Advances in Social Science, Education and Humanities Research, volume 290

2nd International Conference on Economic Development and Education Management (ICEDEM 2018)

Analysis of Factors Influencing Lean Production Based on Interpretative Structural Model

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***Abstract*—Toyota Production System (TPS) is a lean production, which was introduced to China and applied to the manufacturing site. The purpose of lean production is to improve the management quality of manufacturing enterprises, so as to achieve effective management and control of the visual scene of lean production, which is the focus of this paper. Based on Kanban principle, this paper classifies the influencing factors of lean production by interpretative structure model, and constructs a hierarchical structure model of influencing factors, so that the influencing factors of lean production are clearer. Effective use of the relationship between various factors in the implementation process can avoid risks ahead of time and improve the efficiency of enterprises.**

Keyword—The lean production; Influence factor; Visualization; Interpretative structural model

I. INTRODUCTION

The important process of lean production in manufacturing plants prohibits all waste in the production process so as to continuously improve the production system. The ultimate goal is to achieve the best product quality and to respond quickly to market demand. However, there are some problems in the implementation process, so we use the interpretative structure model to divide the influencing factors of lean production into different levels, so that enterprises can solve the problems pertinently.

At present, scholars at home and abroad have done in-depth research on lean management, which provides a solid theoretical basis for this paper to explore the influencing factors of lean implementation visualization. Bayat (2017) and others evaluate the influence degree and interaction of various factors in practical work on the basis of lean production. [1]Anita (2013) and others embedded lean tools and concepts in it, which is conducive to the improvement of lean production system [2]. The implementation of lean production is to improve the competitiveness of enterprises through product quality, shortening the time of die changing, continuous improvement and effective facility layout [2].

Pei Zhengzhao and Lin Yu (2016) aim at perfecting the lean evaluation system, introduce policy management, use multi-level fuzzy comprehensive evaluation method to solve the problem, and thus determine the focus of the next stage of enterprise promotion of lean [3]. The introduction of lean production mode by Dong Yao (2017) and others has led to a low level of implementation of lean production mode in most enterprises in China. The fundamental reason is that many factors affecting the implementation of lean production can not be accurately analyzed in China's manufacturing industry. [4]Ma Qiaochu, Zheng Shuozhong (2016) and others can not effectively relate the traditional production system to the manufacturing site, while ignoring the function of guiding enterprises to achieve strategic objectives [5].

II. SELECTION OF INFLUENCING FACTORS OF LEAN PRODUCTION

Lean production Kanban is a tool to transfer and control the production process through visual form, to simulate the workflow needed in the manufacturing process, and to understand the influence factors of manufacturing industry more clearly.

A. Kanban design

Kanban usage presents the analysis of specific work to ensure lean production, which can improve the efficiency of enterprise work and reduce waste in all aspects. According to the needs of production operation and site management, lean production Kanban can be displayed according to the process of DMAIC (Definition, Measurement, Analysis, Improvement, Control) [6].

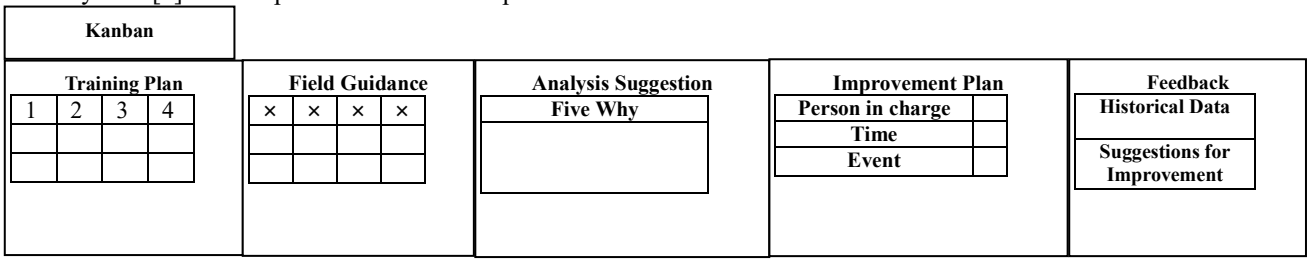

Fig. 1 KANBAN DISPLAY FORM

B. Extraction of Influencing Factors

ISM was developed by Professor J. Warfield in 1973, and eventually formed a multi-level hierarchical structure model. It is an effective method to analyze complex relationship structures [7]. By consulting relevant technical experts, the evaluation factors are revised, and the factors are integrated, deleted and supplemented. Finally, 12 factors affecting the visualization of lean production are obtained.

