OPTIMIZATION OF A FLEXIBLE MANUFACTURING SYSTEM (FMS) FOR HIGH TECHNOLOGY PRODUCT PRODUCING FACTORY VIA THE MODULARIZATIONS OF PRODUCTION SYSTEMS

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Optimization of a Flexible Manufacturing System (FMS) for High Technology Product Producing Factory via the Modularization of Production Systems

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Dedication

I would like to dedicate this research to my parents, Mr and Ms Karunakaran.

Acknowledgement

I would like to thank Ir. Dr Mohammad Shahril Osman for his great effort in guiding me in this thesis. I would like to thank the management of Universiti Malaysia Sarawak (UNIMAS) for the financial assistance in the purchase of the parts necessary to conduct the experiments necessary to achieve the objective of this thesis.

In addition, I would like to thank wife, Sreeja Haridas and my children, Prashanth, Shanthi and Arjun for putting up with my absence while I worked on this research for five years. I would also like to thank Pradeep Karunakaran, Lim Siaw Ling, Sanny Lehe, Alexon Jong and Chai Ko Chen for the help they gave me while doing this research.
Abstract

The objective of this research is to justify the utilization of buffers in High Technology Product Producing Factories (HTPPF) especially in the hard disk industry. This is significantly different from the trend in other industries such as canned food or car, where machines are joined and the process are continuous from start to end. In the latter industries, buffers are counted as stock and a waste, but in HTPPF, buffers are critically important to enable research activities to achieve daily upgrade of the Key Quality Characteristics (KQC) of the product. This has enabled the hard disk industry to increase the data capacity of a 95mm diameter Al-NiP disk from 1 GB in 1995 to 800 GB in 2012. A common trend among hard disk manufacturers, especially in Japan, Taiwan and also the Western Digital factory in Johor, was to join up all the production machines, which is preventing research activities. The assumption made by HTPPF is that dedicated research lines should be a good enough test bed for research activities required to achieve the technological improvements to the products. This is a wrong assumption because research lines are not always running and it is a fact that upon startup of a line, the yield is bad and this has to stabilize before any research changes can be made. Therefore the best test bed for research is a production line, which already has a good yield and a small change in chemical for example, can show up at the final test point to indicate if improvement to the KQC has occurred. Lack of awareness of this technique has caused a number of HTPPF to have decreased market share or close down. The few successful HTPPF that utilizes buffers operates them manually. This introduces human made defects, contamination and also a decreased throughput. In this research, designs were developed to automate these buffers such that humans need not handle the products, while at
the same time enabling researchers to stop the production line to test out their hypotheses. Having designed these improvements, the next problem to solve is the throughput of HTPPF. So designs were made to solve the defect detection system (DDS) which is always the bottleneck in HTPPF. The next problem is to solve the wastage in the current system due to the inaccurate demand predictions at the factory, wholesaler and supermarket. To solve this problem a feasibility study was made to enable a customer ordering a product with a credit card to initiate factory machines to immediately manufacture it.
Objektif kajian ini adalah untuk mewajarkan penggunaan penampan dalam kilang yang menghasilkan Produk Teknologi Tinggi (HTPPF) terutama dalam industri cakera keras. Ia adalah berbeza daripada trend dalam industri lain seperti makanan dalam tin atau kereta yang, mana mesin-mesin di sambung dan proses adalah berterusan dari mula hingga akhir. Dalam industri yang terkemudian, penampan dikira sebagai stok dan pembaziran, tetapi di HTPPF, penampan adalah amat penting untuk membolehkan aktiviti penyelidikan untuk mencapai kenaikan taraf harian “Key Quality Characteristics (KQC)” produk. Hal ini membolehkan industri cakera keras meningkatkan keupayaan data cakera diameter 95mm Al-NiP daripada 1 GB pada tahun 1995 kepada 800 GB pada tahun 2012. Trend yang biasa amalkan di kalangan pengeluar cakera keras terutamanya di Jepun, Taiwan dan juga kilang Western Digital di Johor, adalah menyambung semua mesin pengeluaran bertujuan menghalang aktiviti penyelidikan. Andaian yang dibuat oleh HTPPF adalah bahawa penyelidikan dibuat ke atas mesin yang ditetapkan untuk membuat aktiviti penyelidikan yang diperlukan untuk mencapai peningkatan teknologi kepada produk. Ia adalah andaian yang salah kerana mesin-mesin yang ditetapkan untuk penyelidikan tidak selalu berjalan. Apabila mesin-mesin tersebut startup, hasilnya salalu buruk dan ia mesti distabilkan sebelum apa-apa perubahan penyelidikan boleh dibuat. Oleh yang demikian medan ujian yang terbaik bagi penyelidikan adalah mesin-mesin yang serdang menjalankan pengeluaran, yang sudah mempunyai hasil yang baik dan perubahan yang kecil dalam kimia contohnya, boleh muncul di pusat ujian akhir untuk menunjukkan sama terdapat peningkatan kepada KQC telah berlaku. Kurangnya kesedaran teknik ini telah menyebabkan beberapa HTPPF mengurangkan saham pasaran atau menutup...
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List of Abbreviations, Symbols & Specialized Nomenclature

