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Some Advanced Topics on Innovation-focused Lean/Agile Management

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Abstract

This paper discusses some innovative activities in the lean context, and these are closely related to customer needs and environmental sustainability. Namely, 1) General concept and systematic procedure of leanised product development. This topic consists of the ideas of proactive and reactive approaches, where the former is planning phase-focused approach and the latter is recovery phase-focused style of management and both are very critical factors for product development performance. For the second issue, newly developed matrices-based systematic procedure for relevant product development is proposed. 2) General discussion on application of green-lean methodology, especially Karakuri technology, to process development activity. Typical patterns of its application will be summarised with case example.

Keywords: Reinforcement of Lean Scheme; Innovation, New Product Development; Matrices-based Procedure; New Process Development; Green-lean Management; Karakuri Technology

1. Introduction

Basic concept and technical procedures of lean management has been reinforced since 1930s along with Japanese industrialisation (Womack et al., 1990). During this century-long industrial history, various extensions have been carried out to adapt radical changes of business environment such as global competitiveness, increasing social responsibility, intensifying scale and complexity of management issues, highly developed customer needs, arguments on environmental sustainability *etc* (Katayama and Bennett, 1996; Katayama and Bennett, 1999; Katayama, 2010; Suzuki, 2015). The topics being discussed in this paper are on some innovative activities in the lean context, which are deeply drawn attention among professionals, and these are closely related to the last two issues listed in the previous paragraph, *i.e.* customer needs and sustainability (Katayama, 2011). Various concepts and terms related to innovation are summarised and categorised followed by their review as the introductory remarks. Then, following two issues will be focused to discuss. 1) General concept and systematic procedure of leanised product development. For the first issue, the ideas of proactive and reactive approaches is introduced and discussed, where the former is planning phase-focused approach and the latter is recovery phase-focused style of management and both are very critical factors for product development performance. Essential point to argue is how to manage both styles with fine balance. For the second issue, newly developed matrices-based systematic procedure for relevant product development is proposed, which is under application in various global firms tackling with TPM awards. 2) General discussion on application of green-lean methodology, especially Karakuri technology, to process development activity. Here, typical patterns of Karakuri application for process innovation will be summarised with case example.

1.1 Category of innovation

There are many research works on innovation and their typical classification is given below.

◈ Object-wise classification

(1) Product Innovation: Development of new products, new services *etc.* (JIPM Ed., 1999)
(2) Process Innovation: Development of new equipments/facilities for manufacturing, assembly, chemical reaction, logistics operations *etc.* (JIPM Ed., 1999)
(3) Technology Innovation: Development of new materials, new manufacturing methodologies *etc.*
(4) Market Innovation: Development of potential demand, new sales channel *etc.*
(5) Business Innovation: Development of new supply chain, new collaborative network such as new, new value chain *etc.* (Porter, 1985)
(6) Social Innovation: Development of new society, which is linked with the Sustainable Development Goals (SDGs) adopted in United Nations Summit and Society 5.0 by Japanese government.

◈ Style-wise classification

(1) Disruptive/Sustaining Innovation (Christensen, 1997)

Figure 1 illustrates the relation between the concept of disruptive and sustaining innovations. When disruptive innovation occurs as a new innovation, market will be befuddled and reconstructed with business growth.

Then sustaining innovation becomes major activity to support this growth. Along with the mutation of market mind and/or value sense, business retreat again to encourage next disruptive innovation. Here, the important issue in this cycle is well-balanced process of both type of innovations for sound market growth. This implies preparation of aggressive investment on disruptive innovation with raising certain level of profit by sustaining innovation.

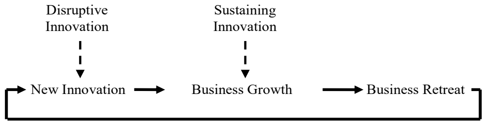


Figure 1. A typical Innovation Cycle.

(2) Closed/Open Innovation (Chesbrough, 2003)
These styles of innovations must be also carefully balanced as these has different aspects of merits and demerits as described.

