Journal of Applied Sciences

ISSN 1812-5654

science alert

ANSInet
an open access publisher
http://ansinet.com

Journal of Applied Sciences 10 (11): 878-886, 2010
ISSN 1812-5654

Effective Design and Analysis of Pattern Making Process Using Value Stream Mapping

Mohammad D. Al-Tahat
Department of Industrial Engineering, Faculty of Engineering and Technology,
University of Jordan, Amman 11942, Jordan

Abstract: The purpose of this study is to use VSM to investigate the performance of traditional methods of pattern making thereafter to compare that with the performance of an automated one. The VSM is used for analyzing and controlling the flow of material and information through the pattern making process and allows documenting production methods, recording and investigating the information involved in the system. VSM is used to investigate a fully automated pattern production system, which uses the principles of Computer Aided Design (CAD) and Computerized Numerically-Controlled (CNC) machine tool. A foundry company is selected to implement the VSM tool. The production cycle time, number of needed buffers is used as indicator for evaluating the performance of the traditional and automated production methods. Both production methods are carefully monitored and data is collected and analyzed. Consequently, state maps for both types of production systems are developed, constructed, discussed and brainstormed with senior engineers of the foundry and the weakness points are addressed and treated. As a result, a VSM-based performance evaluation is presented for both methods of pattern manufacturing; therefore the paper proved that VSM is a helpful tool not only for process improvement but also for decision making.

Key words: Value stream mapping, pattern making, re-engineering, lean tools, production management, productivity improvement

INTRODUCTION

Lean principles are newly industrial modified tools that are being used for the design of effective production systems. Value Stream Mapping (VSM) (Al-Tahat, 2009); Kaizen (Imai, 1977); The 5S philosophy (Hirano, 1996); Total Productive Maintenance; Cellular Manufacturing; Just-In-Time (JIT) Production; Six Sigma; Reduce, Reuse and Recycle (3R); Total Quality Management and others are some important lean tools (Vais *et al*., 2006). A very brief description of the most common lean tools is given by Monden (1993), Feld (2000) and Nahmias (2001). The focus in this study is to use the VSM. A value stream is a collection of all activities and actions that are required to bring resources through the main flows, starting with the design and ending with the final pattern (Abdulmalek and Rajgopal, 2006). The crucial objective of VSM is to identify all types of waste in the value stream and to take actions to try eliminating these (Rother and Shook, 1999). VSM creates a common basis for the production process, thus facilitating more thoughtful decisions to improve the value stream (McDonald *et al*., 2002). VSM is created using a predefined set of standardized icons (Rother and Shook, 1999; Tashtoush *et al*., 2001). VSM requires following a pattern's production path and drawing a visual representation of every process in the material and information flow. Taking the value stream viewpoint means working on the big picture and not individual processes. VSM creates a common basis for the pattern making process, thus facilitating more thoughtful decisions to improve the process (McDonald *et al*., 2002). Generally nine steps are followed when using VSM tool, these are; Meeting; Training Data collection, Constructing the current-state map, Reviewing the current-state map, Targeting improvement, Constructing the future-state map, Formalizing improvement and Overcoming traditional thinking

AZAL FOUNDRY AND PATTERN MAKING SHOP

This study is considering a multi products steel and iron foundry system that uses mainly Ferro-alloys, steel scrap and return, to convert them into finished steel or iron castings and finally deliver the finished casting to the customers. Since some of the information is confidential, the foundry is referred to as AZAL throughout this study. AZAL was built at the North of Jordan on an area exceeds 110000 m^2 and has a capacity of more than 2500 tons/year of salable steel and/or iron castings on the basis of a two

Corresponding Author: Mohammad D. Al-Tahat, Department Industrial Engineering, Faculty of Engineering, Jordan University of Science and Technology, P.O. Box 3030, Irbid 22110, Jordan
Tel: +962-2-7201000 Fax: +962-2-7201074

shift operation, conforming to DIN, JIS, ASTM and BS quality standards. AZAL is established to meet the domestic demands and to expand into export markets as well. AZAL includes all the necessary production lines to manufacture, produce casting and form the different types of castings used in industry, agriculture, construction and the infrastructure for the engineering industries and supported engineering complementary industries, which depend on castings. The product mix of the foundry includes but not limited the following casting alloy types: low alloy steel castings; stainless steel; 12/14 Mn-steel castings (Mn-B1); 2Cr-14 Mn-steel castings (Mn-C); heat resistance steel castings (H.R. SCH22, H.R. SCH13); Ni-hard cast iron; high Chrome cast iron (High Cr-CI); 25 Cr-12 Ni steel castings; and ductile rolls.

