Reducing of Manufacturing Lead Time by Implementation of Lean Manufacturing Principles

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ABSTRACT

Many organizations today are interesting to implementing lean manufacturing principles that should enable them to eliminating the wastes to reducing a manufacturing lead time. This paper concentrates on increasing the competitive level of the company in globalization markets and improving of the productivity by reducing the manufacturing lead time. This will be by using the main tool of lean manufacturing which is value stream mapping (VSM) to identifying all the activities of manufacturing process (value and non-value added activities) to reducing elimination of wastes (non-value added activities) by converting a manufacturing system to pull instead of push by applying some of pull system strategies as kanban and first on first out lane (FIFO). ARENA software is used to simulate the current and future state. This work is executed in the state company for electrical industries in Baghdad. The obtained results of the application showed that implementation of lean principles helped on reducing of a manufacturing lead time by 33%.

Key words: Manufacturing Lead Time, Lean Manufacturing System, Value Stream Mapping, Pull System.

تقليل وقت التصنيع بتطبيق مفاهيم التصنيع النحيف

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الخلاصة

تهتم العديد من المؤسسات مهتمة بتطبيق مفاهيم التصنيع النحيف التي تمكنها من حذف الخسائر لتقليل وقت التصنيع. هذا البحث يركز على زيادة المستوى التنافسي للشركة في الأسواق العالمية و تحسين الإنتاجية والمرونة بتقليل وقت التصنيع. ولتحقيق هذا الهدف يتم استخدام الأداة الرئيسية التي هي مخطط مسار القيمة لتحديد كل فعاليات العملية التصنيعية (التي تضيف والتي لا تضيف قيمة) لتقليل و حذف الخسائر (الفعاليات التي لا تضيف قيمة) بتحويل نظام التصنيع من نظام دفع إلى نظام سحب باستخدام بعض إستراتيجيات نظام السحب مثل نظام السحب حسب الطلب (Kanban) و انجاز الطلب الداخل أولا (FIFO). استخدمت برمجية (ARENA) المحاكاة الحالة الواقعية والحالة المستقبلية المقترحة لعملية التصنيع. وهذا العمل تم تنفيذه في الشركة العامة للصناعات الكهربائية في بغداد. وقد أظهرت النتائج التي تم الحصول عليها من التطبيق تقليل وقت تصنيع المنتج بنسبة 33%.

الكلمات الرئيسية: وقت التصنيع, نظام التصنيع النحيف, مخطط مسار القيمة, نظام السحب.

1- INTRODUCTION

Nowadays, the success of any company is identified by its ability to quickly respond to the market changes, so the companies pay more effort to reducing their manufacturing lead times, **Yadav, et al., 2012**. Reductions in manufacturing lead time can generate numerous benefits, including lower work in process and finished goods inventory levels, improved productivity, lower costs. More importantly, reductions in manufacturing lead time increase flexibility and reduce the time required to respond to customer orders, **Samad, et al. 2013**. Manufacturing Lead Time refers to the total time it takes to complete the manufacturing process of a product. It is the time from when an order is ready to start on the production line to when it becomes a finished good, **Hari, et al. 2013**. A lead time is the period of time between the initiation of any process of production and the completion of that process, **Karunesh, and Thotappa, 2013**.

2- LEAN MANUFACTURING

The origins for initiatives of the lean manufacturing are traced to the Toyota Production System (TPS) and were started by Ohno (1978) and Shingo (1989) at TPS with its focus on the systematic and efficient use of the resources through level of scheduling. The term "lean manufacturing" as Ohno (1978) states, is providing a way to do more and more with less and less inventory, less human effort, less movement of material , less equipment and less time while coming closer to supplying the customers with what they want exactly, **Ravet, 2011.** Lean manufacturing means eliminating wastes by identifying non value added activities thorough out the supply chain. The five fundamental Lean principles are to specify value from the point of view of customer, identify the value stream, make the identified value flow, set the pull system which means only make as needed and finally perfection in producing what the customer wants and by when it is required in the right quantity with minimum waste**, Sambathkumar, and Vijayanand, 2013.**

3- VALUE STREAM MAPPING (VSM)

Value stream mapping is a mapping tool that helps on representing material and information flows of manufacturing process and also that signal and control the material flows. This representation facilitates the process of identify the value adding activities in a value stream of manufacturing process and eliminating the non value added activities, or wastes through implementation of lean principles, **Romero, and Chavez, 2011**. VSM is a visualization tool oriented to the version of TPS for lean manufacturing. It helps people to understand and identifying the work processes and then implementing of Toyota Production System tools and techniques, **Thorsen, 2004**. The value stream mapping (VSM) suite of tools can be used to map the current state of a production line and design a desired future state. , they provide a roadmap for how VSM can provide necessary information for analysis of equipment replacement decision problems encountered in lean manufacturing implementation, **Dighe, and Kakirde, 2014**. The focus of VSM is on a product “value stream” (all actions required to transform raw materials into a finished product) for a given “product family” (products that follow the same overall production steps). In applying VSM, waste is identified at a high level along the value stream in the form of all elements that prohibit or hamper flow and in the form of inventory (raw materials, work-in-process (WIP) and finished goods). In future state design, major issues that create waste in the process are addressed, **Romero, and Chavez, 2011**.

4- METHODOLOGY

To achieve the Research objectives the following steps will be applying:

1-Identifying a product and studying a manufacturing process of the product in details.

2-Draw flow diagram of the manufacturing process.

3-Documenting a list of activities flow for manufacturing process with the number of workers and the time required for each activity to identify a waste (non-value added activities) in the process.

4-Draw the value stream mapping for the current state of manufacturing process by using Visio Software.

5-Identify the areas of waste in current state and eliminating all non-value added activities to adding the requisite improvement (kaizen) by applying some of pull strategies as kanban, supermarkets and FIFO strategies to make a system pull instead of push to reducing long waiting time, overproduction and other wastes to reducing lead time.

6-Developing a future state of a process and an action plan after implementation of lean principles to achieve a high efficiency and lead time reduction.