◆Open Innovation Merit: Effective deal with shortening product life cycle and diversification of customer's value sense, Demerit: Being stranded on a reef often

◆Closed Innovation Merit: Attribution of business profit to own company through occupation of highly competitive technologies and know-how, Demerit: Spending huge cost and long time during the period from entry of R&D to completion

1.2 Category of sustainability

Argument of sustainability, which must be closely linked with innovation, is categorised by object-wise way as follows (Katayama and Lee, 2018).

(1) Environmental Sustainability: Protection of Environmental Destruction
(2) Industrial Sustainability: Business Activity as Going Concern
(3) Social Sustainability: Human-centred Everlasting Social Structure

1.3 Innovation in a strategic behavioural model

Innovation function/activity tends to be more critical than before among business firms. Figure 2 shows a general strategic behavioural model of manufacturing industries which are supposed to adopt or follow this robust structure explicitly or tacitly.

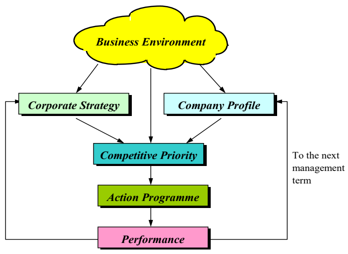


Figure 2. Strategic behavioural model of manufacturers developed by MFP-International Project (Miller et al., 1993; Katayama, 1998).

Where, competitive priority (CP) is pattern of priority assignment to each elemental issue forming business unit's competitiveness, which consists of cost/price competitiveness (C), quality competitiveness (Q), delivery competitiveness (D), flexibility competitiveness (F), serviceability (S), Innovativeness (I) etc.
Action programme (AP) is set of activities for attaining predetermined goal based on the priority assignment to each member of CP, then, followed by the Performance (P), which is set of outcomes obtained through activities. Recent years, causal relation of innovation as a CP member, way to launch its proper activity and the resultant contribution represented in this model becomes important business success factor (Suzuki and Katayama, 2001).

2. Product innovation

In this chapter, among variety of innovation categories, product innovation is focused to discuss.

2.1 Proactive and reactive approaches

First issue to consider is its conceptual aspect, in which proactive and reactive types of attitudes concerning with this activity are two contrasted ways. Figure 3 represents general structure of product development activity adopted in TPM (Total Productive Maintenance and Management) which is one representative lean scheme born in Japan in 1971. In this drawing, there are two operation phases, i.e. proactive and reactive phases, where α% of total possible problems is eliminated in proactive phase which is before starting of production trial. Then, during the term between production trial and stable mass production, remaining β% of total possible problems must be eliminated in reactive phase. Based on this structural feature, TPM scheme recommends to pursue α =100 % and β=0 % as shown in Figure 4 [where, α and β denote the rates of problem elimination by proactive and reactive operations respectively].

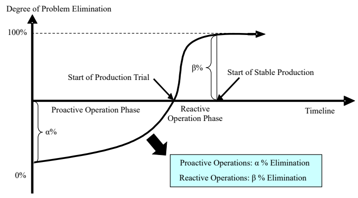


Figure 3. Relation of proactive and reactive activities in ordinary NPD (α + β = 100 %) (Nakano, 2005)

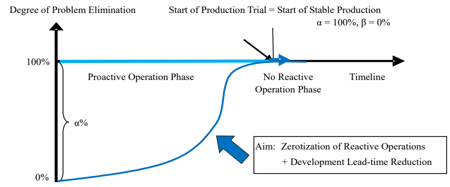


Figure 4. Relation of proactive and reactive activities in Lean-driven NPD (α + β = 100 %) (Nakano, 2005).

