Study of Karakuri Kaizen

Omkar Kalbhor¹ Tanmay Neve² Omkar Pachpor³ Nikhil Bhoite⁴ Aniket Deshmukh⁵

¹,²,³,⁴,⁵Department of Mechanical Engineering
Pimpri Chinchwad College of Engineering & Research, Ravet, Pune, India

Abstract— Japanese “karakuri Kaizen activities” with the power of skilled workers at actual work sites are considered to be “Japanese style grass-roots innovation (Js-GRI)”. Js-GRI comes into existence from collaboration with R&D division. In the context of accelerating globalization and a complex business environment, the development of hybrid technologies using existing methodologies for synergistic outcomes has been recognized as a novel management problem. Therefore, this paper addresses the integration of methodologies originating in the lean management scheme and analyzes the impacts on business performance. The results suggest that based on several measures such as elimination of useless operations, worker training, energy conservation, and so on, the degree of leanness is significantly elevated by the utilization of combined elementary technologies. The desire to increase productivity can effectively accomplished through the adoption of low cost automation by their characteristic small and medium size companies. The concept and principles of low cost automation are basically the same as those of full automation except that the former builds improvement around existing equipment and machine system rather than replacing whole system with automated processes. The primary activity of every manufacturing organization is material handling.

Key words: Karakuri Kaizen

I. INTRODUCTION

Lean management is regarded as an effective business strategy for constructing effective and reliable supply chains operating throughout the world. Based on the constitutional concept of this management style, that is, a contradiction-driven approach, a number of methodologies and case applications have been developed in the manufacturing industry, a major player in supply chains. However, in the context of accelerating globalization and a complex business environment, many novel management problems have been recognized, such as managing both business functions and industries; the reinforcement of lean management transferability among manufacturing sites including offshore plants; the necessity of developing hybrid technologies using existing methodologies for synergistic outcomes; and so on.[1]

The characteristic know-hows of materializing the meticulous analog mechanisms in products, which have been seen in the karakuri mechanical dolls since the early Edo period (in the 17th century), are associated with the Japanese manufacturing practices of today as the karakuri technology. And, Japan Institute of Plant Maintenance (JIPM) has been organizing “Exhibition of Karakuri Contraption & Improvement” since 1993, viewing the karakuri technology as a backbone underlying the present Japanese manufacturing expertise. The karakuri is the mechanism which is activated by springs, gears, and other analog mechanisms. Specifically, it ingeniously utilizes the law of gravity, the principles of the lever, the spring, the cam, the pulley, and so on. What lies behind are “simple,” “hand-made,” and “low cost.” These three key words are applicable in today’s environmental design, and are highly relevant to “frugal innovation” which has come to be seen and heard in academic conferences in the field of innovation management. Moreover, it has come to be known that they have influenced significantly to today’s robotics technology, which is one of the leading cutting-edge industries of Japan. Since the Meiji era (around the 1870’s onward) in Japan, aside from the traditional craftsmanship, the then advanced technologies have been widely introduced from the West. By mastering them, “Mitsubishi Zero Fighter Aircraft (in 1940)” and “Battleship Yamato (in 1941)” were developed. As was proven by such technical expertise (Ra-I in those days), the Japanese cutting-edge technological capabilities in heavy industries centering on the military were rapidly catching up with the level of the advanced western nations at that time. It is fair to say, therefore, that the Japanese-original way of manufacturing was created even before World War II to a considerable extent, by integrating the traditional (Japanese-style) technologies/skills and the then advanced technologies from the West. It is also true, however, that in some latest industrial sectors like aircraft industry, basic research and design work was highly emphasized, while much less attention was paid for production engineering and mass production engineering to deal with production in large[3]

II. KARAKURI TECHNOLOGY

The Japan Institute of Plant Maintenance (JIPM), leading promoter of total productive maintenance and management (TPM), held an exhibition on karakuri technology in Japan (JIPM 2009) with the purpose of not only exchanging ideas about the displayed technologies among domestic manufacturers but also introducing TPM activities to overseas manufacturers.