7- Simulation of current and future state by using ARENA software to calculating a lean measurements and comparison the results.

4- THE MEASUREMENTS OF LEAN MANUFACTURING SYSTEM

The main measures of lean manufacturing are calculated as follows:

1- Manufacturing cycle time (CT), **Hopp, et al. 1990.**

$$CT=LT= T_w + T_s + T_p + T_i \quad (1)$$

Where:

T_w= waiting time, T_s= set up time, T_p= processing time, T_i= inspection time and LT= lead time.

2- Throughput (TH) (part/hour), **Standridge, 2004.**

$$TH = \frac{WIP}{CT} \quad (2)$$

Where:

WIP = work in process (unit) and CT= manufacturing cycle time (hour).

3- Value added ratio (VAR), **Karunesh, and Thotappa, 2013**.

$$VAR = \frac{VAT}{CT_t} \quad (3)$$

Where:

VAT= value added time (min) and CT_t= total cycle time (min).

4- Production capacity per week (Pc), **Dinesh, and Prabhukarthi, 2013.**

$$Pc = Wt \times P \quad (4)$$

Where:

Wt= available work time per week (hour) and P= Production rate (unit per hour).

5- SELECTING OF THE PRODUCT AND IMPLEMENTATION

To implementing a methodology of the research a product which is selected is the rotor of air coolant motor consist of three parts: rotor, shaft and sleeve as shown in **Fig. 1**, also studying a manufacturing process of the product in details including total cycle time, value added time, number of workers for each activity identifying all types of activities in manufacturing process (value added, non-value added and non-value added but necessary). The stages of product manufacturing process and their cycle times for patch production of (100 rotor) are shown in **Table 1**. and **Fig. 2** show the flow diagram of manufacturing process.

The next step after identifying the activities and flow diagram of manufacturing process is draw a current state value stream mapping as shown in **Fig. 3, Fig. 5** and **Fig. 7** to identifying the areas of waste by kaizen (continuous improvement) to solve the problems of the manufacturing process by application of pull system strategies in proposed future state value stream mapping as shown in **Fig. 4, Fig. 6 and Fig. 8** to improving the productivity and reducing a manufacturing lead time.

ARENA software (version 14.50) is used to simulate the current and future state of rotor manufacturing process as shown in **Fig. 9** to simulate a research problem and estimate a various performance parameters of lean manufacturing system as shown in **Table 2**. which show the simulation results. Also **Fig. 10** show the percentages of production activities type in current and future state of manufacturing process.

CONCLUSIONS

1- Implementation of lean manufacturing principles help on reducing a production lead time and improving of productivity and efficiency of production process.

2-Value stream mapping can be a valuable and an effective tool for identifying and eliminating the wastes and it also suggests ways to reducing non value added times in a manufacturing process.

3- By applying lean principles, the lead time of rotor manufacturing process is reducing by 33% and also value added ration (VAR) is increasing by 66%.

4- After the improving and reducing of a manufacturing lead time the future state will become current state, in that still more new developments and improvements can be added and this process will be repeated to obtain better results until an ideal state is established.

REFERENCES

- Dighe, S. B. and Kakirde, A., 2014, *Lean Manufacturing Implementation Using Value Stream Mapping: A Case study of Pumps Manufacturing Company,* International Journal of Science and Research, Vol. 3, No. 6, PP. 2492- 2498.

- Dinesh, J., Prabhukarthi, A., 2013, *Reduction of Lead Time Using Value Stream Mapping in Pump Manufacturing Industry*, Proceedings of the National Conference on Manufacturing Innovation Strategies & Appealing Advancements, College of Technology, Coimbatore, India, PP. 1-6.

- Hari, G., Sandeep, N. and Doss, K., 2012, *Manufacturing Lead Time Reduction of Gear Box Side Frame Using Lean Principles*, SASTECH, Vol. 11, No. 1, PP. 25-32.

- Hopp, W. J., Spearman, M. L., Woodruff, D. L., *1990, Practical Strategies of Lead Time Reduction*, Manufacturing Review, Vol. 3, No. 2, pp.78-84.

- Karunesh, G. and Thotappa, C., *2013, Lead Time Reduction in Order Execution of Horizontal Slurry Pumps Using Lean Concepts for Mining Equipments Manufacturing Company,* International Journal of Scientific & Engineering Research, Vol. 4, No. 3, PP. 1-15.

- Ravet, D., *2011, Lean Production and Agile Organization: The Link Between Supply Chain and Sustainable Development*, Dorich House Group « Developing Sustainability » Area: Material Manufacturing and Design, https://hal.archives-ouvertes.fr .

- Romero, D. and Chavez, Z., *2011, Use of Value Mapping Tools for Manufacturing Systems Redesign*, Proceedings of the World Congress on Engineering, Vol. I.

- Samad, M. A., SaifulAlam, M. D. and Tusnim N., 2013, *Value Stream Mapping to Reduce Manufacturing Lead Time in a Semi-Automated Factory* **,** Asian Transactions on Engineering , Vol. 02, No. 06, pp. 2221- 4267.

- Sambathkumar, R., Vijayanand, V., 2013, *Implementing Lean Tools in Centrifugal Pump Manufacturing Industry*, Manufacturing Innovation Strategies & Appealing Advancements.

- Standridge, C. R., *2004, How Factory Physics Helps Simulation*, Proceedings of the Winter Simulation Conference, pp. 1103-1108.

- Thorsen, W. C., 2004, *Value Stream Mapping & VM*, General Motors Corporation's Worldwide Facilities Group.

- Yadav, R. , Shastri, A. and Rathore, M., *2012*, *Increasing Productivity by Reducing Manufacturing Lead Time through Value Stream Mapping*, International Journal of Mechanical and Industrial Engineering, Vol. 1, No. 3, PP. 31-35.

