Production Development

Monica Bellgran • Kristina Säfsten

Production Development

Design and Operation of Production Systems



Monica Bellgran, Dr. Haldex AB Biblioteksgatan 11 SE-103 88 Stockholm Sweden monica.bellgran@mdh.se Kristina Säfsten, Dr. Jönköping University School of Engineering SE-551 11 Jönköping Sweden kristina.safsten@ith.hi.se

ISBN 978-1-84882-494-2 e-ISBN 978-1-84882-495-9 DOI 10.1007/978-1-84882-495-9 Springer London Dordrecht Heidelberg New York

British Library Cataloguing in Publication Data A catalogue record for this book is available from the British Library

Library of Congress Control Number: 2009939259

© Springer-Verlag London Limited 2010

Apart from any fair dealing for the purposes of research or private study, or criticism or review, as permitted under the Copyright, Designs and Patents Act 1988, this publication may only be reproduced, stored or transmitted, in any form or by any means, with the prior permission in writing of the publishers, or in the case of reprographic reproduction in accordance with the terms of licences issued by the Copyright Licensing Agency. Enquiries concerning reproduction outside those terms should be sent to the publishers.

The original edition of this book was published in Swedish by Studentlitteratur as *Produktions-utveckling – Utveckling och drift av produktionssystem.* © Studentlitteratur, Lund, 2005

The use of registered names, trademarks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant laws and regulations and therefore free for general use.

The publisher makes no representation, express or implied, with regard to the accuracy of the information contained in this book and cannot accept any legal responsibility or liability for any errors or omissions that may be made.

Cover design: eStudioCalamar, Figueres/Berlin

Printed on acid-free paper

Springer is part of Springer Science+Business Media (www.springer.com)

Acknowledgements

We are grateful to the following for permission to reproduce copyright material: Fig. 1.1, line drawing in Sect. 1.2.4, line drawing in Sect. 1.3.1, Fig. 5.13, Fig. 5.14, Fig. 5.15, Fig. 8.2, Fig. 8.12, Fig. 8.18, Fig. 10.7, and Fig. 12.1 are reprinted by permission from the originator Mario Celegin; Fig. 1.2 from Crossfunctional co-operation and networking in industrial settings, Royal Institute of Technology, Stockholm, Copyright © 2002 (Gabrielsson 2002) is reprinted by permission from the originator Asa Gabrielsson: Fig. 2.2 from Theory of Technical Systems, Springer-Verlag, Berlin, Copyright © 1988 (Hubka and Eder 1988), is reprinted by permission from Springer-Verlag GmbH, Heidelberg; Fig. 2.3 from Robotics and Computer Integrated Manufacturing Vol. 3, No. 2, Decision support in design and optimization of flexible automated manufacturing and assembly, Copyright © 1987 (Seliger et al. 1987) is reprinted by permission from Elsevier; Fig. 2.7 from Från Taylor till Toyota, Studentlitteratur, Lund, Copyright © 2000 (Sandkull and Johansson 2000) is reprinted by permission from Studentlitteratur AB; Fig. 2.8 from Performance Assessment of Assembly Systems, Royal Institute of Technology, Stockholm, Copyright © 2000 is reprinted by permission from the originator Magnus Wiktorsson (Wiktorsson 2000); Fig. 3.1 and Table 10.1 from Restoring our Competitive Edge: Competing Through Manufacturing, John Wiley & Sons, Inc. New York, Copyright © 1984 (Hayes and Wheelwright 1984) are reprinted by permission from John Wiley & Sons; Table 3.2 from Restoring Manufacturing in the Corporate Strategy, John Wiley & Sons, Inc., New York, Copyright © 1978 (Skinner 1978) is reprinted by permission from John Wiley & Sons, Inc.; Table 3.4 from Manufacturing Strategy: linking competitive priorities, decision categories and manufacturing networks, Production Economic Research in Linköping, Dissertation, Linköping, Copyright © 2002 (Rudberg 2002) is reprinted with permission from the originator Martin Rudberg; Table 3.5 from Produktionslogistik, Studentlitteratur, Lund, Copyright © 2003 (Mattsson and Jonsson 2003) is reprinted by permission from Studentlitteratur AB; Fig. 3.9 and Fig. 3.12 from Manufacturing Strategy: Text and Cases, 2nd edition, Palgrave, Hampshire, Copyright © 1985 (Hill 2000) are reprinted by permission from vi Acknowledgements