At AZAL the pattern shop is well equipped for the manufacture of wooden pattern, AZAL is making patterns only for its need (i.e., for its products only and not for commercial purposes). The determination of the pattern material is depending on the quantity of casting needed. And the pattern composed of more than one component, components. Some components of patterns are: upper half, lower half, risering system, feeding systems and others. The manufacturing process is started from the design and technology department. In this department the design is prepared, all the sequence of operation is then determined and all the needed documents and drawing is set. After preparing of all drawings, shrinkage rate is determined and the material type of pattern is selected, furthermore the technical drawing is created. Consequently the drawings are transformed into a physical entity (pattern) on special plate of wood with a scale of 1:1. Then the pattern components will be built. Step by step ending with a final pattern. The final pattern is sent to the quality control checkpoint and finally the pattern if it is accepted is used to make the new casting. All of these operations were monitored and then presented in Table 1. The management was complains continuously because of lengthy lead time taken for producing and preparing casting patterns in the proper time, there for this work was conduct to help the foundry in reducing the lead time by a proper alternate technology.

MAPPING THE TRADITIONAL PATTERN MAKING SYSTEM

Total pattern production cycle time is investigated here, activities of producing pattern is classified into two main groups; the first activity group includes production and in quality operations, while the second includes the other activities like design, drawing, measuring technology, etc. two Value Stream Map (VSM) are developed These are; VSM for production and in process quality operations and VSM for planning and technology operations.

Table 1: Process plan for producing wooden-pattern under traditional production methods

Operation No.	Operation name	Operation time (h)
1	Order reception	0.08
2	Order registration	0.50
3	Planning manager confirmation	0.03
4	Decision making	0.25
5	Send to technology department	0.03
6	Technology design	2.00
7	Technology drawing	1.00
8	Drawing check	0.25
9	Technology approval	16.0
10	Specimen measuring	2.50
11	Design modification, if needed	0.50
12	Approval of technology and part dimensions	4.00
13	Prepare final and full drawing set	4.00
14	Check final and full drawing set	1.00
15	Sending to pattern shop	0.08
16	Reception of final and full drawing	0.50
17	Drawing analysis	1.50
18	Computation of shrinkage allowances	0.50
19	Requirement identification	1.50
20	Wood preparation	0.02
21	Wood sawing	5.00
22	Prepare surfaces	0.02
23	Surfaces finishing	3.00
24	Thickness value	0.02
25	Thickness justification	3.50
26	Gluing and assembly	7.00
27	Waiting	8.00
28	Justification of dimensions	2.50
29	Gating system making	2.00
30	Risering system making	1.50
31	Core boxes making	16.0
32	Check all parts	0.08
33	Quality check	20.0
34	Painting	0.02
35	Kneaded	5.00
36	Drying	3.00
37	Painting	5.00
38	Kneading	0.30
39	Drying	3.00
40	Coating	4.00
41	Drying	4.00
42	Storing	0.02

VSM for production activities: According to the process plan presented in Table 1, value stream map for production activities and in process quality check has been developed and presented as depicted in Fig. 1. All data for the state map were collected. The boxes in the map represent the operation and the number inside the box is the processing time under the traditional pattern making methods.

It should be noted that this data was collected at the same time as walking the pattern shop and talking to the foreman and operators at each operational step. The processing times are all based on the average of producing average complex pattern.

