AGH Journal of Mining and Geoengineering • vol. 36 • No. 3 • 2012

*Maria Rosienkiewicz**

IDEA OF ADAPTATION VALUE STREAM MAPPING METHOD TO THE CONDITIONS OF THE MINING INDUSTRY

1. Value Stream Mapping method

The Value Stream Mapping (VSM) method is one of the tools of the lean manufacturing methodology. It originates in the Toyota Production System (TPS). In Toyota this method was called "Material and Information Flow Mapping". This technique enables analyzing and designing the flow of materials and information required to bring a product or a service to an internal or external customer. In the automotive industry it is widely used to optimize processes, eliminate waste, set proper level of stock and, last but not least, to actually see and understand the real process. VSM helps to understand and streamline work processes using tools and techniques of Lean Manufacturing. The aim of VSM is to identify, demonstrate and decrease waste in the process. It can serve as a starting point to help management, engineers, production associates, schedulers, suppliers and customers recognize waste and identify its causes. VSM can be a communication tool, but also may be used as a strategic planning tool. A value stream can be defined as all the actions — both value added and non-value added — currently required to bring a product (service) through the main production flows essential to every product [5].

Value Stream Mapping is used to represent the current state of the production system and the future ("ideal") state that are developed to implement lean solutions. Future state map is a basis in the process of developing implementation plans to install lean systems [5]. VSM is in fact a sophisticated flow charting method that helps visualizing processes and track performance. This method enables determining which steps add value and which do not. A step (operation) that adds value can be defined as a step in the production process that improves the product for the customer. Non-value added steps can be defined as activities

* Faculty of Mechanical Engineering, Wrocław University of Technology, Wrocław

that do not contribute to the product or the process and should therefore be eliminated. They are simply waste.

In a typical manufacturing enterprise a current state map is usually created as a one-page flow chart that depicts the existing production path of a product from the customer's request to delivery. An important goal of value stream mapping is to identify processes that do not provide value so they can be improved. In lean methodology, value is described as anything the customer is willing to pay for. Processes that do not provide value are called waste.

Implementation Lean Manufacturing philosophy in VSM method is that each process of the value stream should produce only what the next process (its customer) needs. In addition, it should be done exactly in time the recipient actually reported demand. This concept aims to combine all the processes in a value stream in a fluent flow, that will guarantee the shortest execution time, the highest quality and lowest cost. Mapping, as a qualitative (not quantitative) tool, allows to describe the company's organization in a detailed way in order to create the right conditions for the flow and helps avoiding making random decisions [5].

Before drawing a current-state map it is necessary to identify value streams existing in a company and to select a representative value stream, for which the map will be developed.

2. Value and waste definition

In the Lean methodology right understanding of value is crucial. Only customer can properly define the value. Value definition is meaningful only when it is expressed in relation to a particular product or service (or both) that meet customer needs at a specified price in a specified time. To enable using the Value Stream Mapping method in the mining industry a definition of value must be established. Mining industry is very specific and therefore it requires proper understanding of the idea of value. Its definition is crucial to determine the value stream, develop a current-state map and consider implementing a pull system. As it was mentioned, the value stream is defined as all the actions required to bring a product through the main production flows essential to every product. The essence of Value Stream Mapping is to see the flow and waste, and its sources in the value stream. The table contains a summary of examples of waste that can be find in a mining environment and the 7 types of waste defined in the automotive industry [3].

The Figure 1 presents an example of dividing mining operations into value added and non-value added.

The example comes from an article Lean management implementation in mining industries written by A.F. Klippel, C.O. Petter and J.A. Valle Antunes [2]. The operations were classified according to Shigeo Shingo's classification into A — essential operations, B — auxiliary operations and C — useless operations. Essential operations (A) are related to the net labor, that adds value to the product. Auxiliary operations (B) do not value to the product but they are necessary for the essential operations to be carried out. Useless operations (C) mean waste along the process and should be eliminated.