NOMENCLATURE

List of Symbols and Abbreviations

Symbol	***Description***
CT_t	Total Cycle Time
CT	Cycle Time
FIFO	First in First Out
LD	Lead Time
TH	Throughput
T_i	Inspection Time
T_p	Processing Time
TPS	Toyota Production System
T_s	Set up Time
T_w	Waiting Time
VAR	Value-Add Ratio
VAT	Value-Add Time
VSM	Value Stream Mapping
WIP	Work-in-Process

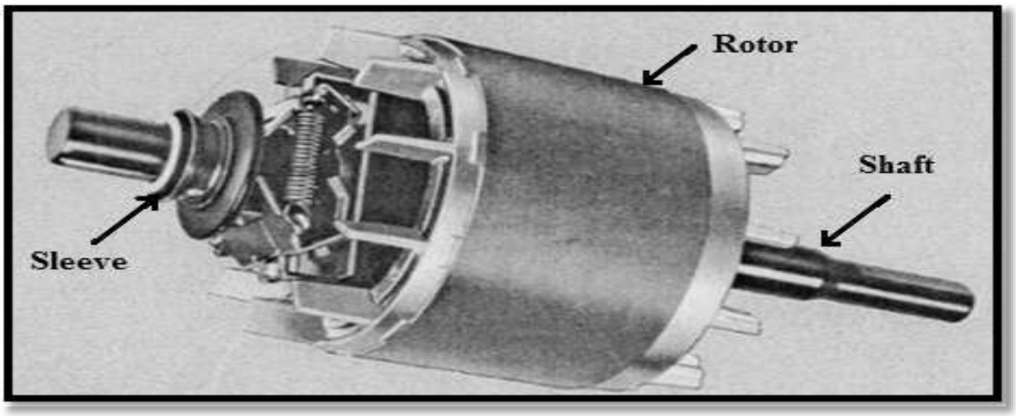

Figure 1. A Selected Product (Rotor of Air Coolant Motor).

Table 1. Operations Sequence of Product Manufacturing Process.

part	Operation	Cycle Time (min)
Rotor	Cutting process of laminations	60
	Annealing process	240
	Stacking process	55
	Casting process	50
	Cutting process	25
	Turning process	75
Shaft	Turning process of the shaft	50
	Cleaning process of the shaft	10
	Initial grinding process	75
	Final grinding process	75
	Milling process	68
	Chemical coating process of the shaft	125

Sleeve	Turning process of the sleeve	65
	Cleaning process of the sleeve	75
Assembly Process	Assembly process of rotor with shaft	71
	Assembly process of rotor with sleeve	60
	Painting process	30