After collecting all the information and material flows, they are connected as indicated by arrows in the map, representing how each operational step receives its schedule from pattern shop foreman. Total processing

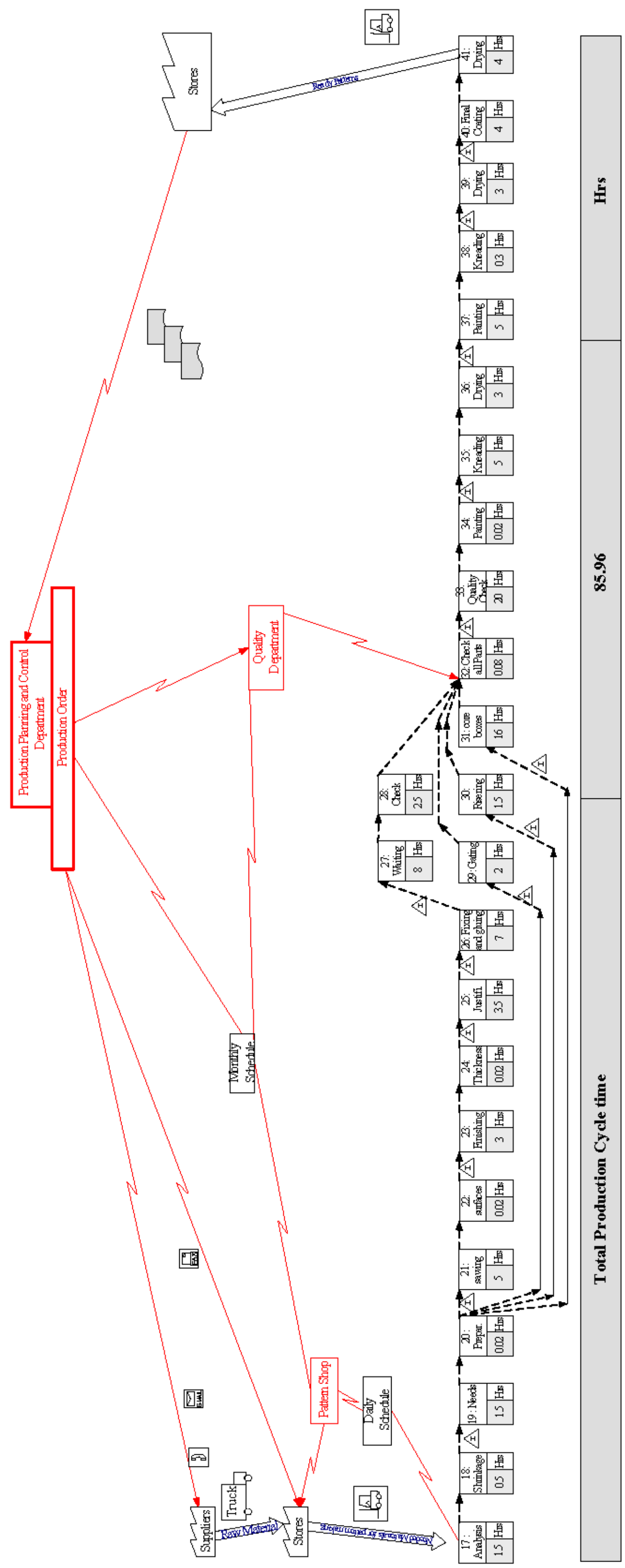

Fig. 1: Value stream map for production and in process quality operations

Table 2: Distribution of time between production activities and planning and technology activities

Name of activity group	Average time (h)	Time (%)	Needed buffers	Working methods
Planning design and technology	32.73	27.6	6	Traditional pattern making methods (labor intensive)
Production and in process quality check	85.96	72.4	14	
Total time (h)	118.7	100.0	20	

time (or value-added) is indicated at the bottom of the state map, which is 85.96 h. This time is calculated by adding the processing time for each process in the value stream. The processing time for each process is the average, which was determined by using actual data from the company.

VSM For planning and technology activities: VSM for planning and technology department is created and presented as in Fig. 2. As seen in Fig. 2, the total average time needed to produce average complex pattern is 118.7 h, or 14.8 working days. This amount of time is distributed between different production activities as shown in Table 2.

MAPPING THE AUTOMATED PATTERN MAKING SYSTEM

In addition to the traditional pattern making method AZAL has the opportunity to use more advance pattern making technology. Computer Aided Design (CAD) and Computerized Numerically-Controlled (CNC) machine tool for carpentry can be proposed to AZAL to be considered as an alternative method of production as will as to enhance the productivity of the pattern shop. The details of these operations were investigated, analyzed, recorded and presented in Table 3.

Auto CAD software with the needed facilities is installed in the design department of the company; furthermore a skillful operator is hired. A full drawings set of final design for an average complex pattern is prepared, then a CNC carpentry machine tool for another company is used, consequently the pattern is produced.