TABLE 1
Types of waste

7 types of waste defined in the automotive industry	Examples of waste that can be noticed in a mine
Overproduction wastes	Mining capacity may outstrip the plant's ability to process ore
Motion wastes	Operators may have to walk a long way for crib breaks or to hand over; trucks driving not optimal roads
Waiting wastes	Trucks may be waiting at a dump site; excavators can wait for coming back trucks
Transportation wastes	Moving mined ore many times before it reaches its final destination; spare parts, material transportation in the wrong place
Inventory wastes	Keeping either to excess or too little inventory on site
Defective production wastes	Having to fix trucks after oil overfills
Processing wastes	Processing ore to a better grade than the customer is willing to pay; drilling more holes than necessary

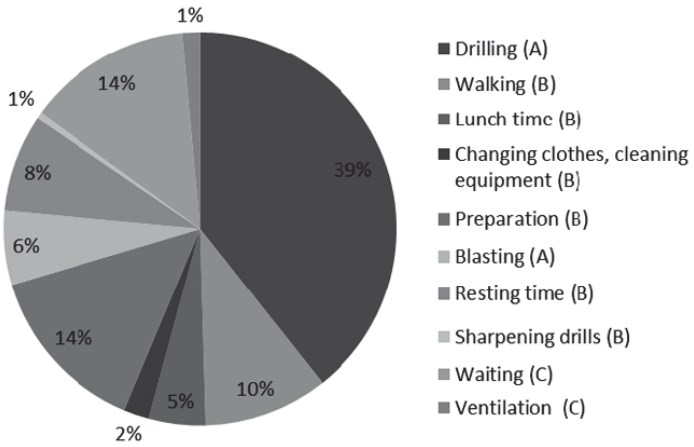

Fig. 1. Operations carried out in a mining block

The example shows that the total amount of time spent on the essential operations (drilling, blasting) takes only 45.5% of the whole mining block. 39.6% of the time is spent on the auxiliary operations (commuting, sharpening drills changing clothes, having lunch, resting period etc.). Given example presents that 15% of the whole mining block take useless operations (waiting and ventilation).

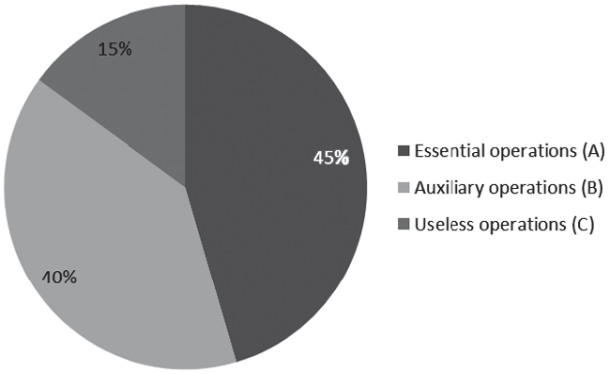

Fig. 2. Operations classified according to Shigeo Shingo classification

To increase the efficiency of the process a set of improvements was proposed. After implementing the solutions measurement was carried out again. The total amount of time spent on the essential operations took after implementing improvements 60.7% of the whole mining block. 33.5% of the time was spent on the auxiliary operations and useless operations took 5.8% of the whole mining block. Given example shows that using lean manufacturing methods helps to increase the efficiency of the mining processes.

VSM method is widely used mainly in the automotive industry and in manufacturing enterprises. The way of proper value stream mapping is described in the literature mainly in reference to the stable and repetitious production. Literature does not provide a guidance explaining how to implement VSM method in a mining environment. These conditions are very specific and differ significantly from the processes in typical manufacturing companies. Therefore, in order to properly verify if the VSM method can be useful in the mining industry, two concepts of Value Stream Mapping in a mine were developed. While developing the concepts of adapting VSM, two alternative definitions of value were proposed. According to the first definition value in the mine is the particularly characterized ore. All the features that it should have in order to meet customer requirements were defined. In the second approach value is the service of providing machines from the heavy machinery compartment to the extraction area. Two different definitions of value implicates in developing two different value stream maps.

