Progettazione e gestione degli impianti di produzione”, can download the spreadsheets by accessing their course home-page from the Politecnico di Milano “Corsi online platform” (<http://corsi.metid.polimi.it/>), ii) the same applies (by accessing their courses home-pages) for the students of Politecnico di Milano, attending the courses titled “Design and management of production systems” and “Impiantistica industriale e gestione della produzione”, iii) all other readers can download the spreadsheets by accessing the website of the FrancoAngeli publishing house (Biblioteca multimediale, www.francoangeli.it). As for the solutions, at the end of each tutorial there are given general indications about the values that the solution should take. This is because, in relation to the approximation of numerical values and to possible alternative choices in solution development, it is more appropriate to give a results range rather than a precise value. However, teachers who wish to take this workbook as reference book for tutorial development in their teaching class can ask the author the provision of Microsoft Excel© spreadsheets fully solved (in this respect, please send an e-mail properly documented to marco.garetti@polimi.it).

Premessa

Questo libro deriva da un ripensamento del modo di organizzare le attività di esercitazione complementari a corsi teorici sulla progettazione e gestione dei sistemi di produzione. Tradizionalmente infatti le esercitazioni sono state basate su singoli esercizi o case-studies che se, da un lato, consentono di costruire facilmente il “caso giusto” per la specifica applicazione teorica, dall’altro, difficilmente permettono allo studente di “immedesimarsi” nella realtà produttiva di una vera azienda. La novità di questo eserciziario consiste nell’aver ubicato tutte le applicazioni della teoria all’interno di due “aziende di riferimento” che, nella prima parte del libro, vengono fatte conoscere al lettore con tutta una serie di dettagli sui loro prodotti, sulle tecnologie utilizzate, sugli impianti, sull’organizzazione, sulla gestione della produzione ecc.

Le due aziende fanno riferimento alle due principali macroclassi cui appartengono i sistemi di produzione industriale e cioè la classe delle produzioni di processo e quella delle produzioni manifatturiere¹.

Lo scopo della prima parte del libro è di far “appartenere al lettore” ciascuna di queste due aziende, così da metterlo in grado di comprenderne la mission produttiva, i punti di forza e i vincoli operativi, i dati di configurazione e di operatività e le caratteristiche gestionali in atto.

A seguire, la seconda parte del libro presenta 14 tutorials che costituiscono altrettante occasioni di applicazione della teoria all’interno della realtà delle due aziende di riferimento. Dal punto di vista dell’apprendimento si ha così il formidabile vantaggio, nei diversi tutorials, di operare senza soluzione

¹ Si precisa che i dati e le informazioni contenuti nella descrizione delle due aziende di riferimento, pur provenendo da effettive realtà industriali, sono stati in talune parti opportunamente modificati sia per ragioni didattiche, che per ragioni di riservatezza (ciò non inficia tuttavia lo stretto realismo dei casi trattati). Si ricorda inoltre che i dati numerici riportati in questo testo sono da ritenere come indicativi e possono differire dai dati presenti nei fogli di calcolo Excel©.

di continuità all'interno della medesima realtà di cui semplicemente si vanno a esaminare aspetti diversi, ma sempre con uno stretto e realistico aggancio alla concretezza e alla complessità di una situazione "vera". Inoltre, questo tipo di approccio si presta a interessanti collegamenti logici e operativi fra un tutorial e l'altro, facendo ben comprendere allo studente le caratteristiche di continuità, interconnessione e complessità che sempre caratterizzano i problemi di progettazione e gestione dei sistemi di produzione.

I 14 tutorials sono divisi in 2 gruppi, i primi 7 coprono i più importanti problemi di progettazione dei sistemi di produzione andando dal dimensionamento di produzioni di processo batch e in linea, al dimensionamento di sistemi di fabbricazione a job-shop, a cellule e in linea e di sistemi di montaggio di vario tipo. Il secondo gruppo di 7 tutorial è invece dedicato ai problemi di gestione dei sistemi di produzione andando dall'analisi dei costi, alla gestione delle scorte, ai diversi orizzonti di programmazione della produzione (a lungo, medio e breve termine), fino ai metodi del Just in Time e al controllo in tempo reale.