VSM for production activities: Value stream map for production activities and in process quality operations, for the process plan shown in Table 3, has been developed and presented as depicted in Fig. 3. All data for the state map were collected. Total processing time is indicated at the bottom of the state map, which is 60.4 h. This time is calculated by adding the processing time for each process in the value stream.

Table 3: Process plan for producing wooden-pattern under automated production methods

No. Operation	Operation name	Operation time (h)
1	Order reception	0.08
2	Order registration	0.50
3	Planning manager confirmation	0.03
4	Decision making	0.25
5	Send to technology department	0.03
6	Specimen measuring	2.50
7	Technology design and sketching/ Technologist	2.00
8	Technology drawing using AutoCAD/ Operator	8.00
9	Building of 3D models	16.0
10	Drawing check/Technologist	0.25
11	Technology approval/ Technologist	0.50
12	Design modification, if needed/ Operator	1.00
13	Approval of final drawings and design	0.50
14	Printing full drawing set	1.00
15	Copying and filing	1.00
16	Sending 3D model file to CNC machine	0.15
17	Drawings analysis	1.00
18	Requirement identification	0.50
19	Simulated run	1.00
20	Approval	0.10
21	Machine set up/Delignite wood/ Size 120×120×30 cm	5.00
22	Cup manufacturing/ Upper pattern plate	3.00
23	Drag manufacturing/ Lower pattern plate	3.00
24	Core boxes making	16.0
25	Check all parts	0.08
26	Quality check	20.0
27	Painting	0.02
28	Kneaded	5.00
29	Drying	3.00
30	Painting	5.00
31	Kneading	0.30
32	Drying	3.00
33	Coating	4.00
34	Drying	4.00
35	Storing	0.02

Table 4: Distribution of time between production activities and planning and technology activities

Name of activity group	Average time (h)	Time (%)	Needed buffers	Working methods
Planning design and technology	33.8	35.9	7	Automated pattern making methods
Production and in process quality check	60.4	64.1	10	
Total time (h)	94.2	100.0	17	

VSM for planning and technology activities: As seen in the Fig. 4, the total average time needed to produce average complex pattern is 94.2 h, or 11.8 working days. This amount of time is distributed between different production activities as shown in Table 4.

RESULTS AND DISCUSSION

The study uses Value Stream Process (VSM) to investigate the performance of traditional methods of pattern making and to compare with the performance of the automated one. It has been observed that the