III. ESTABLISHMENT OF STRUCTURAL MODEL FOR INFLUENCING FACTOR INTERPRETATION

When researching complex lean production problems, ISM model can dissect the logical relationship between elements of complex system, which is helpful to visualize and visualize more intuitively. It is especially suitable for system analysis with many variables, complex relationships and unclear structure, and also for scheduling of plans.

A. Establishing adjacency matrix A

Based on the above factors, the adjacency matrix A is established, which fully reflects the institutional relationship between the two factors of visualization, and describes the basic binary relationship or the direct connection between the system elements. The obtained adjacency matrix A:

TABLE I ADJACENCY MATRIX

	S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8	S_9	S_{10}	S_{11}	S_{12}
S_1	0	1	0	0	0	0	0	0	1	0	1	1
S_2	0	0	0	0	0	1	1	0	0	0	0	0
S_3	0	0	0	0	0	0	0	0	0	0	0	0
S_4	0	0	0	0	0	1	1	0	0	1	0	0
S_5	0	1	0	0	0	0	0	0	1	0	1	0
S_6	1	0	0	0	0	0	0	0	0	0	0	0
S_7	0	0	0	1	0	0	0	1	0	0	0	0
S_8	0	0	0	0	0	1	0	0	0	1	0	0
S_9	0	0	0	0	0	0	0	0	0	0	0	1
S_{10}	0	0	0	0	0	1	0	0	0	0	1	0
S_{11}	0	0	0	0	0	0	0	0	0	1	0	1
S_{12}	0	1	1	0	0	0	0	0	0	0	0	0

TABLE II REACHABLE MATRIX M OF INFLUENCING FACTORS

	S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8	S_9	S_{10}	S_{11}	S_{12}
S_1	1	1	0	0	0	0	0	0	1	0	1	1
S_2	1	1	1	0	0	0	0	0	1	0	1	0
S_3	0	0	1	0	0	1	0	1	0	0	1	0
S_4	0	0	0	1	1	0	0	1	0	1	1	0
S_5	1	1	1	0	1	1	1	1	1	1	1	1
S_6	1	1	0	0	1	1	0	0	1	1	1	1
S_7	0	0	0	1	0	0	1	0	0	1	0	0
S_8	0	1	1	0	0	0	1	1	0	1	1	0
S_9	0	0	1	0	0	1	1	0	1	1	1	1
S_{10}	0	1	0	0	0	0	0	0	0	1	1	0
S_{11}	0	0	0	0	1	1	0	0	0	1	1	0
S_{12}	0	1	1	0	1	1	0	1	1	1	1	1

B. Establishing reachability matrix M

The adjacency matrix reflects the direct relationship between the influencing factors, and the reachable matrix M reflects the indirect relationship between the influencing factors. Reachability matrix:

TABLE III ANALYSES THE FACTORS AFFECTING LEAN PRODUCTION

Influence factor	Describe
S1 Staff Streamlining Efforts	Operators can adjust flexibly so that they can work at full load.
S2 Reasonable Operational Rhythm	Actual working hours/daily requirements = work rhythm.
S3 5S Management Standardization	Develop 5S-based activities to reduce action waste and road congestion.
S4 Scientificality of Kanban Quantity	Use Kanban design correctly in manufacturing enterprises to reduce process loopholes.
S5 Reasonable Arrangement of Processes	The production cycle can be greatly shortened before the implementation of lean production.
S6 Reasonable Layout	Reasonable U layout of equipment, no frequent replacement of equipment during processing.
S7 The Choice of Error Prevention Measures	Can we effectively improve the methods of misuse?
S8 Reasonable Sequence of Operations	It can be processed in the order of order arrival in the shortest time, and each job has corresponding relaxation time.
S9 Degree of Man-Achine Separation	Whether it can achieve full automatic operation.
S10 Executive Power	Can we finish the order on time and finish the related work according to the regulations?

Table III, cont	
S11 Effectiveness of Feedback	Whether the employee feedback the actual rectification in the prescribed way.
S12 Strength of Waste Control	Reduce or even eliminate waste of raw materials and accessories, optimize operation to reduce waste.

