Manufacturing strategy improvement based on lean methodology

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Abstract. The implementation of lean manufacturing philosophy has been carried out in various types of industries and has also been adopted in the service sector under the name lean service. The waste identification methodology as the mainstay of the first phase is a unique practical tool for various companies. This paper proposes a methodology for formulating an output-based improvement strategy for implementing lean manufacturing steps. The development of improvement strategies is based on the Key Performance Indicator of achieving various types of waste reduction, manufacturing system design parameters and business value achievements. Examples of the application of calculations, analysis and measurement of success have been given to various types of industries. Stages of formulation and evaluation of improvement strategies have been presented in a coherent and easy to understand and are quickly searched for the required data.

1. Introduction
For the past years, requirements for manufacturing have increased significantly. From having products with long market life cycles to the short market life cycles [1]. Globalization and technological changes are two of the main reason manufacturing strategies keeps changing [2]. There are more exposure to new products than ever before which increase the competitiveness level on the same market. If a manufacturing company doesn’t give new products every once in a while, the company will be overtaken quickly by the rival companies. By applying manufacturing strategies, manufacturing sectors could enhance their business performance [3] and also could have the advantage over the rivals company and reap higher export performance [4]. The performance of manufacturing strategy which are flexible and could also accommodate the real needs of the company to increase the production rate is needed [5]. A good manufacturing strategy will significantly influence the manufacturing performance that is used [6]. But what is a good manufacturing strategy? There are many kinds of research on that, from the sustainable strategy [7] to fit manufacturing which encompass lean methodology which is one of the most used or researched nowadays.

Lean methodology are intended to highlight the value of a company and eliminate the waste on the company. The lean methodology that is used will give the company a strategy by addressing these level of importance on the production floor to eliminate waste [8]. A thorough implementation of
it will improve the operating efficiency on manufacturing company [9] which results will be an increase of profits by reducing the cost that was resulted from the waste [10]. On manufacturing strategy, lean method could be used as a monitor for the real-time activity that happened on the factory to analyze what really happened on the production floor and collect the real time data which will give a more flexible approach on the production [11]. While there are more advantages for using lean method, companies are not often prone to its adaptation [12]. Lean itself cannot be done in a short amount of time, because of the needed preparation for the company itself and the employees for such complexity and difficult method [9]. The employees cannot just change the way they work just because the higher-ups said them to, the discipline needed to do something new while they always work differently is hard to build [8]. When unsuccessful implementation occurs, it’ll leave great impact on the company’s resources and even importantly on the employees’ confidence and trust to the lean methodology.

The always improving strategy for companies to use to increase the productivity always needs some kind of integration between many systems on the company [13]. The lean methodology which encompass many kinds of aspects and systems to eliminate the waste that exist on the production process especially on manufacturing company use integration on different unit on the company to accommodate it. As technologies keeps improving, the manufacturing strategies of a company should improve too in terms of technology by using lean electronically [14], which has been researched on its credibility to operate as expected. By using lean, manufacturing strategy will be more inclined towards minimizing cost by improving efficiency [9]. It could be started by having strategy which give workers the same amount of workload and minimizing movement for better efficiency, no waste needed, even if it’s insignificant towards the process itself. As the former manufacturing strategy leans more on principles of economies which does not complies with leanness and resulting a considerable amount of waste and difficulty of reconfiguration, lean is all about the overall performance that a factory should give [15]. Elimination in the value stream, instead of some points, will create processes with less human effort, space, capital, and time required making products at less costs and fewer defects [12], it is what a manufacturing strategy should strive for.

The purpose of this research is determining the manufacturing strategy improvement of existing manufacturing system environment with the use of waste elimination and further analysis within lean manufacturing. The improvement will be based on waste identification and hows the improvement will increase the value of waste elimination. Further, manufacturing design parameter and business value evaluation will be used to obtain the impact value of each improvement recommendation.

2. Method and Materials

The manufacturing system environment in general, consist of raw material acceptance, production process, assembly process, inspection and packaging. Those will be regarded as the required phases that is needed to be improved. Each phase will be evaluated with manufacturing design parameter and cost. Further, waste identification will be used for each phase to have initial evaluation based on lean methodology. Business value evaluation will be based on the proportion of profit contribution and potential cost reduction in the future.

The key performance indicator for waste elimination is how much will be deducted in percentage, the easiness of elimination and future risk of returning. This will be the basic rule of how setting the direction, the big picture, supplier and customer involvement, fitting the plan and buy-in ensure will be evaluated for its effectiveness. The integrated factor as the value of continuous improvement will be introduced to link the waste elimination, manufacturing design parameter and business value evaluation. The value of integrated factor has been identified to be different in different manufacturing system or company as this research object for implementation.
3. Results and discussion

3.1. Result of each particular factor within waste, manufacturing design and business value

A typical approach of lean manufacturing will require the stage of understanding waste, setting the direction, understanding the big picture, detailed mapping, getting suppliers and customer involved, checking the plan fits the direction and ensuring buy-in. All of these stages however, will depend on the accuracy of waste identification in the beginning. Thus, the success of waste elimination can be regarded as the key point of lean methodology. The waste factor is symbolized from 1 to n as the waste element can be identified in different number or can have more waste in the future. The Figure 1 shows the requirement variables of waste elimination, manufacturing design parameter and cost, and business value evaluation. The result test within different companies can be seen in Table 1.