In general, there are two ways of approaches in this situation.
(1) Reactive-oriented management: Relatively quick, but actually, very bad as bomb is transferred to customers.
(2) Proactive-oriented management: In theory, very good, but a long preparatory lead time and concerned people will be tired due to time consuming and huge volume of work.
Actually, there are a number of troubles have been occurred that weaken the performance of new product development in the second case such as long lead-time due to huge proactive considerations, disappearance of reactive skills, exhaustion of engaged people *etc*.
For instance, for the first issue, in NPD performance of smart phone business, most of Japanese companies tend to lose their competitiveness due to slow response (Katayama, 2014). For the second issue, in Fukushima nuclear power plant, nobody knows proper activity against melt-down with explosions because of poor knowledge, no training, no manuals about this sort of accident. And finally, for the third issue, people belonging to some SME companies is tired on continuous performance improvement because of too much work, difficult to tackle with, huge deep knowledge required *etc*. Possible countermeasure for this problem is to develop new version of lean scheme, which is simplified, enjoyable with recognition scheme for employees. Hopeful third type of management style described below might be effective.
(3) Balanced management: This management style can overcome the demerits of both approaches. Where, potential of proactive and reactive operations is both required. From skill development point of view, this situation is very ideal as people have to concern both approaches and their skills are automatically trained through struggling with this way.
More concretely, development lead-time must be designed firstly, then investigation and selection of problems must be performed based on the classification of expected significant troubles in proactive phase followed by designing trouble shooting methods with training in reactive phase as illustrated in Figure 5. This process is now implemented and evaluated in many companies' TPM audit processes.

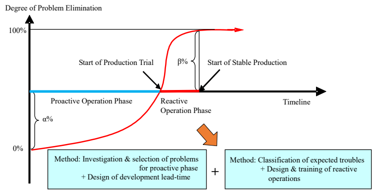


Figure 5. Revised relation of proactive and reactive activities in NPD (α + β = 100).

2.2 Matrices-based systematic procedure for relevant product development

Second issue to consider is its procedural/operational aspect, in which matrices-based systematic logic is examined.

Table 1. Matrices for relation analysis between demand feature (specification) and product specification.

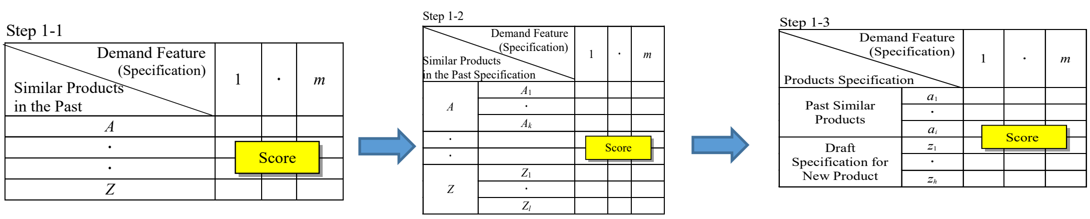


Table 1 represents proposed general structure of product development procedure in the form of matrices, which enables relation analysis between demand feature (specification) and product specification. In Step1-1, surveyed demand feature for the new product and similar products in the past is cross-investigated in terms of proximity analysis through scoring. Then, specification of each product in the past is deployed in the matrix given in Step 1-2 followed by selection of significant product specification items based on score values in Step 1-3. Where, draft new product specification items are also added in the bottom of the matrix.
Table 2 represents the relation between required demand feature for new product and candidate material specifications in the form of matrix. Proximity is also identified through evaluating score values in Step 2-1 and matrix in Step 2-2 can be created by selecting significant score values. Table 3, the relation between required demand feature for new product and candidate manufacturing methods etc., can be filled by the same manner.

Table 2. Matrices for relation analysis between demand feature (specification) and material specification.

Table 3. Matrices for relation analysis between demand feature (specification) and manufacturing methods etc.

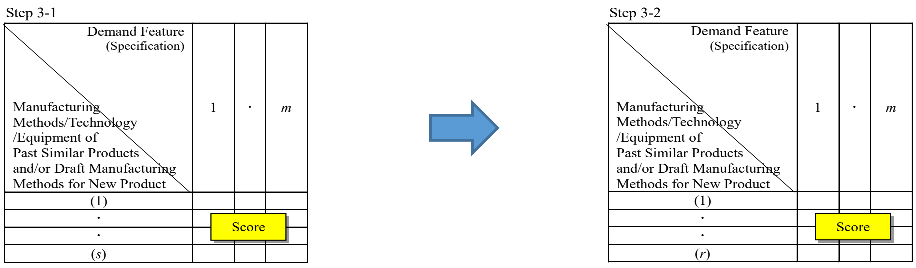
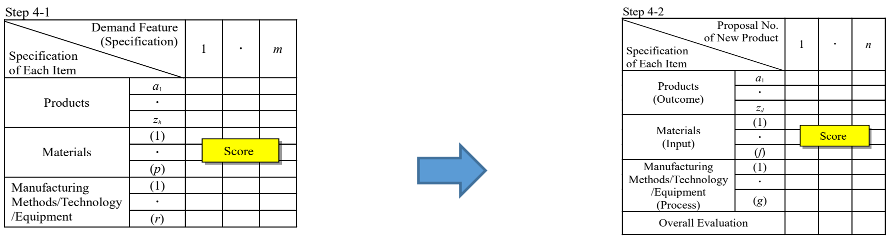