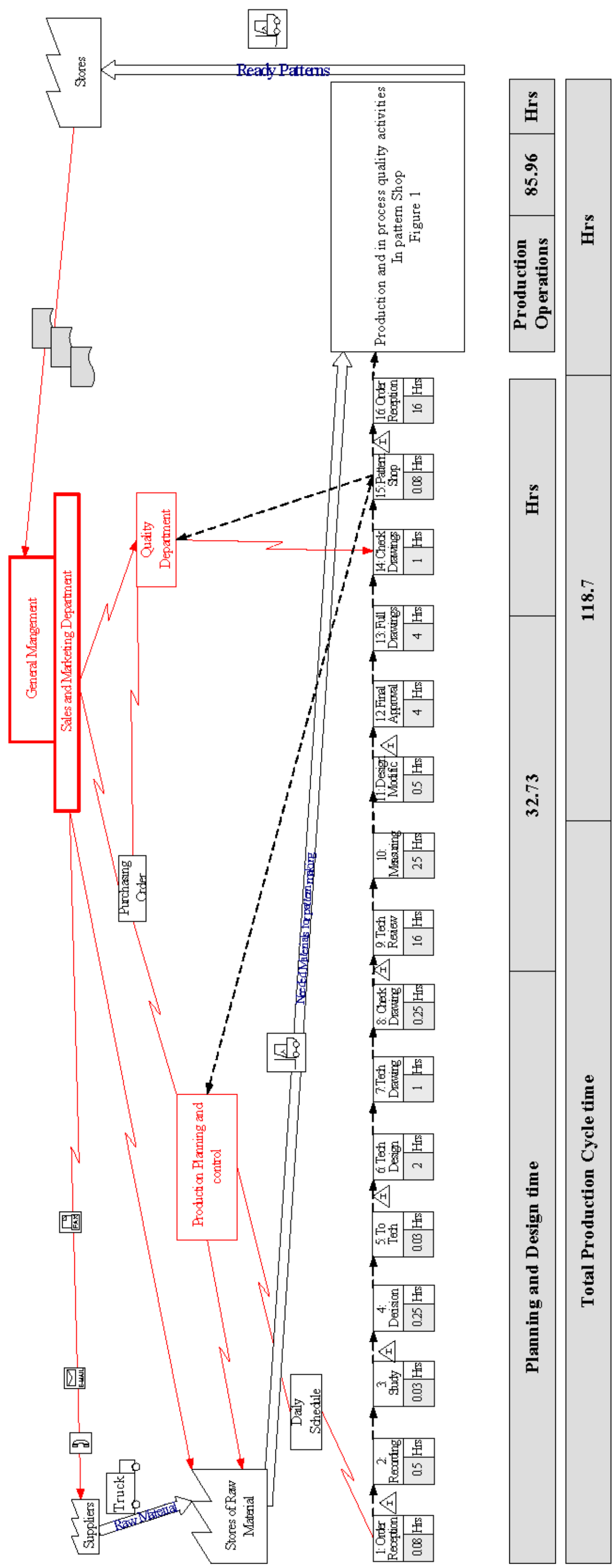

Fig. 2: Value stream map for planning and technology operations

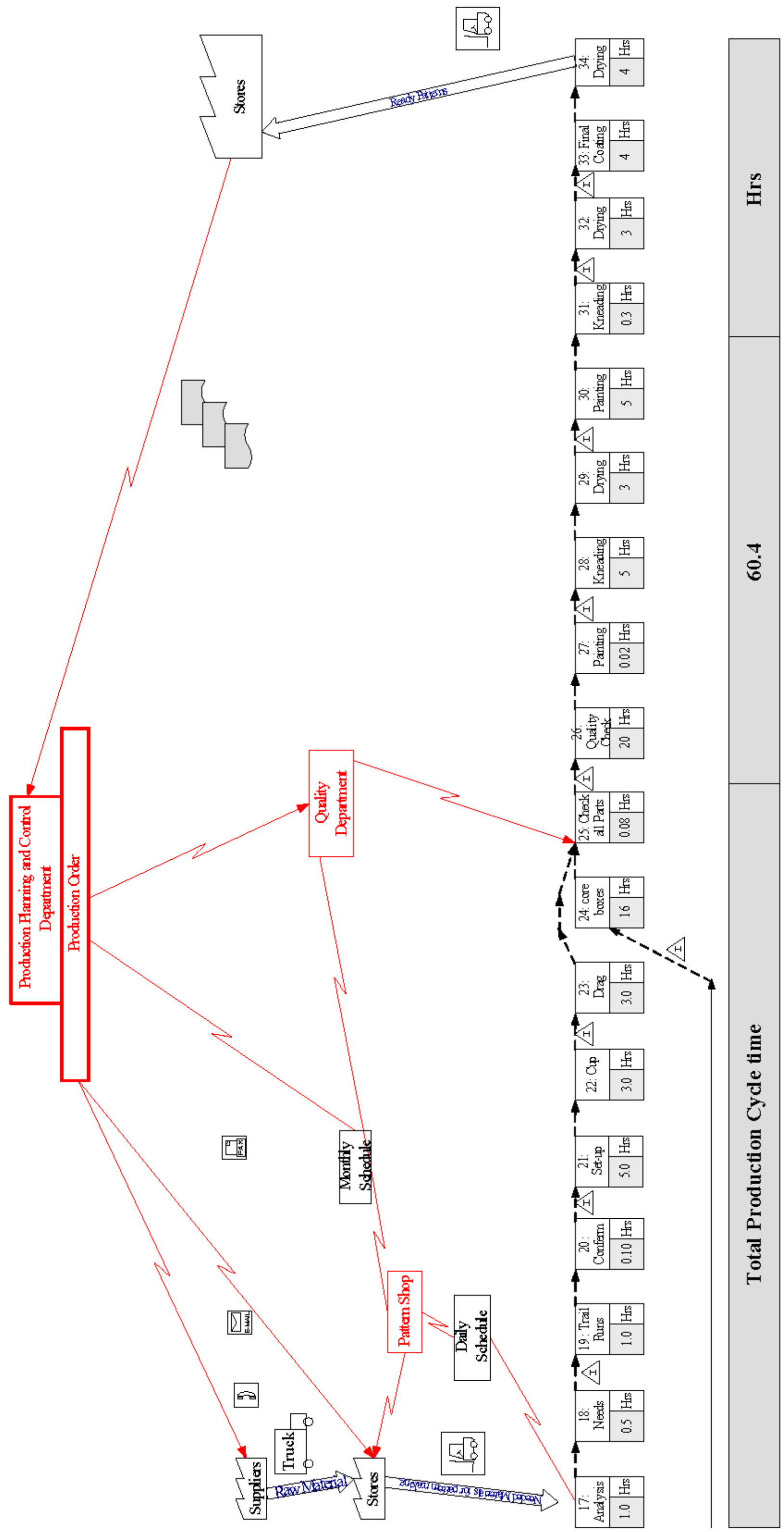

Fig. 3: Value stream map for production