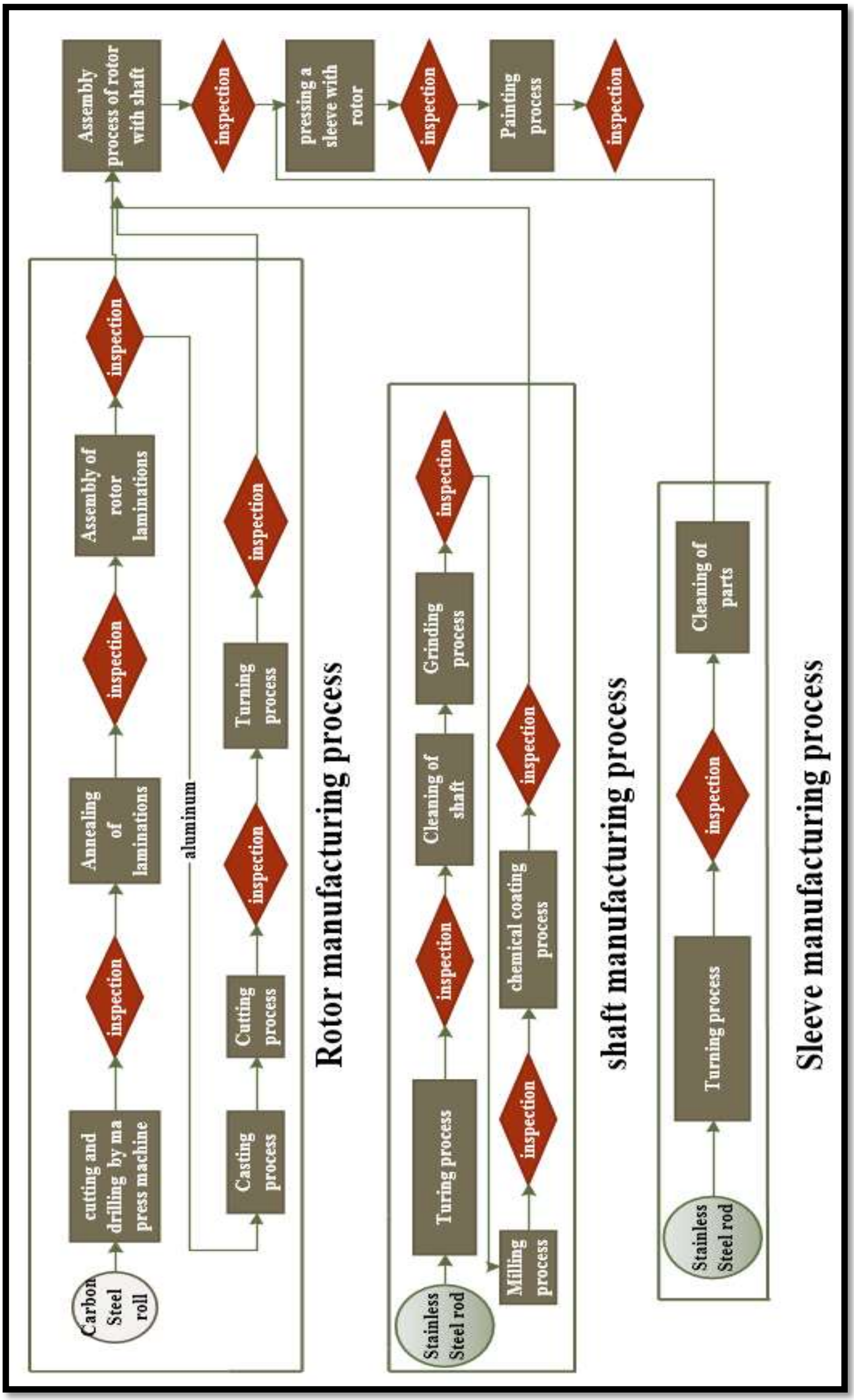

Figure 2. Flow Diagram of Rotor Manufacturing Process

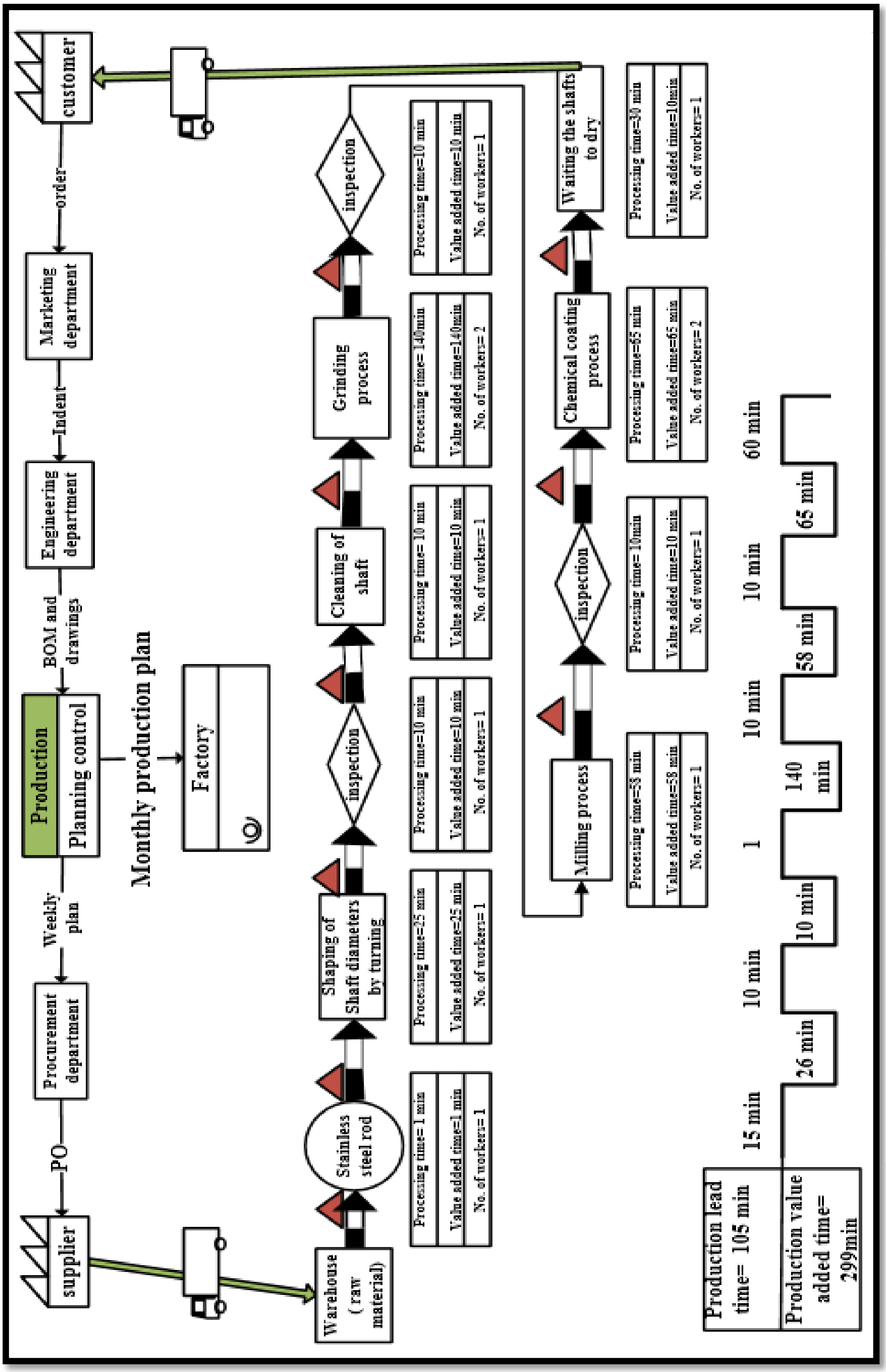

Figure 3. Current state value stream mapping of rotor manufacturing process

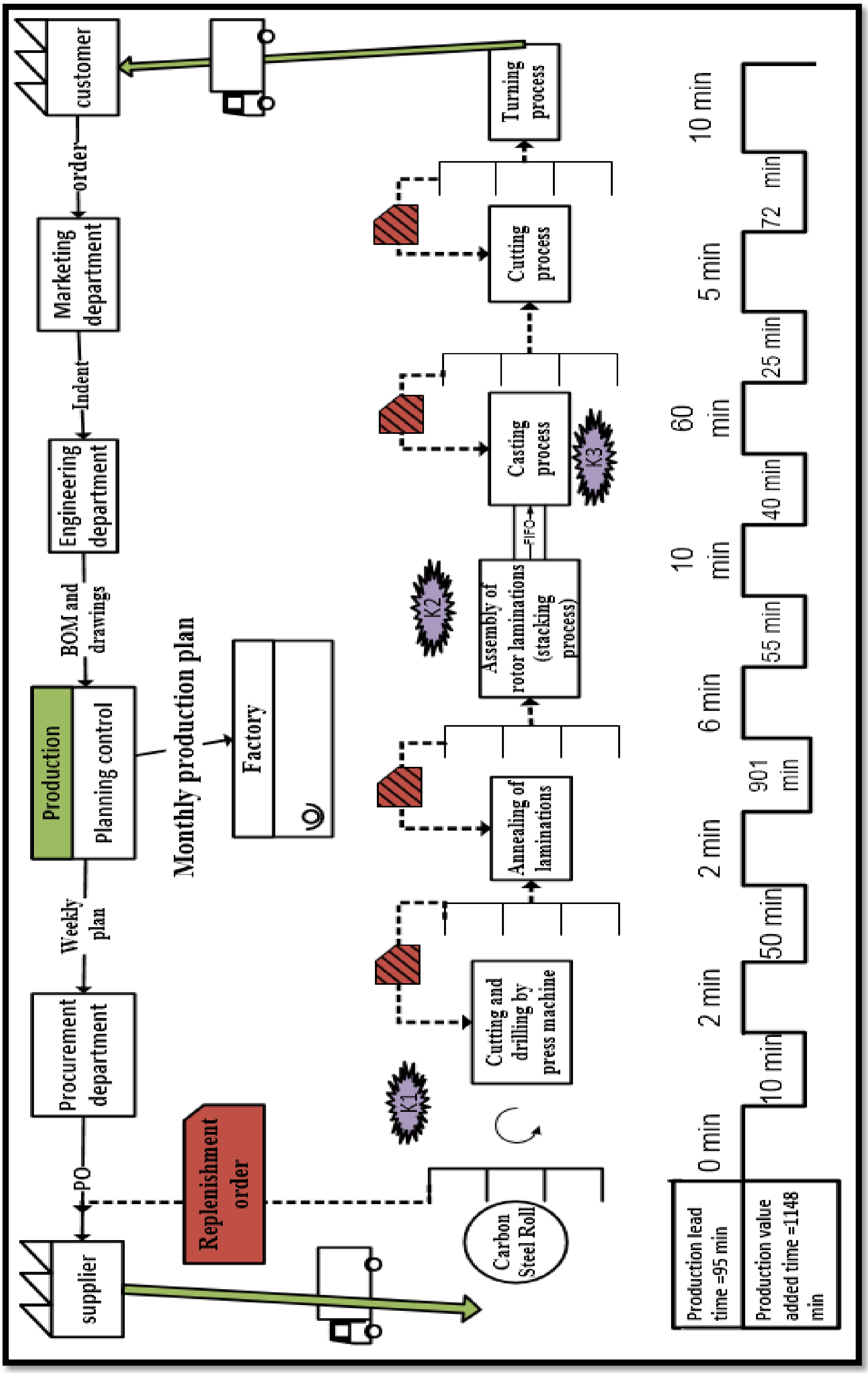