Palgrave Macmillan Publishers Ltd.; Fig. 3.11 and Fig. 8.8 from Operations Management, 3rd ed. Prentice Hall, Pearson Education, Inc., Upper Saddle River. NJ., Copyright © 2001 (Slack et al. 2001), are reprinted by permission from Pearson Education, Inc.: Table 3.6 from Produktionsekomi, Studentlitteratur, Lund. Copyright © 2000 (Olhager 2000) is reprinted by permission from Studentlitteratur AB; Fig. 4.3 from Det nya bilarbetet, Konkurrensen mellan olika produktionskoncept i svensk bilindustri 1970–1990. Copyright © 1990 (Berggren 1990) is reprinted by permission from the originator Christian Berggren; Fig. 5.1 and Fig. 9.4 from Pilot Production and Manufacturing Start-up in the Automotive Industry: Principles for Improved Performance, Doctoral Thesis, Chalmers University of Technology, Gothenburg, Copyright © 1999 (Almgren 1999) are reprinted by permission from the originator Henrik Almgren: Fig. 5.2 and Fig. 5.12 from Från system till process – kriterier för processbestämning vid verksamhetsanalys, Linköping Studies in Information Science, Dissertation No. 5, Linköping, Copyright © 2001 (Lind 2001) are reprinted by permission from the originator Mikael Lind; Fig. 5.3 from Product Design: Fundamentals and Methods, John Wiley & Sons Ltd., Chichester, England, Copyright © 1995 (Roozenburg and Eekels 1995) is reprinted by permission from Wiley-Blackwell, Oxford; Fig. 5.5 from Manufacturing Systems Design and Analysis: Context and Techniques, Chapman & Hall. London Copyright © 1994 (Wu 1994) is reprinted with kind permission of Springer Science and Business Media; Fig. 5.6, Table 5.1 and Fig. 9.10 from Nyanskaffning av produktionssystem – mer än bara inköp, IVF-Rapport 99827. Göteborg, Copyright © 1999 (Johansson and Nord 1999) are reprinted by permission from the CEO Mats Lundin: Fig. 5.8 from Handbok för utformning av alternativa monteringssystem till konventionell linemontering, Chalmers University of Technology, Gothenburg, Copyright © 1981 (Engström and Karlsson 1981) is reprinted with permission from the originator Tomas Engström: Table 5.5 from Product Design and Development, 2nd ed, McGraw-Hill Higher Education, USA. Copyright © 2000 (Ulrich and Eppinger 2000) is reprinted by permission from McGraw-Hill; Fig. 5.10 from Model-based Approaches to Managing Concurrent Engineering, Journal of Engineering Design, Vol. 2, No. 4, Copyright © 1991 (Eppinger 1991) is reprinted by permission from Taylor & Francis Ltd. (http://www.informaworld.com); Fig. 5.18 and Table 5.6 from Inter-Project Learning: A Quality Perspective, Linköping Studies in Science and Technology, Thesis No. 839, Linköping, Copyright © 2000 (Antoni 2000) is reprinted by permission from the originator Marc Antoni; Fig. 5.19 from Lärande mellan projekt, In: Berggren C, Lindkvist L (eds.) Projekt, Organisation för målorientering och lärande, Copyright © 2000 Studentlitteratur, Lund, (Tell and Söderlund, 2001) is reprinted by permission from Studentlitteratur AB; Fig. 6.2 from International Journal of Production Economics, Vol. 41, pp. 335–341, Manufacturing Strategy and Capital Budgeting Process, Copyright © 1995 (Pirttilä and Sandström 1995) is reprinted by permission from Elsevier; Table 6.5 from Strategi för produktion och produktutveckling: integration och flexibilitet, Publica, Stockholm, Copyright © 1993 (Lindberg et al. 1993) is reprinted by permission from the editor Per Lindberg; Fig. 7.2, Fig. 7.3, Fig. 7.4 and Fig. 7.5 from Learning to see, Copyright