Per facilitare lo sviluppo delle esercitazioni, ciascun tutorial fa riferimento agli schemi di un foglio Excel© che funge da guida e strumento di soluzione di ogni singola applicazione. In questo libro, viene illustrata l'impostazione dei fogli di supporto Excel© caso per caso, mentre tutti i diversi fogli elettronici (completi dei dati di lavoro, ma mancanti delle soluzioni), sono liberamente reperibili sulla base delle seguenti indicazioni: i) gli studenti del Politecnico di Milano, iscritti al corso "Progettazione e gestione degli impianti di produzione", possono scaricare i file accedendo alla homepage del loro corso dalla piattaforma "Corsi on-line" del Politecnico di Milano (<http://corsi.metid.polimi.it/>), ii) lo stesso vale (accedendo alla homepage dei rispettivi corsi) per gli studenti del Politecnico di Milano, iscritti ai corsi "Design and management of production systems" e "Impiantistica industriale e gestione della produzione", iii) tutti gli altri lettori possono scaricare i file accedendo all'area multimediale del sito www.francoangeli.it, avendo a disposizione il libro acquistato. Per quanto riguarda le soluzioni, alla fine di ciascun tutorial vengono fornite delle indicazioni di massima sui valori che la soluzione deve assumere (infatti, in relazione all'approssimazione dei valori e alle alternative di scelta possibili è più corretto indicare per la soluzione un range di massima, piuttosto che non un valore preciso). Esiste inoltre la possibilità per i docenti che intendano adottare questo eserciziaro come strumento di lavoro nella loro classe di richiedere all'autore la fornitura dei fogli Microsoft Excel© risolti (a tal riguardo inviare una e-mail opportunamente documentata a marco.garetti@polimi.it).

Section 1

Industrial Reference Companies

1. Reference Company for Process Production: the NylPro Group

1. Introduction¹

The NylPro Group is the company assumed as a reference case for the process production class of production facilities. Within this book, the environment of the NylPro Group will be used as a reference for developing both plant design and production management issues that are typical of the process production type of companies.

NylPro is an Italian chemical group with the main site located in Milan and several production plants distributed in various regions of Italy (2 in the North, 1 in the Centre and 1 in the South). All these plants produce different variants of nylon-based products – differing from each other for the recipes (that is, the quantity of raw materials each product requires).

The geographical distribution of the production plants is dependent on the main local demand of markets served, as nylon has numerous applications spanning from the textile sector to the food and beverage sectors.

2. The product

Nylon is a thermoplastic material chemically defined as condensation copolymers formed by reacting equal parts of a *diamine* and a *dicarboxylic acid* and made by linear macromolecules laid in parallel.

Nylon has a broad variety of applications as (see fig. 1):

- single wire for filtering fabrics in chemical industry, fishing lines, food envelopes and containers, magnetic tapes, etc;

¹ The description of the NylPro Group has been freely inspired from reality of process companies of chemical sector. Thus even if data and situations are strictly realistic, no direct reference to existing companies can be made.

- polymer for injection melted mechanical components as gears, screws, etc.

Figura 1 – Typical application of nylon



3. Production processes for nylon

The nylon production processes can be divided in two different classes:

- primary processes: the raw material is oil based and the process output is made of nylon chips;
- secondary processes: nylon chips are the raw material and the process output is made of plastic film, plastic rope or casted objects.

Primary processes belong to the process production type of manufacturing and they can lead to two different factory solutions:

- discontinuous process flow (or batch): where each phase of the production process is performed on independent machines working on a pre-determined quantity of material (the batch);
- continuous process flow: where the material is processed during its continuous flow within the production plant.

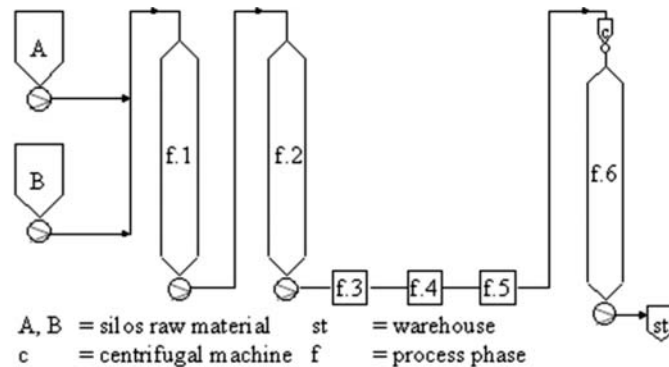
3.1. Continuous process

In a continuous flow production system (fig. 2), only one type of product can be realized. The tanks A and B contain the two raw components (*i.e.* diamine and dicarboxylic acid), derived from oil that, being in the liquid state, can be pumped directly to the polymerization tower. The usage of two similar towers for polymerization (f.1 and f.2), in the facility described in fig. 2, is due to the reaction time: in fact, fixed the production capacity Q of the system (in terms of production volume per hour), the volume of the reaction tower V is connected to the process reaction time t by means of the formula:

$$V [m^3] = Q [m^3 / h] \times t [h]$$

Where t is the reaction time (in hour) and Q is the production capacity (in m^3/h). After the polymerization, through the phases from f.3 to f.5 the chips are obtained. The final phase (f.6, post-condensation) completes the production cycle.

Figure 2 – Continuous process for nylon production



In this type of facility, the flow of material is continuous and, as a consequence, the adjustment of each phase is strictly dependent on the other phases. The optimal utilization of the plant is achieved after a transitory phase consequent to the start up, during which it is not possible to exploit the entire capacity of the system. The stops of the system should also be carefully planned, due to the high costs involved. As a consequence, the flexibility is sacrificed in order to attain cost efficiency. Product type and production rhythm can be changed by only paying high set-up costs due to extended production stoppage and waste of material.