Notes:
WR(waste review) WR1: amount of deduction WR2: easiness of elimination WR3: future risk of returning MP(manufacturing parameter) MP1: process rate MP2: capacity MP3: utilization & availability MP4: lead time MP5: cost PC(profit contribution) PC1: contribution amount PC2: potential future cost reduction

Figure 1. Waste identification within manufacturing phases

Table 1. Result test of waste elimination, manufacturing design parameter and business value

| COMPANY 1 | COMPANY 2 | COMPANY 3 |
|-----------|-----------|-----------|
| P1         | P2         | P3         | P4         | P5         | P1         | P2         | P3         | P4         | P5         | P1         | P2         | P3         | P4         | P5         |
| WR1        | 0.87       | 0.64       | 0.62       | 0.73       | 0.68       | 0.66       | 0.60       | 0.83       | 0.70       | 0.84       | 0.85       | 0.71       | 0.72       | 0.64       | 0.84       |
| WR2        | 0.62       | 0.61       | 0.66       | 0.89       | 0.64       | 0.80       | 0.76       | 0.67       | 0.73       | 0.87       | 0.87       | 0.66       | 0.82       | 0.61       | 0.63       |
| WR3        | 0.77       | 0.73       | 0.61       | 0.66       | 0.88       | 0.68       | 0.90       | 0.62       | 0.90       | 0.74       | 0.75       | 0.79       | 0.68       | 0.83       | 0.78       |
| MP1        | 0.73       | 0.83       | 0.74       | 0.82       | 0.87       | 0.61       | 0.82       | 0.68       | 0.71       | 0.85       | 0.65       | 0.63       | 0.87       | 0.88       | 0.63       |
| MP2        | 0.82       | 0.65       | 0.64       | 0.88       | 0.77       | 0.65       | 0.71       | 0.81       | 0.79       | 0.89       | 0.84       | 0.74       | 0.65       | 0.69       | 0.88       |
| MP3        | 0.69       | 0.70       | 0.90       | 0.82       | 0.65       | 0.74       | 0.78       | 0.83       | 0.60       | 0.82       | 0.63       | 0.77       | 0.78       | 0.89       | 0.90       |
| MP4        | 0.83       | 0.71       | 0.70       | 0.63       | 0.75       | 0.65       | 0.66       | 0.66       | 0.68       | 0.74       | 0.71       | 0.84       | 0.62       | 0.67       | 0.66       |
| MP5        | 0.65       | 0.62       | 0.76       | 0.78       | 0.82       | 0.62       | 0.82       | 0.89       | 0.80       | 0.69       | 0.80       | 0.61       | 0.76       | 0.66       | 0.81       |
| PC1        | 0.82       | 0.88       | 0.62       | 0.86       | 0.65       | 0.62       | 0.68       | 0.64       | 0.89       | 0.82       | 0.90       | 0.64       | 0.78       | 0.90       | 0.67       |
| PC2        | 0.66       | 0.74       | 0.87       | 0.65       | 0.89       | 0.71       | 0.83       | 0.73       | 0.61       | 0.63       | 0.73       | 0.73       | 0.63       | 0.77       | 0.77       | 0.78       |

3.2. Result of integrated factor to determine the improvement

Integrated factor value is a coefficient of each company for handling the continuity of required phases. The value should be regarded as how each phased is connected, or the position of relationship within the sequential process. The proposed two values has been used for describing the degree of relationship and the contribution for the whole process as the representation of business value. Degree of relationship and the contribution can be seen in Figure 2, while the result of implementation can be seen in Table 2.


**Figure 2.** Integrated factor value description

| COMPANY 1 | COMPANY 2 | COMPANY 3 |
|-----------|-----------|-----------|
| P1 RAW material acceptance | P2 Production process | P3 Assembly process |
| Degree of relationship with Phase 1 | Degree of relationship with Phase 2 | Degree of relationship with Phase 3 |
| Degree of relationship with Phase 4 | Degree of relationship with Phase 5 | |

Table 2. Result implementation of integration factor value

| COMPANY 1 | COMPANY 2 | COMPANY 3 |
|-----------|-----------|-----------|
| P1 RAW material acceptance | P2 Production process | P3 Assembly process |
| Degree of relationship with Phase 1 | Degree of relationship with Phase 2 | Degree of relationship with Phase 3 |
| Degree of relationship with Phase 4 | Degree of relationship with Phase 5 | |

Note:
- DR(degrees of relationship)
- DRP1: degree of relationship with Phase 1
- DRP2: degree of relationship with Phase 2
- DRP3: degree of relationship with Phase 3
- DRP4: degree of relationship with Phase 4
- DRP5: degree of relationship with Phase 5
- CW: contribution to the whole process

4. Conclusion
A research has been conducted to obtain a simple methodology for defining the manufacturing strategy improvement with the advantages of waste elimination within lean manufacturing. The intended key performance indicator for respected waste has been formulated to adapt with the several types of waste in different approach. The manufacturing design parameter is also combined with the expected business value within the manufacturing company. As a result, a typical approach for certain manufacturing company with the minimum required data produce an accurate improvement recommendation with the predicted impact.

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