Adopting Lean Principles: A Case Study

N.S.M.Shalahim

***Abstract*—This paper presents a case study in which improved activities in a manufacturing centre is conducted. The manufacturing centre practices make-to-order which manufacture its' product during a particular period when the order is received from its' customer (seasonal). The objective of this study is to plan activities for the manufacturing centre to fully utilize its resources (employees, machines, and methodology) during the period when the demand is low (off-season). This paper proposed to adopt Lean Principles as the main thrust aligned with The Seven Management and Planning Tools (7 MP) in achieving the objective. Only Affinity Diagram, Matrix Data Analysis, and Activity Network Diagram will be represented in this paper while in the actual case study other tools of the 7 MP tools will be used. The result shows that simple method of planning the activities during the off-season period using 7 MP tools align with the Lean Principles can make significant contribution to utilize the resources.**

***Index Terms*— Lean Principles, Seven New Management and Planning Tools, Seasonal Demand**

I. Introduction

Literature suggested forecasting, make-to-stock, and exponential smoothing were the reasonable methods in attending seasonal adjustment problem [3], [4]. Adaptive methods in exponential smoothing were also suggested [1]. However, the methods suggested are highly depending on the accuracy of the forecast in demand order [5]. Occurrence in making wrong decision in forecasting will increase the size of inventory for raw material and also increase the number of processes product which are not needed by the customer [2]. This situation is regarded as waste [6].

This paper presents a case study which improved the utilization of the manufacturing centre resources (employee, machines, and methodology) during off-season period. This paper proposes a methodology to introduce simple planning tools (7 MP) aligned with Lean Manufacturing philosophy in handling seasonality demand in a manufacturing centre.

II. Literature Review

Various approaches have been suggested in attending the off-season period in seasonality demand manufacturing companies [5], [3]. One of the approaches is to practice forecasting in inventory control. It controls safety stock and holds inventories of raw material and manufactured products. However, this approach is not popular amongst seasonal manufactured companies and is treated rather casually [2].

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Another suggestion is to adopt method such as simple exponential smoothing to set the value in smoothing the parameters and stabilizing the seasonal demand [1]. However, there is no evidence that adaptive smoothing parameters have offered any significant advantage in forecast accuracy [2]. This also will contribute to unnecessary waste in inventory of material and unwanted products in manufacturing companies [6].

The off-season period in seasonality demand could also result as waste if no proper planning is implemented during this period. Wastes that could result from the seasonality demand is waiting time, where the employee needs to wait for a long time for the next seasonal period. Lean Manufacturing is a multi-dimensional approach that encompasses wide variety of management practices, which can be aligned together to create value towards customer [9]. Based on this information, the empirical study considers adopting the Lean Manufacturing principles as the main emphasis in this research work.

The Seven Management and Planning Tools (7 MP) are used in this empirical research because they provided methods of organizing verbal data. The basic 7 QC tools were very effective but focused on numerical data. The 7 MP tools are; Affinity Diagram (AD), Interrelationship Diagram (ID), Tree Diagrams, Matrix Diagram, Matrix Data Analysis (MDA), Arrow Diagrams (Activity Network Diagram), and Process Decision Program Charts (PDPC). These tools are used for untangling the intricate relationships among the different elements of a problem and to make it easy to clarify a situation, establish a plan and get to the root of the problem.

In brief, AD is used to find the most important factors from a large number of ideas, opinions, and issues. ID is used to find the cause and effect relationships in data using graphical techniques, while Tree Diagram is used to get from a high level to a low level detail (goals to tasks). Matrix Diagram is used to map between two sets of information (e.g. sets of current and future processes) and MDA quantifies and arranges data presented in a Matrix Diagram, to find more general indicators that would differentiate and give clarity to large amount of complexly intertwined information. PDPC is a tool for preventing unanticipated problems frequently occurring in complex systems and achieving desired objectives. Only three of these tools which are AD, MDA, and Arrow Diagram are presented in this paper.
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III. The Empirical Research

This empirical research is based on a case study in a manufacturing centre that experiences seasonal environment. The research objective is to utilize the manufacturing resources during the off-season period. To achieve the objective, the centre's resources such as man, machines, material, method, and environment are taken as dependent variables while the off-season period also known as 'idle

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time' is used as independent variables. Figure 1 shows the manufacturing centre's demand patterns throughout the years.