C. Hierarchical division of influencing factors

Reachable set R (Si) denotes the set to which Si can reach; preceding set Q (Si) denotes the precursor set to which Si can be reached; the highest-level element set determines the highest-level element Ri according to R (Ri) = R (Ri) Q (Ri), and so on, finds out the element sets of each layer.

TABLE IV ANALYSIS TABLE OF INFLUENCING FACTORS

i	R(Si)	Q(Si)	R(Si)∩Q(Si)
1	1 2 9 11 12	1 2 5 6	1
2	1 2 3 9 11	1 2 5 6 8 10 12	2
3	3 6 8 11	2 3 5 8 9 12	3
4	4 5 8 10 11	4 7	4
5	1 2 3 5-12	4 5 6 9 10 11 12	5
6	1 2 5 6 9 10 11 12	4 5 6 9 10 11 12	6
7	4 7 10	5 7 8 9	7
8	2 3 7 8 9 10	3 4 5 8 12	8
9	3 5 6 7 9 10 11 12	1 2 5 6 9 10 11 12	9
10	2 5 6 9 10 11 12	4 5 6 7 8 9 10 11 12	10
11	5 6 9 10 11 12	1-6 8 9 10 11 12	11
12	2-6 9 10 11 12	1 5 6 9 10 11 12	12

From the model, we can see the hierarchy of lean management effect and its relationship with each other. As shown in Figure 2.

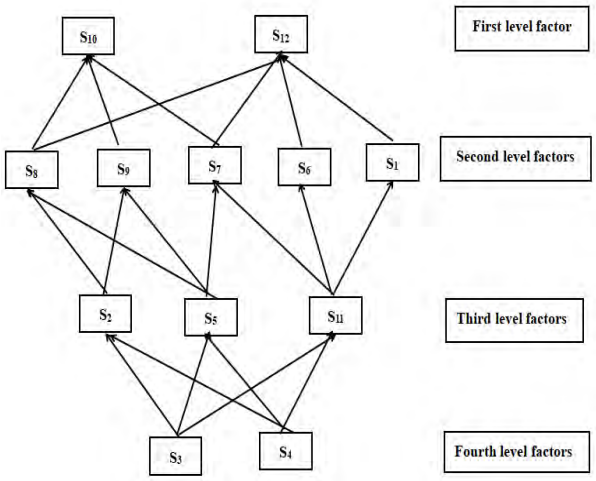

Fig. 2 EXPLANATORY STRUCTURAL MODEL OF INFLUENCING FACTORS

D. Hierarchical analysis of influencing factors

The first level of factors affecting lean production is S10 and S12, which have a direct impact on lean production. It is the core requirement for enterprises to carry out lean production on time, according to quality and quantity. The positioning and layout of enterprise strategy are based on execution ability. Waste control is the core idea of lean production management. It is a protracted battle and should be eliminated from the beginning.

The second factor is the production level of lean production. One flow is an important factor in realizing lean production process. The whole process is clear and clear, reducing the demand of staff, so as to achieve fewer people. The reasonable application of man-machine separation degree and error prevention needs to be combined with fixed working mode to realize the idea of rapid mode change, which can automatically deal with abnormal phenomena in time and reduce the error rate of operators.

The third level of influencing factors. It is not blindly copying and implementing the business process of an enterprise to analyze its operation rhythm and sequence. The implementation of lean process can bring amazing benefits to the organization. In order to ensure the implementation of the rectification work, the rectification and feedback can complete the rectification task strictly according to the prescribed time and route, so that all departments and working groups can maintain a high sense of urgency.

The fourth influencing factors, 3S and 4S, are the fundamental influencing factors. The primary task of establishing lean production system is to do a good job of 5S, to design Kanban quantity suitable for production, to improve the production efficiency of enterprises, to achieve total quality management, to balance production, to establish standard process operation is the most direct and effective way to improve the site.

IV. SUMMARY

Through the comprehensive analysis of the factors affecting the whole lean production, this paper concludes that lean production is not only a set of tools and methods to improve efficiency, reduce errors in work, and effectively solve problems. Sim is used to divide the influencing factors into different levels and analyze the specific problems, which is more conducive to the implementation of lean production. Lean production can be regarded as an advanced mode of modern management because it can minimize inventory, perceive and eliminate waste, shorten the development and production cycle, and bring huge benefits to enterprises. It has gradually been widely used by enterprises in various fields. Therefore, in-depth research and application of lean production is of great and far-reaching significance to improve China's manufacturing management model and enhance the competitiveness of enterprises in the market.

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