Table 4 represents the aggregated specifications of products, materials and manufacturing methods *etc.* and the significance on demand specifications in Step 4-1 can be evaluated by the score values. Then, final matrix shown in Step 4-2 can be created through combinatorial selection from candidate specifications in the Step 4-1 matrix. This process is now implemented and evaluated in many companies' TPM audit processes.

Table 4. Summary of specifications and evaluation matrices created by specification scores.



3. Process innovation

In this chapter, process innovation is focused to discuss. Especially, Karakuri technology-utilised manufacturing process is regarded as one topic to discuss as the matter of process innovation (JIPM Ed., 2009; 2018; 2019; Katayama and JIPM, Ed., 2012; Katayama, 2017).

3.1 Introductory remarks of Karakuri technology

Karakuri technology is a sophisticated technological contrivance by utilising elementary mechanisms and physical phenomena which contribute business and environmental sustainability. As this technology utilises various natural energy such as gravity, electro-magnetic energy, wind, leverage, pulley *etc.*, concerned cost is free and environmental sustainability is strongly promised.

The authors concern joint research project on Karakuri technology design and analysis on the platform of JIPM (Japan Institute of Plant Maintenance). This technology is, therefore, positioned as one of the kernel technologies of TPM. Outline of the project is summarised as follows.
Member: JIPM + Operations & Production Management Laboratory (OPML) at Waseda University; Mission: Karakuri Case Collection and Analysis; Duration: 2011-ytd; Source of the Cases: Annual Karakuri Exhibition (About 200 case presentations every year from 1993).
One of the important outcomes produced by this project is the general bill structure of Karakuri technology which is illustrated in Figure 6.

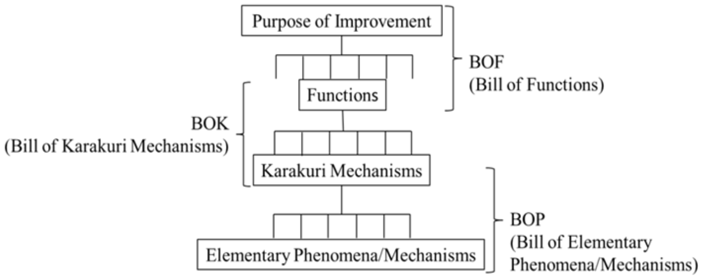


Figure 6. Bill structure of Karakuri technology (Katayama et al., 2014).

Where, relationship between purpose and function called BOF, function and Karakuri mechanism called BOK and Karakuri mechanism and elementary phenomena/mechanisms called BOP are established through substantial number of investigations including statistical analysis. Some of the issues identified as the member of BOK is summarised in Table 5.

Table 5. Extracted functions and Karakuri mechanisms (Katayama et al., 2015).

Function		Karakuri Mechanism	
1.	Labor Saving	1.	See-saw
2.	Time Saving	2.	Balancer (Tenbin)
3.	Automation	3.	Rotation
4.	Operation Efficiency Improvement	4.	Slide
5.	Power Generation	5.	Link
6.	Output Amplification	6.	Pulley
7.	Change of Power Direction	7.	Spring
8.	Power Transmission	8.	Chain
9.	Switching	9.	Gear
10.	Movement Control	10.	Clutch
11.	Position Fixation	11.	Stopper
12.	Release of Restraint	12.	Lock/Unlock
13.	Movement Termination	13.	Cylinder
14.	Avoidance of Defect/Fuguai	14.	Electro-Magnetic
15.	Support of Direction Change		
16.	Support of Transportation		
17.	Support of Rotation Movement		

3.2 Desired functions for Karakuri

Function listed in Table 5 is derived from theoretical consideration, however practically, following functions being provided by Karakuri contrivance are urgently desired.
(1) Automatic return operation of tray/pallet (Internal logistics function)
(2) Automatic work rotation (Function for alleviating heavy muscle work)
(3) Bottleneck-less smooth flow (Function to realise Heijunka operation)
(4) Elimination and/or simplification of handling operation (Function to suppress manual operations)
(5) In-line Karakuri contrivance (Function providing affinity with line operations).