3. Concepts of value stream mapping in the mining conditions

The concept corresponding with the first value definition will allow to map the current state and thus will:

— Illustrate the material and information flow process during the haulage process (haulage vehicles and excavators),
— Enable observation of the link between material and information flows,

— Identify problems in the material and information flows,
— Illustrate how much time does the haulage process really takes,
— How much of that time, excavated material is actually processed, and how much time is taken by the non-added value operations.

In the current organizational system in the mine, machines and equipment are delivered to the extraction area according to the rules of the push system.

The aim of the research based on the concept derived from the second definition of value is to analyze the possibility of rearranging this push system into pull system. Pull system works according to the lean manufacturing rules. The aim of the Value Stream Mapping in this approach is to develop a current-state map that describes the machinery (including appropriate parts and materials) and information flow dedicated to the service of providing machines from the heavy machinery compartment to the extraction area or other destination.

4. Concept of an algorithm of observing and measuring a process

The mining conditions are very specific and therefore the process of observing and measuring (that is necessary to develop a proper current-state map) has to be properly adjusted. There are very strict rules on safety in the mine. This is why it is impossible for an observer to perform some of the measurements.

Therefore, adjusted to these limitations, an algorithm to collect data, information and measurements was developed. The algorithm is shown in the figure above. The collected data, information and measurements will enable drawing the current-state map of the chosen mining process. The algorithm describes all the steps there are necessary to take in order to collect all the needed data, observations and information essential to develop a current-state map. The algorithm includes gaining data regarding both — information and material flow.

There is a term coming from Japanese language called “gemba”. It means “the actual place” and is often used for the shop-floor or any other place where value-creating work actually occurs. The term is used to stress that real improvement requires a shop-floor focus based on direct observation of current conditions where work is done. For example, standardized work for a machine operator cannot be written at a desk in the engineering office — it has to be defined and revised on the “gemba” [4]. This is why it is so important to perform all the observations personally in the extraction area.

5. Summary

In the next stage of research on verifying the possibility of implementing Value Stream Mapping method into mining industry, observations and measurements according to the developed algorithm will be carried out. Subsequently, the two current-state maps will be developed according to two different value definitions.