The purpose of karakuri technology is to automate an objective operation. One category of low-cost automation (LCA) is considered (Albertos 1989). Karakuri technology is used to make objective operations easier and to increase productivity. The technology uses a simple mechanism based mainly on the natural principles of the following (TPM Age Editorial 1999):

a) Mechanics o Lever
   o Pulley
   o Gear wheel
   o Cam-link mechanism
b) Hydromechanics
c) Magnetics
d) Electricity
e) Sound
f) Optics
g) Physical properties [1]

TABLE 1 shows a list of features of the three lean module technologies based on the survey of each technology above. The list includes (1) the main purpose, (2) the
elemental technology, and (3) instances of the elemental technology.

A. Features

<table>
<thead>
<tr>
<th>Tech.</th>
<th>Main purpose</th>
<th>Elemental tech.</th>
<th>Instances of elemental tech.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Five-sense</td>
<td>Detection of</td>
<td>Five senses</td>
<td>1) Sight</td>
</tr>
<tr>
<td>tech.</td>
<td>information</td>
<td></td>
<td>2) Hearing</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3) Smell</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>4) Taste</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>5) Touch</td>
</tr>
<tr>
<td>Poka-yoke</td>
<td>Prevention of</td>
<td>Trigger factors</td>
<td>1) Weight</td>
</tr>
<tr>
<td>tech.</td>
<td>mistakes</td>
<td></td>
<td>2) Number</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3) Location</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>4) Order</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>5) Timing</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>6) Life of machine part</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>7) Number of lines in program, etc.</td>
</tr>
<tr>
<td>Karakuri</td>
<td>Automation</td>
<td>Natural engineering</td>
<td>1) Mechanics</td>
</tr>
<tr>
<td>tech.</td>
<td></td>
<td>principles</td>
<td>2) Hydromechanics</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3) Magnetics</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>4) Sound</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>5) Optics</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Physical properties</td>
</tr>
</tbody>
</table>

Table 1:

B. Merits

1) Quality (Q)
The JIT part delivery is perfectly realized and mistakes in part utilization can be decreased.

2) Cost (C)
The development cost of the case is low because the model technology in the case is simple. Moreover, the management cost for controlling kanban is unnecessary when the case is applied.

3) Delivery (D)
JIT part delivery can be realized. Thus, the waiting time in the relevant process will be decreased.

4) Productivity (P)
The number of mistakes in the relevant operation will be reduced and productivity of the operation will be improved.

5) Safety/Hygiene (S/H)
Distraction will be decreased and therefore accidents/injuries during the relevant operation will be decreased.

6) Environment (E)
Office implements for maintaining a kanban management system, such as paper, calculators, and so forth are unnecessary. Moreover, the case does not require electricity.

7) Morale (M)
The case development process using natural principles provides good training for manufacturing engineers and operators.

2) Case 2

Fig. 1: Kanban between Proximate Processes

Fig. 2: Vehicle for Delivering One Part with Pulley (Before Movement of Vehicle to Next Process)

Fig. 3: Vehicle for Delivering One Part with Pulley (After Movement of Vehicle to Next Process)
Fig. 4: Simple Karakuri Structure for Handling Operation using Gravitation Force to Provide Efficient Storage and Easy Unloading Process

In the field of agriculture, various (manual) handling operations must be performed through the year. Farmers have to move objects off the ground on a conveyor or move objects manually or by conveyor from point A to point B (e.g. handling of containers) From the point of view of unpowered technologies or technologies based on low-thrust operation energy we can use following elementary phenomena, mechanisms or components:
1) Gravitation force (weight) - see Fig. 2
2) Magnetic force
3) Lever mechanism (seesaw mechanism)
4) Cam mechanism
5) Link mechanism
6) Lock-up or release mechanism
7) Spring
8) Gear etc.[4]

Industrial enterprises use karakuri devices for the following purposes:
1) Development, design and installation of low CO2 production technologies based on simplification, process streamlining or energy saving of moving parts.
2) Improvement of energy use efficiency by recovery of wasted energy or storing of energy,
3) Elimination of unnecessary or irrational (human) efforts.
4) Utilization of unpowered technologies or technologies based on low-thrust operation energy.[4]

III. CONCLUSIONS
Karakuri transport trolley transported (moved) an object with common weight and dimensions at a distance of 2 (3) m and returned back to starting position without additional energy supply. Obtained results indicate there is potential for karakuri-based technical means in agriculture to save energy and human effort. For future development is necessary to deeply study the issues connected to karakuri mechanisms and present obtained results to agricultural engineers.

REFERENCES