and in process quality operations, automated scenario

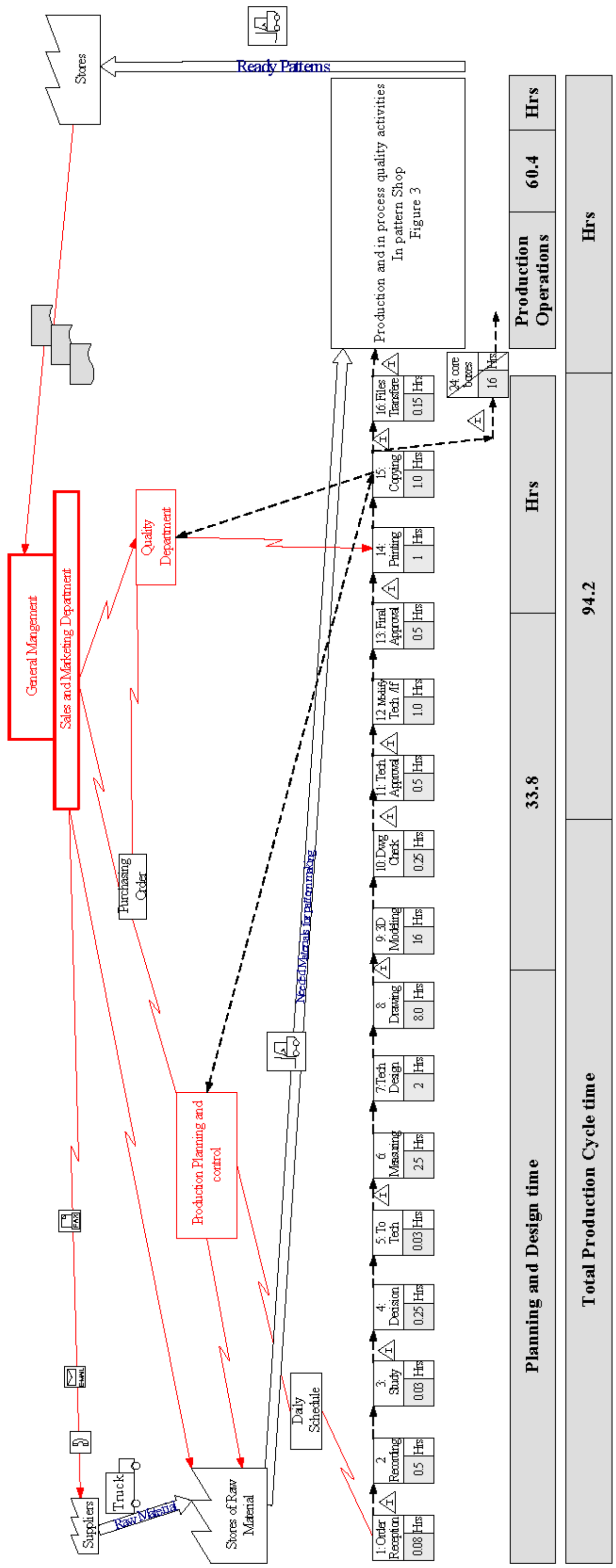

Fig. 4: Value stream map for planning and technology operations, automated scenario