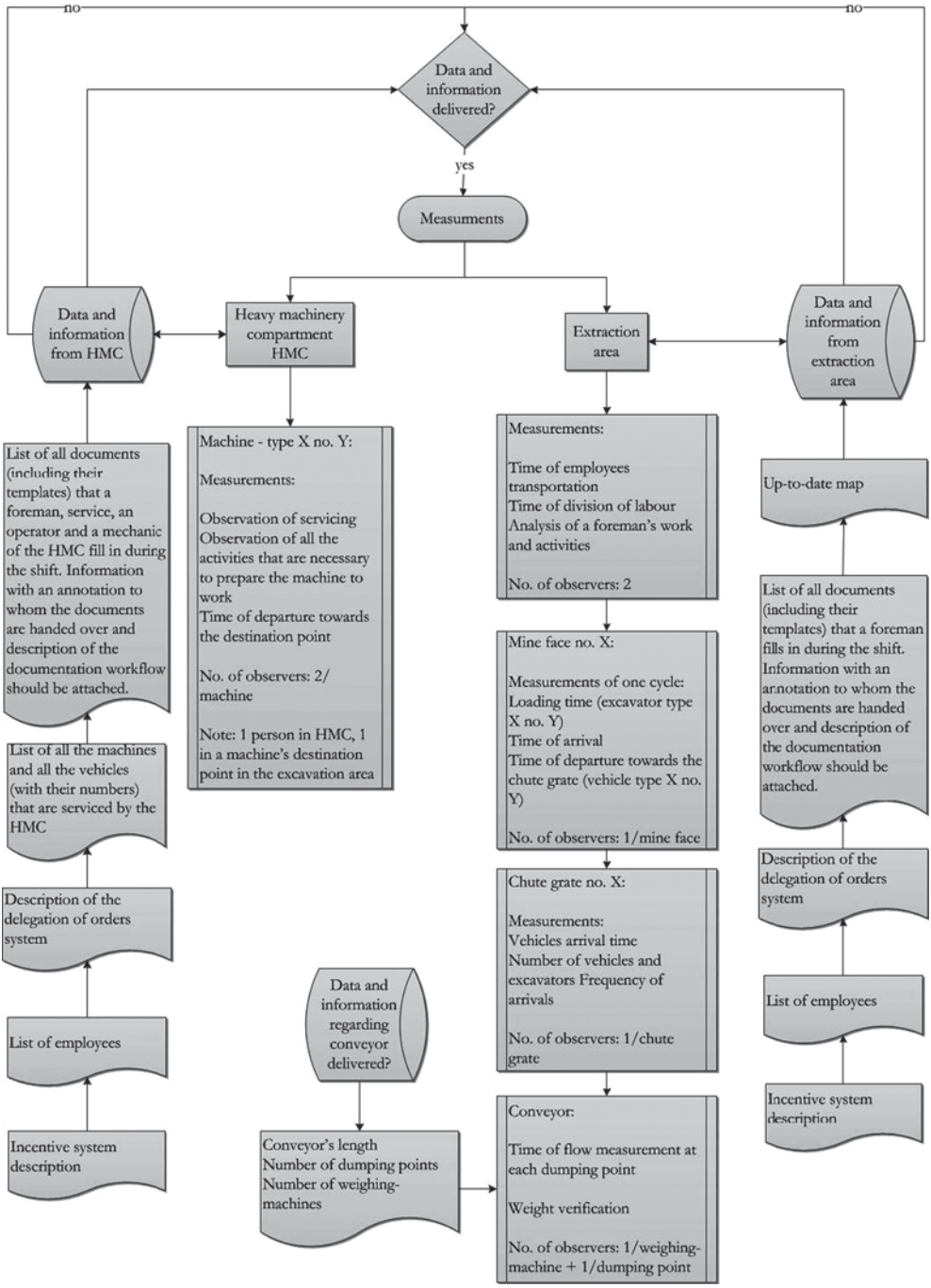

Fig. 3. An algorithm of collecting data, information and measurements

After drawing the maps, all the operations will be divided into value added and non-value added according Shigeo Shingo's classification. Additionally an Failure mode and effects analysis of the analyzed process will be performed. The FMEA is a methodology that enables finding errors in a process and errors causes and therefore is the basis for further process improvement [1]. The aim of the FMEA analysis is to identify potential flaws of the process and to design solutions for problems that have high risk priority number (RPN).

Afterwards, areas of waste will be identified. Then, based on the obtained results a comparative analysis of both concepts will be performed. Next step will be to develop a future-state map that will be the basis in the process of developing implementation plan.

REFERENCES

[1] *Chlebus E.*: Techniki komputerowe CAx w inżynierii produkcji. Wydawnictwa Naukowo-Techniczne, Warszawa 2000.

[2] *Klippel A.F., Petter C.O., Valle Antunes J.A.*: Lean management implementation in mining industries. Dyna, march, part 75, number 154, Medellin, Kolumbia.

[3] *Lavin B., Sanford R.*: The Application of Lean Manufacturing in a Mining Environment. International Mine Management Conference, Melbourne K. Dunstan.

[4] *Marchwinski C., Shook J., Schroeder A.*: Lean Lexicon. A graphical glossary for Lean Thinkers. Fourth Edition, The Lean Enterprise Institute Cambridge, MA, USA 2008.

[5] *Rother M., Shook L.*: Naucz się widzieć. Eliminacja marnotrawstwa poprzez mapowanie strumienia wartości. Wydawnictwo Lean Enterprise Institute Polska, Wrocław 2009.