Acknowledgements vii

© 1999–2008 Lean Enterprise Institute, Inc. All rights reserved, (Rother and Shook 2002) are reprinted by permission from Lean Enterprise Institute: Fig. 7.8 from Production System Evaluation: A Theoretical Analysis. Linköping Studies in Science and Technology, Thesis No. 638, Linköping university, Linköping, Copyright © 1997 (Öhrström 1997) is reprinted by permission from the originator Pernilla Öhrström; Fig. 8.4 from Industriell ekonomi, Studentlitteratur, Lund Copyright © 1997 (Aniander et al. 1997) is reprinted by permission from Studentlitteratur AB; Fig. 3.7 from Materialadministration och logistik: grunder och möjligheter, Liber Ekonomi, Malmö, Copyright © 1995 (Storhagen 1995) is reprinted by permission from Liber Ekonomi; Fig. 8.9, Fig. 8.10, Fig. 8.11, Fig. 8.13 and Fig. 9.9 from Produktionsekomi, Studentlitteratur, Lund, Copyright © 2000 (Olhager 2000) are reprinted by permission from Studentlitteratur AB; Fig. 8.14 from Integrerad organisationslära, Studentlitteratur, Lund, Copyright © 1995 (Bruzelius and Skärvad 1995) are reprinted by permission from Studentlitteratur AB: Table 8.7 from Control Engineering Practice, Vol. 7, pp. 173-182, Are operators and pilots in control of complex systems? Copyright © 1999 (Mårtensson 1999) is reprinted with permission from the originator Lena Mårtensson: Fig. 9.2 from Product Introduction within Extended Enterprises – Descriptions and Conditions. Linköping Studies in Science and Technology, Licentiate Thesis no. 978, Linköping university, Linköping, Copyright © 2005 (Johansen 2005) is reprinted with permission from the originator Kerstin Johansen; Fig. 9.5, Fig. 9.6 and Fig. 9.7 from Product Development Performance, Harvard Business School Press, Boston, Massachusetts, Copyright © 1991 (Clark and Fujimoto 1991) are reprinted by permission from Harvard Business School Publishing Corporation; Table 9.2 and Table 9.3 from Projektering och idrifttagning av nya produktionssystem – en analysmodell för utvärdering av styrkor och svagheter i det egna företaget, IVF-rapport 96040. Göteborg, Copyright © 1996 (Johansson and Rydebrink 1996) are reprinted by permission from the CEO Mats Lundin; Table 10.4, Table 10.5 and Table 11.1 from TPM-Vägen till ständiga förbättringar, Studentlitteratur, Lund, Copyright © 2000 (Ljungberg 2000) are reprinted by permission from Studentlitteratur AB; Fig. 10.4 and Fig. 10.5 from Process Efficiency and Capability Flexibility, Developing a Support Tool for Capacity Decisions in Manual Assembly Systems. Linköping Studies in Science and Technology, Dissertation No. 617, Linköping university, Linköping, Copyright © 2000 (Petersson 2000) is reprinted by permission from the originator Per Petersson; Fig. 11.1 from Quality from customer needs to customer satisfaction, Studentlitteratur, Lund (Bergman och Klefsjö 2003) is reprinted by permission from Studentlitteratur AB; Fig. 11.2 from Production Disturbance Handling in Swedish Manufacturing Industry: a Survey Study (Ylipää et al. 2004) is reprinted by permission from the originator Torbjörn Ylipää; Fig. 11.3 and Fig. 11.4 from Effektivare tillverkning! Handbok för att systematiskt arbeta bort produktionsstörningar, IVF-skrift 04805, Göteborg (TIME-handbook 2004) are reprinted by permission from the CEO Mats Lundin; Press cutting from SME Manufacturing Engineering Viewpoints section, Vol. 130, No. 2, Lean: Not Just a Better Toolbox (Flinchbaugh 2003) is reprinted by permission from the originator Jamie Flinchbaugh.