Table 5: Measured value before and after process development

Performance measure	Production method Before (Traditional)	After (Automated)	Improvement (%)
Planning and design time (h)	32.7	33.8	-3.40 (decreasing)
Production operation (h)	86.0	60.4	+29.8
Total production cycle (h)	118.7	94.2	+20.6
Number of needed buffers	20	17.0	+15.0

automated production method improves the planning and design time and production operation in hours. Therefore, total production cycle improves and saves time more than 20%. The VSM (Value Stream Mapping) increases the effectiveness of the process. Table 5 presents a summery for the values of these measures before and after process development

It is found that VSM has been attributed to the cause of much of the success of the Japanese firms during 1980s. By VSM it is possible to identify the wasted time and actions in a manufacturing process. By VSM value added time may be created. The study is one of the applications of the Value Stream Mapping; it does not develop a new value system or a supply chain mapping typology. However, it is observed in the study that the time of production diminishes by the usage of automated production methods. This shows evidence on the innovation increases the efficiency of the firms.

Many lean tools can be found in the literature such as; Kaizen, The 5S philosophy, TPM, JIT, six-sigma etc. one main difference between such tools and VSM, is that VSM is visual tools that can describe the whole process by simple free hand sketch on a blank A3 paper using just the pencil.

CONCLUSION

Detailed value stream maps are used to evaluate the performance of the pattern making system under two production methods, traditional method and automated method. The availability of the information provided by the value stream mapping facilitated and validated the decision weather to implement the advanced technology in the system or not. Value stream mapping is a powerful tool for decision making, which highlighted chances for process development and possible improvement.

Average total production cycle time, number of needed buffers in front of each work stage are used as measures for evaluating the performance of the process under the two different scenario. It can be concluded that, value stream mapping helps identify wastes and all the chances to improve and remedy a faulty wasteful situation into an improved more efficient one by elimination of non-added value activities. As a future research, a simulation model may be conducted to find the optimal buffer size in front of each work stage, in order to illustrate to managers potential benefits such as reduced flow time and Work-In-Process (WIP) inventory. Rapid prototyping technology may be considered as another alternative method for pattern making in a future study. Also, production cost may be used as an evaluating criterion in such researches.

ACKNOWLEDGMENTS

This research has been carried out during a sabbatical leave granted to the author Dr. Mohammad D. Al-Tahat from the University of Jordan during the academic year 2009/2010.

REFERENCES

Abdulmalek, F.A. and J. Rajgopal, 2006. Analyzing the benefits of lean manufacturing and value stream mapping via simulation: A process sector case study. Int. J. Prod. Econ.,

Al-Tahat, M.D., 2009. Re-engineering of production processes using value stream mapping tool, case study: ABC plant for producing tissue and hygienic paper. J. Inform. Intel. Knowledge, 1: 309-344.

Feld, W.M., 2000. Lean Manufacturing: Tools, Techniques and How to Use Them. St. Lucie Press, London, ISBN-13: 978-1564442977.

Hirano, H., 1996. 5S for operators. 5 Pillars of the visual workplace. Productivity Press, New York, USA., ISBN: 1-56327-123-0, pp: 121.

Imai, M., 1977. Gemba Kaizen: A Commonsense, Low-Cost Approach to Management. McGraw-Hill, New York.

McDonald, T., E.M. van Aken and A.F. Rentes, 2002. Utilizing simulation to enhance value stream mapping: A manufacturing case application. Int. J. Logistics Res. Appl., 5: 213-232.

Monden, Y., 1993. Toyota Production System: An Integrated Approach to Just-In-Time. 3rd Edn., Kluwer Academic Publishers, USA.

Nahmias, S., 2001. Production and Operations Analysis. 4th Edn., McGraw Hill, New York, ISBN-13: 978-0072417418.

Rother, M. and J. Shook, 1999. Learning to See: Value Stream Mapping to Add Value and Eliminate Muda. The Lean Enterprise Institute Inc., Brookline, MA.

Tashtoush, G., B. Gharaibeh and W. Massarweh, 2001. Converting from mass to lean production, a future look for Jordanian industries. Proceedings of 1st International Industrial Engineering Conference, Sept. 23-27, Amman-Jordan, pp: 30-34.

Vais, A., V. Miron, M. Pedersen and J. Folke, 2006. Lean and green at a romanian secondary tissue paper and board mill-putting theory into practice. Resour. Conserv. Recycling, 46: 44-74.