HTPPF  High Technology Product Producing Factory
FIFO    First In First Out
CDA     Compressed Dry Air
Adept   The company that manufactures Adept robots
HMI     Human Machine Interface
FMS     Flexible Manufacturing System lab of UNIMAS
GE      General Electric company a large USA based company which is pioneering much of robotic controls including the software in the FM
Fanuc   A manufacturer of robots in Japan
GEFanuc The name of the products made by the combination of GE and Fanuc
Cimplicity The name of the HMI made by General Electric company of USA
V+      The software used to run the Adept robots
<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
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<tbody>
<tr>
<td>PLC</td>
<td>Programmable Logic Controller</td>
</tr>
<tr>
<td>Omron</td>
<td>The company that makes the PLC used to control the Adept robots in the FMS lab</td>
</tr>
<tr>
<td>Sysmac</td>
<td>The software used by Omron PLCs.</td>
</tr>
<tr>
<td>CPM1A</td>
<td>The model of the Omron PLC purchased by UNIMAS to simulate control of the Adept robots in the FMS lab</td>
</tr>
<tr>
<td>CTC</td>
<td>Control Technology Coporation - an American company that makes microcontrollers</td>
</tr>
<tr>
<td>MEMS</td>
<td>Microelectromechanical Systems</td>
</tr>
<tr>
<td>NEMS</td>
<td>Nanoelectromechanical Systems</td>
</tr>
<tr>
<td>Honeywell</td>
<td>An American company that makes high technology products</td>
</tr>
<tr>
<td>DCS</td>
<td>Distributed Control Systems; a control system for machines or process developed by Honeywell</td>
</tr>
<tr>
<td>MSRS</td>
<td>Microsoft Robotic Studio</td>
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<tr>
<td>SCADA</td>
<td>Supervisory Control And Data Acquisition – a control and monitor system used in factories all the way up to a grid of an electric company</td>
</tr>
<tr>
<td>Acronym</td>
<td>Description</td>
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<tr>
<td>EMI</td>
<td>Electromagnetic Interference – electromagnetic disturbance of electronic signals</td>
</tr>
<tr>
<td>OEM</td>
<td>Original Equipment Makers which makes a small part of a complete unit like a computer</td>
</tr>
<tr>
<td>DARPA</td>
<td>Defense Advanced Research Projects Agency, USA</td>
</tr>
<tr>
<td>DELL</td>
<td>A computer manufacturer in USA</td>
</tr>
<tr>
<td>AUV</td>
<td>Autonomous Underwater Vehicles</td>
</tr>
<tr>
<td>MIT</td>
<td>Massachusetts Institute of Technology</td>
</tr>
<tr>
<td>Protocols</td>
<td>Procedures and methods used to achieve a communication</td>
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<tr>
<td>POP</td>
<td>Post Office Protocol</td>
</tr>
<tr>
<td>PPP</td>
<td>Point to Point Protocol</td>
</tr>
<tr>
<td>IMAP</td>
<td>Internet Message Access Protocol</td>
</tr>
<tr>
<td>WDM</td>
<td>Wavelength Division Multiplexing</td>
</tr>
<tr>
<td>DWDM</td>
<td>Dense Wavelength Division Multiplexing</td>
</tr>
<tr>
<td>TDM</td>
<td>Time Division Multiplexing</td>
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<td>LAN</td>
<td>Local Area Network</td>
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<tr>
<td>Acronym</td>
<td>Description</td>
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<tr>
<td>DDS</td>
<td>Defect Detection System</td>
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<tr>
<td>PPH</td>
<td>Parts per hour</td>
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<tr>
<td>PM</td>
<td>Preventive Maintenance</td>
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1.0 Introduction

This research is timely because many High Technology Product Producing Factories (HTPPF) are still following the trend of factories that produces the likes of canned food or even cars [1] where all machines are jointed from start to end. These HTPPF have not realized that improvements to product must be done everyday to keep market share. This is why a number of hard disk manufacturers are closing down, especially in Japan and Taiwan (notably Sony, NEC, Matsushita and Trace), which are leaders in joining up production lines from start to end. Currently 90% of hard disks are produced by Western Digital and Seagate, with Toshiba having 10% market share. HTPPF can best be run with buffers in-between production machines to enable research initiatives.

Explanation has been made in this thesis of why researchers prefer to test their hypotheses on a running production line rather than a dedicated research line. It is an accepted fact in the production of hard disks, for example, that upon start-up of a line there is a yield drop and this yield picks up after a while. Therefore on a research line that is not always running, it takes from one to five hours before the yield stabilizes. This discourages researchers from performing research tests on the research line. In a production line, where the yield is already at around 98%, a small change in say a chemical in one particular machine can more easily be examined. Also by using production lines as test beds, many lines can be used. This way more sampling of research can be done, providing a consistent data base to validate results. Research lines are still
available for major changes especially where mechanical changes to machines are involved, but for quick validation of results, the running production line is used [2].

While developing new strategies for increasing research in HTPPF, other major problems were encountered, one being the bottleneck caused by the defect detection system (DDS) and the other being the wastage in the current system, of customer ordering products, factories manufacturing them and how it is finally delivered to customers. These are the empirical problems seen in hard disk factories that try to continuously improve Key Quality Characteristics (KQC), where this researcher has 14 years of working experience.

![Comparison of Research Initiatives generated by two real factories](image)

Figure 1.1: A comparison of Research initiatives generated by two factories, the Western Digital factory in Kuching and Johor, Malaysia.

Western Digital (WD) factory in Johor is fully automated without buffers while the Kuching factory has humans operating the buffers in-between automated production machines. In the current hard disk industry, companies are still bent on full automation (without buffers)