3.3 Relevant example of in-line Karakuri contrivance

In this section, argument is focused on "In-line Karakuri contrivance", which is long-awaited issue in the shop-floor (Katayama et al., 2015). Objective case problem is manual-based drum can filling operation illustrated in Figure 7, of which renovation by implementing Karakuri technology is earnestly required because of the following burden in this process.

a. The filling process is bottleneck due to long operation lead time that causes large work-in-process inventory in input area.
b. Three filling operators are engaged in this process due to heavy work handling

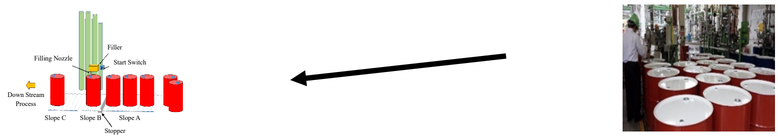


Figure 7. Outline of the drum can filling and transporting process (Before Improvement).

Utilising three Karakuri mechanisms, *i.e.* see-saw, rotation and stopper, to overcome the above burden, a new operation structure was proposed in collaboration with a collaborative company. Figure 8 illustrates proposed operation sequence.

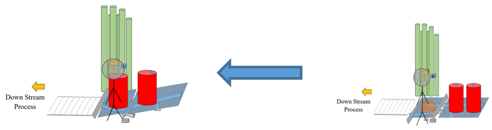


Figure 8. Outline of the drum can filling and transporting process (After Improvement).

Namely, ① Starting from the initial state where many empty drum cans are waiting on the roller conveyer A that is input buffer area of this process (See Figure 7), ②the roller conveyers A and B incline simultaneously as interlocked devices that makes the first drum slide into the filling area properly and the second drum is intercepted by the equipped stopper (See Figure 8), ③The drum arrived at filling position where the right position is guaranteed for filling operation by guide bars. For one touch setting of pouring inlet to the filling nozzle by the operator, round table equipment is useful. ④Automatic filling operation by current equipment is proceeded in the end.

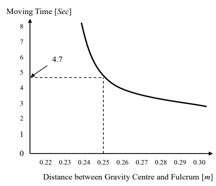


Figure 9. Outline of the drum can filling and transporting process (Before Improvement).

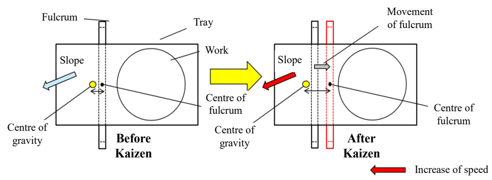


Figure 10. Outline of the drum can filling and transporting process (Before Improvement).

To eliminate bottleneck phenomena at transportation process from input buffer to filling position, sliding speed of work (drum can) must be carefully designed. Figure 9 shows the relation between sliding time and distance between gravity centre and fulcrum, of which characteristics was obtained through mathematical model analysis and physical experiments. This figure suggests distance between gravity centre and fulcrum must be 0.25 m as required moving speed is 4.7 seconds between input buffer and filling position. Parameter tuning for this mission is simple enough as shown in Figure 10. Only thing to do is setting fulcrum bar apart 0.25 m from centre of gravity of the tray that increases the moving speed of drum can.

4. Concluding Remarks

In this paper, some of the product and process innovation-related concepts and methodologies were proposed and discussed for reinforcing lean management scheme based on the concerned literature review. Especially, in product innovation, the ideas of proactive and reactive approaches were introduced and discussed, where necessary procedure to shortening development lead time is proposed. Also, newly developed matrices-based systematic procedure is proposed as a relevant general procedure for new product development. On the process innovation, some of the important aspects of Karakuri technology such as its green-lean feature is discussed and its effective example of in-line application was examined. Through accumulation of this sort of consideration, lean management might provide greater contribution on long-lasting business and environment-secured way of management in the era of ultimate market-driven, competitive industrial society.

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