Figure 4. Future state value stream mapping of rotor manufacturing process

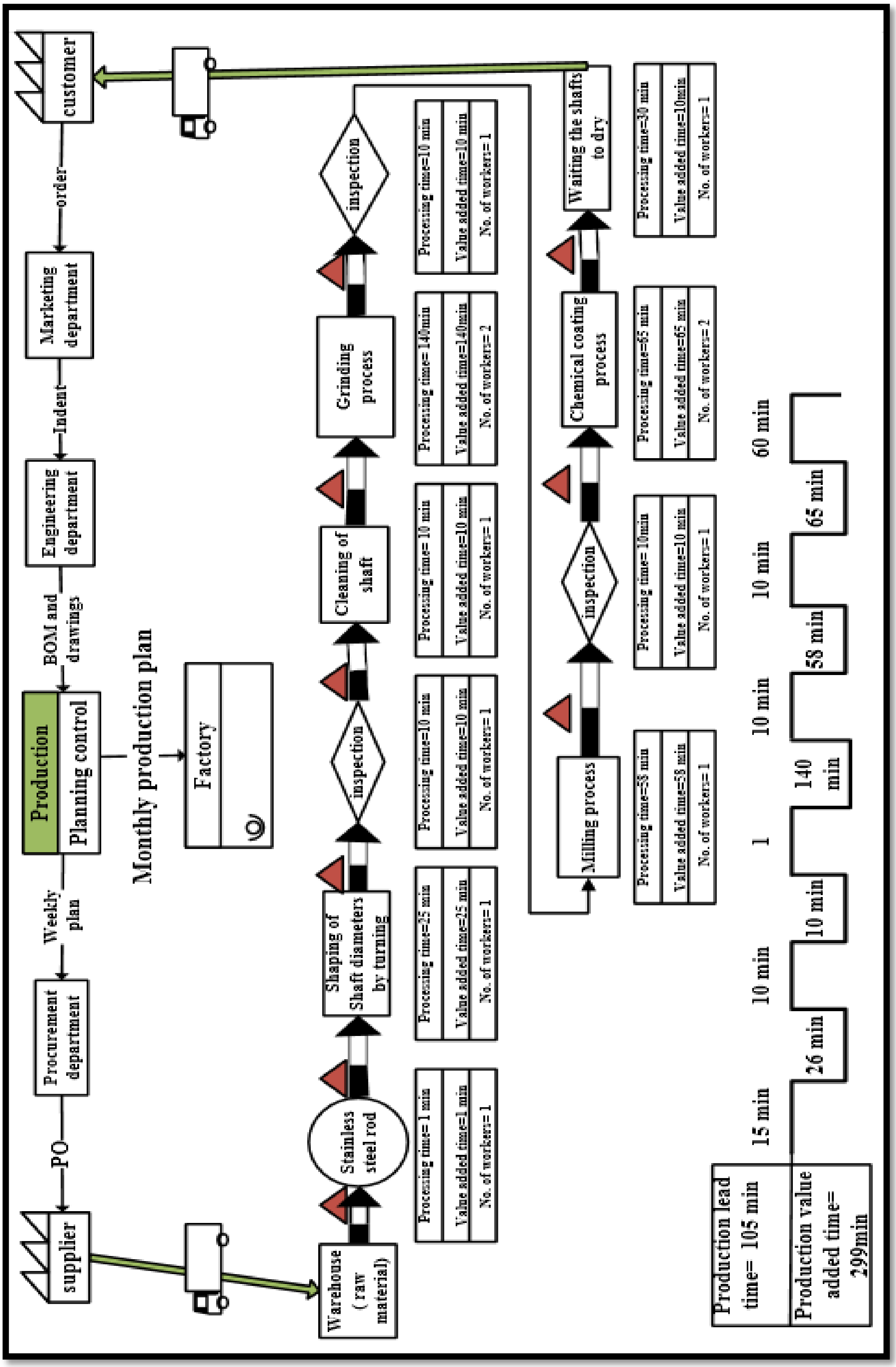

Figure 5. Current state VSM of the shaft manufacturing process

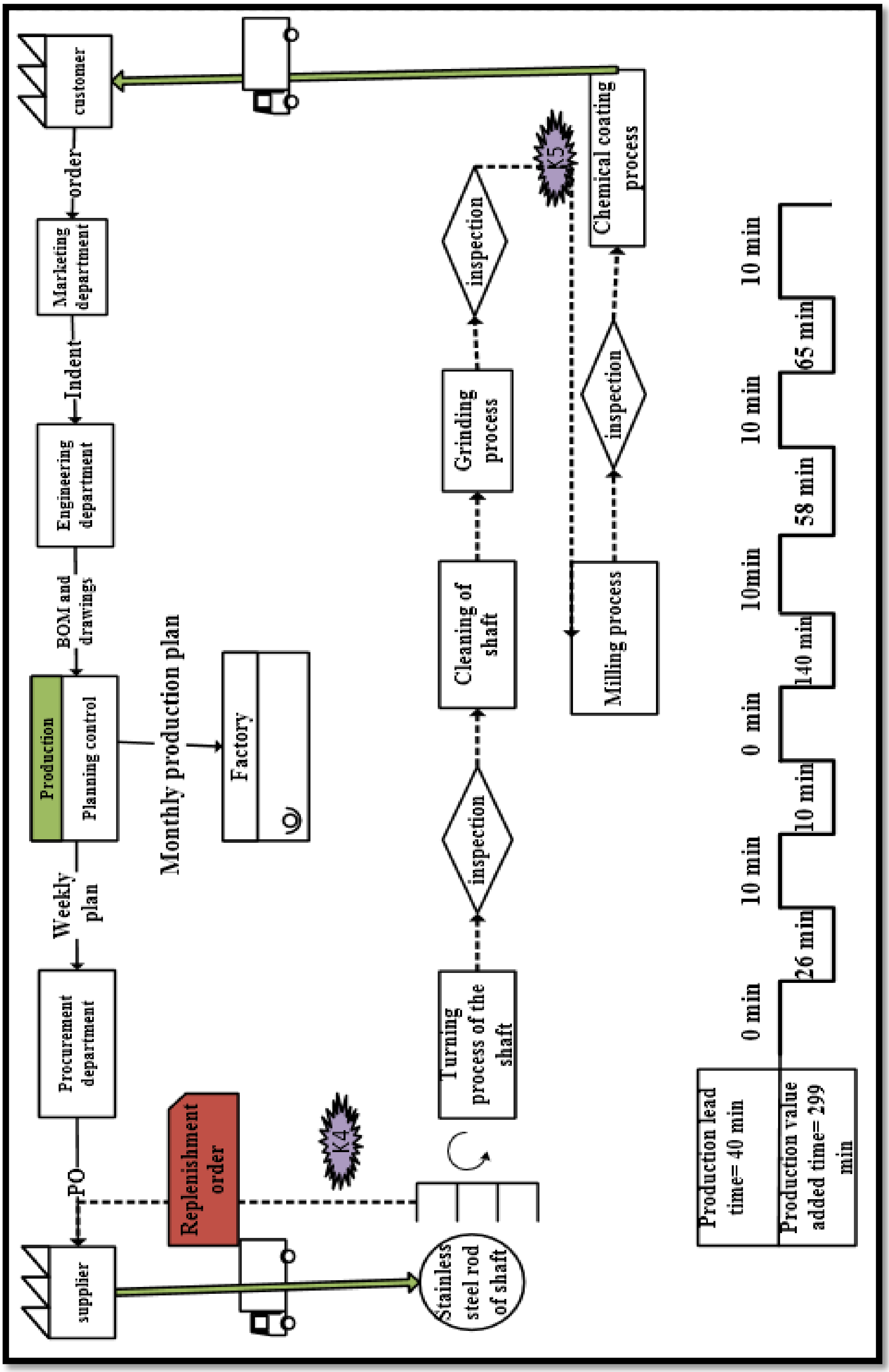

Figure 6. Future state VSM of the shaft manufacturing process

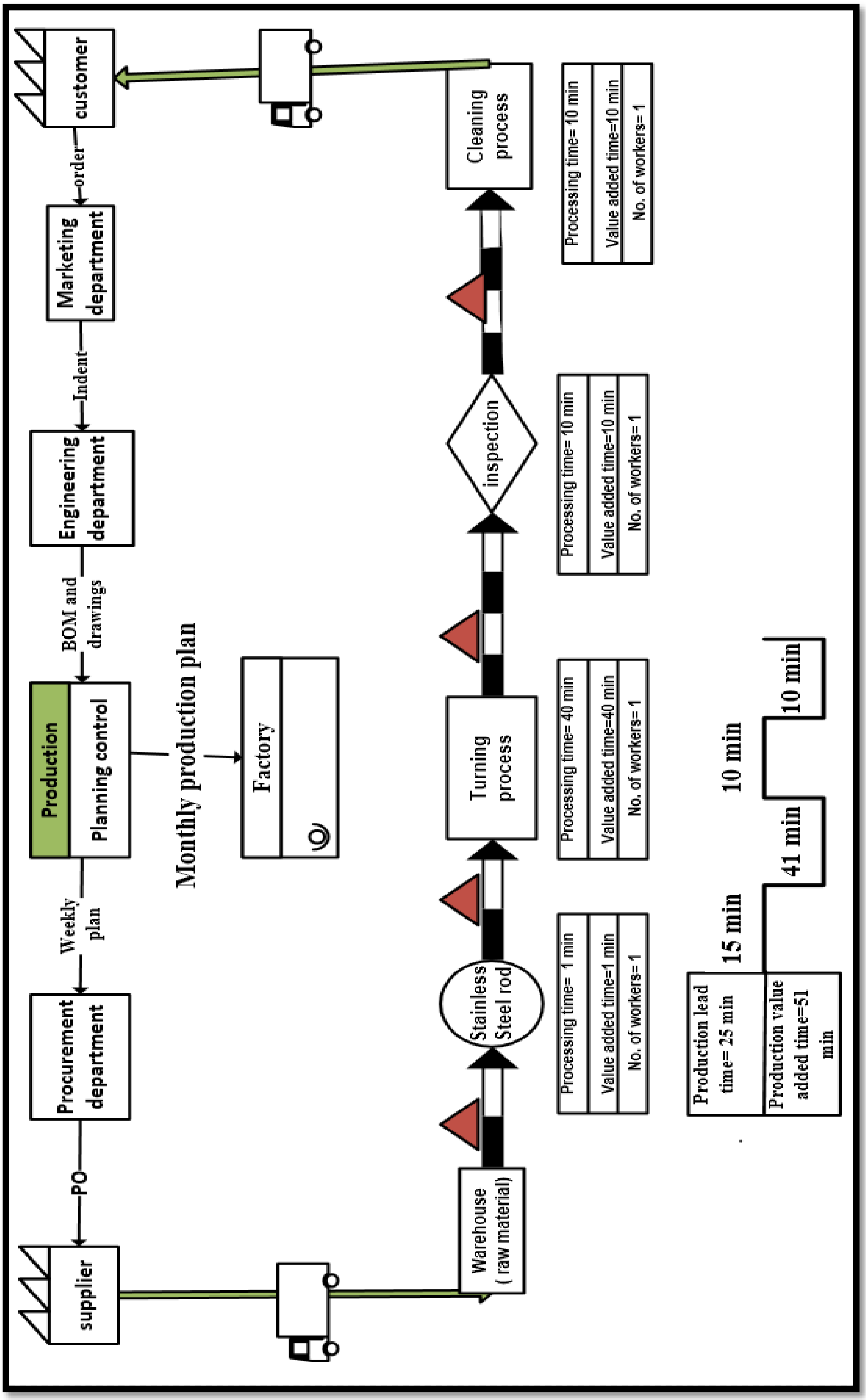