Contents

1	Prod	uction I	Development over Time	1
	1.1	Production Development in Focus		
		1.1.1	Time to Emphasise the Importance of Production	1
		1.1.2	Part of the Product Realisation Process	5
		1.1.3	Structured Way of Working	6
		1.1.4	Road Map of the Book	7
	1.2	Indust	rial Revolutions	9
		1.2.1	The Historical Perspective	9
		1.2.2	The First Industrial Revolution	10
		1.2.3	The Second Industrial Revolution	11
		1.2.4	Black Ford Model T and Fordism	12
		1.2.5	Annual Model Change and Sloanism	17
	1.3	Organ	isational Fundamentals	18
		1.3.1	Scientific Management	19
		1.3.2	Organisational Theory of Importance	
			for Industrial Production	22
		1.3.3	Socio-Technical Organisational Theory	25
	1.4	Toyota	a Production System	26
		1.4.1	The Founder of Toyota	26
		1.4.2	Inspiration from USA	27
		1.4.3	Towards Lean Production	29
		1.4.4	The Toyota Way	30
	1.5	Indust	rialisation in Sweden	31
		1.5.1	Development Towards Mass Production	31
		1.5.2	Alternative Production Concept	32
	1.6	Produc	ction Development: A Summary	34
		1.6.1	External Influences	34
		1.6.2	Actual Options	35
		1.6.3	Strategies and Fundamental Attitudes	36

x Contents

2	Prod	luction S	ystem	37		
	2.1					
		2.1.1	Characteristics of a System			
		2.1.2	Production: A Transformation System			
		2.1.3	Classification of Systems			
		2.1.4	Open System			
	2.2		s a Production System?			
		2.2.1	Terminology			
		2.2.2	The Structure of the Production System			
		2.2.3	Life-Cycle Perspective			
3	Fron	n Busines	ss Plans to Production	49		
-	3.1		ies to Reach Targets			
		3.1.1	Manufacturing Strategy			
		3.1.2	Competitive Factors			
		3.1.3	Decision Categories			
		3.1.4	Formulating and Implementing	00		
		5.1.1	Manufacturing Strategies	63		
	3.2	The Pro	oduction System's Contribution to Competitiveness			
	3.3		tion System and Manufacturing Strategy in Balance			
	5.5	3.3.1	Product Profiling			
	3.4		roduction System at Lesjöfors AB			
4	Prod	Production System Development				
•	4.1	New or Changed Production Systems				
	4.2	Industrial Development of Production Systems				
		4.2.1	Typical Development Situations			
		4.2.2	Industrial Practice			
		4.2.3	Structured Ways of Working			
	4.3	Evaluation: Part of Development.				
		4.3.1	Evaluation of Existing Production Systems			
		4.3.2	Evaluation of System Alternatives			
		4.3.3	Evaluation of Equipment- or System Suppliers			
		4.3.4	Evaluation After Change			
		4.3.5	Factors Affecting Evaluation of Production Systems	98		
	4.4		the Walls"			
	4.5		tion System Designers			
	4.6		ssembly Plant in Uddevalla			
5	Prod	luction S	ystem Development in Theory	109		
_	5.1		nental Concepts and the Knowledge Area			
	J.1	5.1.1	Design and Development			
		5.1.2	Evaluation and Follow-Up			
		5 1 3	Process	114		

Contents xi

	5.2	The Development Process		115
		5.2.1	Design: Problem-Solving and Decision	116
		5.2.2	Activities in the Development Process	118
		5.2.3	Industrial versus Academic Perspectives	121
		5.2.4	Different Approaches to the Design Process	123
	5.3	The Ev	aluation Process	126
	5.4	Produc	tion Development: Part of Product Realisation	130
		5.4.1	Parallel Development Processes	130
		5.4.2	Design Activity Dependency	134
	5.5	Learnir	ng and Production System Development	135
		5.5.1	Comprehensive View and Process Perspective	136
		5.5.2	Development of Production Systems	
			as Process and Project	137
		5.5.3	Learning During System Development	140
6		_	Preparation for Efficient Development	145
	6.1		nework Supporting Development	
			Production System	
	6.2	Contex	tual Aspects	
		6.2.1	Perspectives and Attitudes	
		6.2.2	Company Preconditions	
		6.2.3	Investment Considerations	
	6.3	Manage	ement and Control	156
		6.3.1	Resource Allocation to Production Engineering	
			and Production Development	
		6.3.2	Time Perspective	159
		6.3.3	Work Team Composition	160
		6.3.4	Creativity and Analytical Ability	163
	6.4	A Struc	ctured Way of Working	165
7	Prepa		Design of Production Systems	
	7.1	_	ound Study	
		7.1.1	The Importance of Solid Preparatory Work	
		7.1.2	Starting Point for System Design	
		7.1.3	Evaluation of Existing Production Systems	
	7.2		ıdy	
		7.2.1	Pre-Study Content: Strategic and Pushing	
		7.2.2	To Handle Uncertainties	
		7.2.3	Strategy for Future Production Systems	
	7.3	Resulti	ng Requirement Specification	185
8	_		valuation of Production Systems	191
	8.1	_	Specification	191
		8.1.1	Handling Complexity	
		812	Modelling	194