Figure 7. Current state VSM of the sleeve manufacturing process

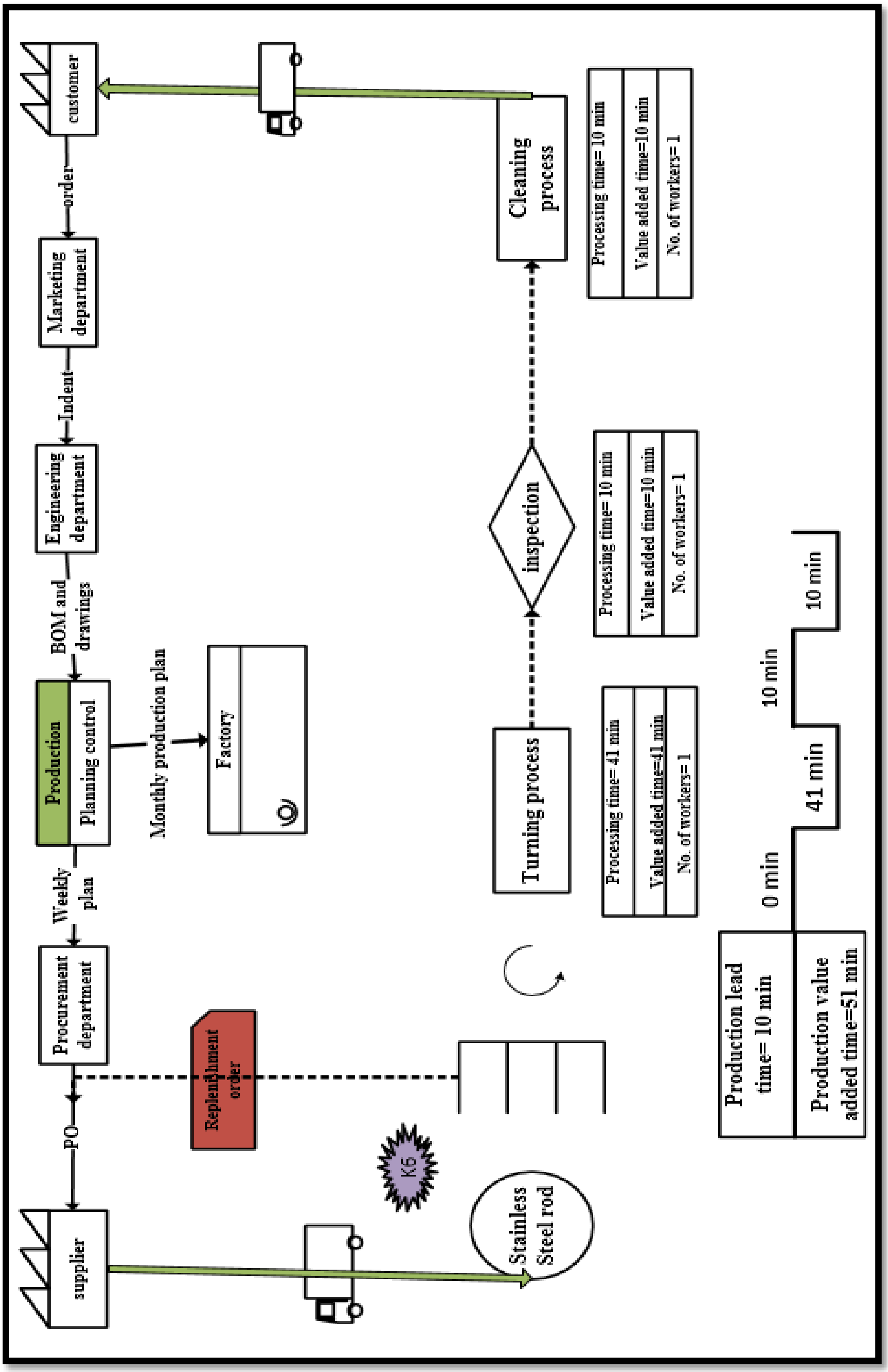

Figure 8. Future state VSM of the sleeve manufacturing process

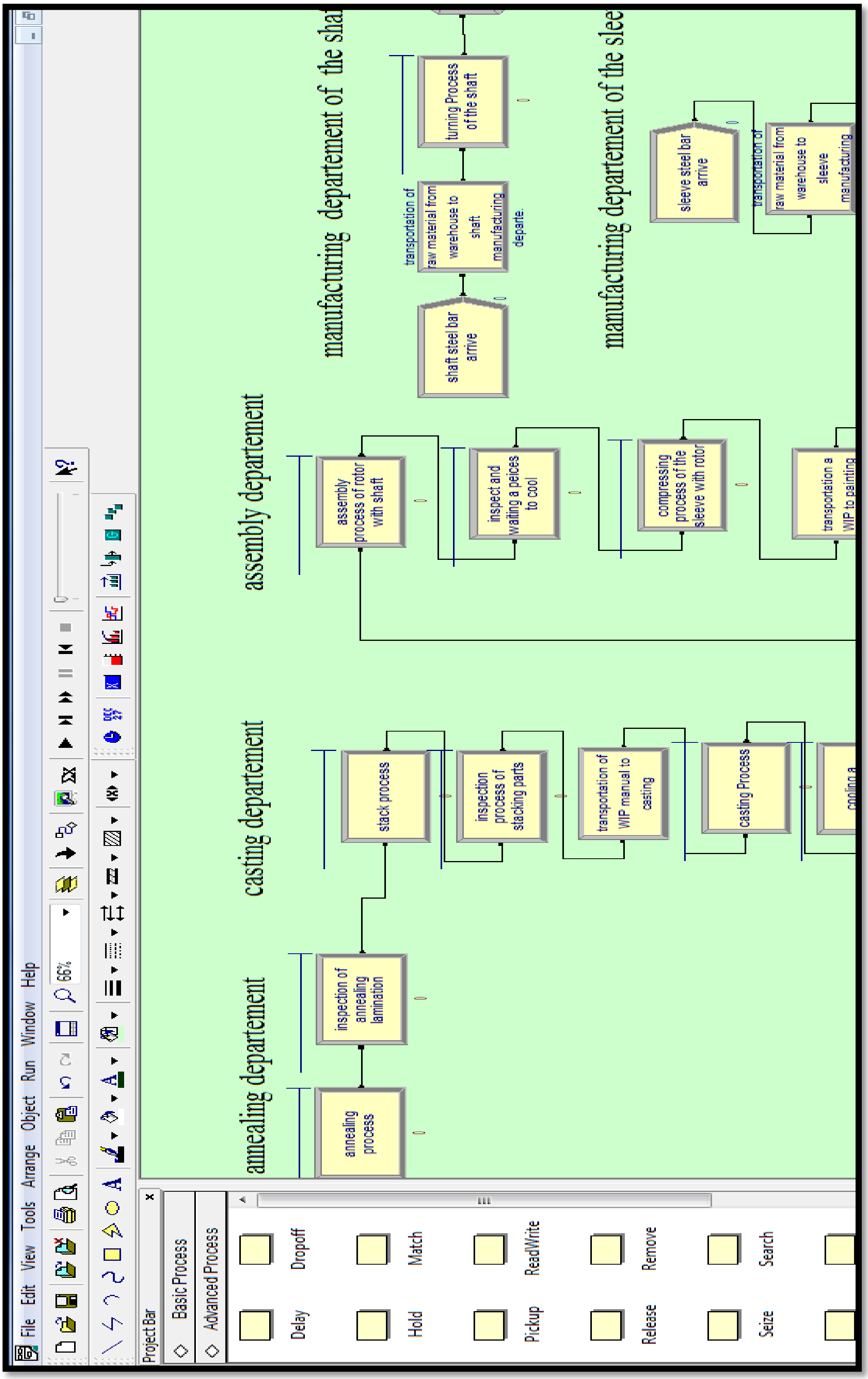

Figure 9. Simulation model of current and future state VSM