xii Contents

	8.2	Develo	ping Conceptual Production Systems	195
		8.2.1	Flows and Flow Principles	
		8.2.2	Flowcharts	197
		8.2.3	Production Planning	200
		8.2.4	Choice of Process and Layout	
		8.2.5	Level of Technology and Automation	209
		8.2.6	Work Organisation and Work Environment	211
	8.3	Evaluat	tion of Solution Alternatives	214
		8.3.1	Conditions for Evaluation During	
			the Development Process	217
		8.3.2	Methods for Evaluation	
	8.4	Detaile	d Design of the Chosen Alternative	220
		8.4.1	Detailed Layout	222
		8.4.2	Planning the Layout	225
		8.4.3	Work Studies	227
		8.4.4	Detailed Design of Work and Work Place	227
	8.5	System	s Solution	230
9	From	Systam	Solution to Production System in Operation	231
,	9.1		nent Production Systems	
	7.1	9.1.1	Terminology	
		9.1.2	Different Start-Up Situations	
	9.2		ng Production Systems	
	9.3		ng and Preparing Production Start-Up	
	7.5	9.3.1	Start-Up Model	
		9.3.2	Organisation and Management	
	9.4	Carry-Out Production Start-Up		
	<i>7</i>	9.4.1	Efficient Start-Up of Production Systems	
		9.4.2	Problems During Production Start-Up	
	9.5		te the Result	
	,	9.5.1	Evaluation of Production System After Start-Up	
		9.5.2	Prerequisites for Evaluation After Start-Up	
		9.5.3	Analysis of the Development Process	
10			ystem Performance	
	10.1		Class Manufacturing	
	40.	10.1.1	Successful Production Systems	
	10.2		Should Be Measured?	
		10.2.1	Productivity and Efficiency	
		10.2.2	Overall Equipment Effectiveness	
		10.2.3	Manual Assembly Efficiency	
	10.2	10.2.4	Measures Associated with Competitive Factors	
	10.3	Measur	res and Methods for Follow-Up in Practice	268

Contents xiii

	10.4	Continuous Follow-Up of Performance	271
		10.4.1 Different Measurement Systems	271
		10.4.2 Use of Measurement Systems	
11	The Art of Avoiding Production Disturbances		
	11.1	Related Concepts	
		11.1.1 Dependability	
		11.1.2 Production Disturbances	280
	11.2	Production Efficiency	282
		11.2.1 Reduced Disturbances Increases	
		Production Efficiency	283
	11.3	Comparison Between Improvement Models	285
	11.4	To Handle Uncertainty	287
	11.5	Eliminating Disturbances During Development	288
		11.5.1 Approach	
		11.5.2 Competence Development and Knowledge Transfer	
		11.5.3 Strategic Concerns	
		11.5.4 Development Process	295
		11.5.5 Participants	
		11.5.6 Means of Assistance.	
		11.5.7 Cooperation with Suppliers	
		11.5.8 Systematic Way of Working:	
		Basis for Robust Production Systems	301
12	Produ	ection Development in the Future	303
	12.1	Trends and Visions	
		12.1.1 Assembly: The Mirror of Change	
		12.1.2 Trends Within Two Sectors	
	12.2	What is Required from Future Production Systems?	
		12.2.1 Key Areas and Success Factors.	
		12.2.2 Lean Production as an Objective	
		12.2.3 Right Automation.	
	12.3	Future Production from an International Perspective	
		12.3.1 Production in Europe	
		12.3.2 Production in USA	
		12.3.3 China: The Factory of the World?	
	12.4	Make or Buy?	
		12.4.1 Basis of Decisions and Carrying Through	
		12.4.2 Consequences of Outsourcing and Relocation	
	12.5	· · · · · · · · · · · · · · · · · · ·	320
	12.5	12.5.1 Snap Shots.	
	12.6	Go for Survival: Create Competitive Advantages	
D of		-	225
кет	erences		325
Inde	ex	······································	335