Table 2. Summary of simulation results for current and future state.

Measurement	Current state	Future state	Improvement ratio %
Production lead time (LT) (min)	2847	1920	33 %
Waiting time (T_w) min	1474	900	34%
Work in process (WIP) (unit)	12	10	16%
Throughput (TH)	72 unit per hr	88 unit per hr	22 %
Value added time (min)	848	927	10%
Non-value added time (min)	448 min	90 min	80 %
Value added ratio (VAR)	29%	48%	66%
Production capacity (Pc)	400 units per week	500 units per week	0.25 %

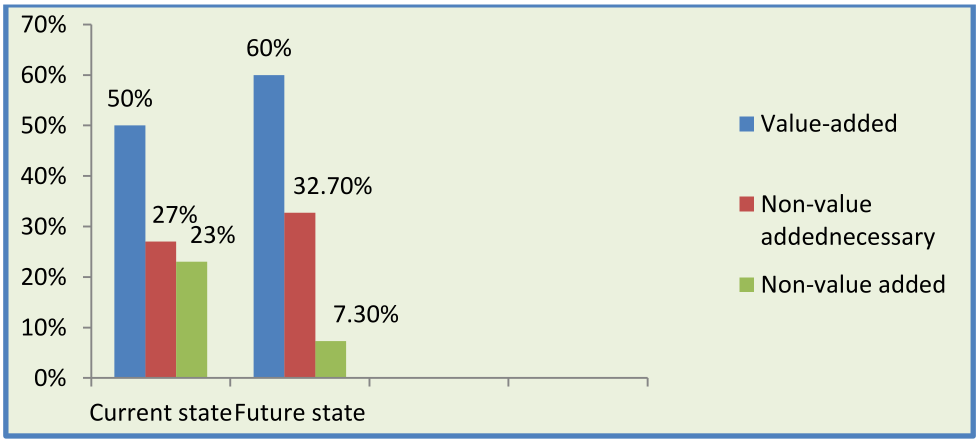

Figure. 10 The percentages of production activities type in current and future state .