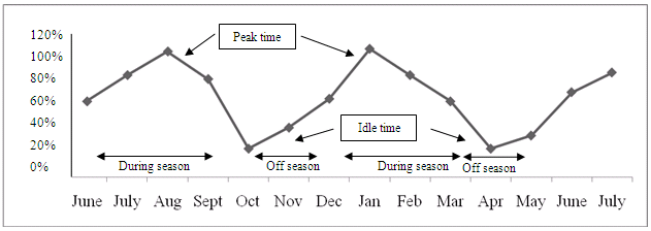

Figure 1 Demand pattern for the manufacturing centre

A. The Seasonal Demand

The manufacturing centre will be fully utilized from June to October and from November to March every year. During this period, the manufacturing centre will utilize every resource in its facility up to 100 percent. The seasonal demand happens because the manufacturing centre always changes their products during every season according to the customers' orders. The manufacturing centre is not permissible to manufacture any product in advance until the exact order, design and quantity are received from the customers. Due to this, the manufacturing centre is also not allowed to hold any inventories for raw materials or products until the exact order is received.

B. Make-to-Order

Due to the seasonal customer demand, the manufacturing centre practices make-to-order instead of make-to-stock. Hence, no high inventory for raw materials and products are required. Consequently the manufacturing process is lean where there is minimum waste. For instance, only one part is processed at any particular time and the employees are responsible for their own products. As a result, the manufacturing centre requires less movement of products while being processed. The other advantage is that there is sufficient number of operators per parts and less waiting time by the operators during the seasonal period.

C. The Off-Season Period

Due to this make-to-order seasonal environment, the operation will be down during the off-season period. This situation does not add any value to the manufacturing centre, especially in waiting time of the operators and machines for new products to come. One of the probable solutions that have been done by the top management is to encourage the operators to go for a holiday during this time. This solution also does not contribute any value to the manufacturing centre especially in the development of their employees and processes. Therefore, the management is planning to include some activities for the employees during this off-season period. The activities are believed to increase the employees' performance at work and will add value to the manufacturing centre environment.

D. Value-added Activities

Some propositions of activities have been forwarded by the employees of the manufacturing centre. These activities have been considered by the top management. The propositions are ranked according to their importance due to the benefits for the manufacturing centre and their employees. Serious attempt are made by the top management to fulfill every proposition of activities made by the employees. The problem arises when prioritizing the activities. All the propositions seem to be important to the manufacturing centre. In order to prioritize the propositions, the manufacturing centre proposes to use 7 New Management and Planning Tools in prioritizing and planning the activities.

E. From Waste to Value

The manufacturing centre has two off-season periods. The off-season period or 'idle time' occurs from the middle of October to end of November and from early March to early June every year. The minimum duration for the idle time is three months every year. The idle time is considered as waste by the top management. Therefore, the top management has plan activities to convert the waste to value added activities for the benefits indulge of the employees and the manufacturing centre during this off-season period.

F. Additional Consideration Factors

In planning the activities, the top management has made a consideration for other factors, which will affect their plan for the off-season period. The factors taken for consideration are:

a) The employee plans to take their annual leave during this period.

b) Different approach for different types of department in the manufacturing centre as shown in Table 1. The manufacturing centre consists of three manufacturing departments. The Central Machining Department (CMD), the Machining Department (MD), and Fitting Department (FD). These departments have various different functions in the manufacturing centre.

Table 1 Types of departments

Department	Function
Central Machining Department	- Handle inventory of raw material - Material cutting - Distributing the material to the machining department
Machining Department	- Material handling towards product realization
Fitting Department	- Acts as quality department - Cleaning the manufactured product from the machine department

When planning the activities to be held during the off-season period, the manufacturing centre is actually planning to practice manufacturing lean. In this lean activity, waste to be eliminated is the 'idle time' or the off-season period. The ultimate aim is to fully utilize every resource in the manufacturing centre during this off-season period.

IV. RESEARCH METHODOLOGY

In order to carry out this empirical study, a set of data and information are collected through the distribution of questionnaires and interviews. The questionnaires are distributed to all employees at the manufacturing centre and a group of employees are selected to be interviewed for the in-depth study. The selection of the employees is based on

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the marks from the questionnaires given previously. Only employees that achieve high marks and suggested a numbers of suggestions will be selected for an interview. The selected employees are from various departments in the manufacturing centre.

The tools that have been used were Affinity Diagram (AD), Matrix Data Analysis (MDA), and the Activity Network Diagram (AND). Brainstorming was conducted to expand the data received from the questionnaires and the interviews. After the brainstorming session, the data were elaborated using AD. AD is used to gather large amounts of intertwined verbal data. It organizes the verbal data into groups based on natural relationship. The formation of distinct groups helps to bring about a meaningful picture, thereby making it feasible for further analysis and to find solutions to the problem. The major problems that have been emphasized from AD will be analyzed using MDA. Five main factors have been elaborated in MDA. MDA consists of a number of columns and rows whose intersections are checked up, to find out the nature and strength of the problem.

This tool helped to get the key ideas and analyzing the relationship or its absence at the intersection and finding an effective way of pursuing the problem solving method. In the final step of MDA, the solutions of the problems with the highest point will be considered. This tool is used to plan the most appropriate schedule for any complex task and all of its related subtasks. It projects likely completion time and monitors all subtasks for adherence to the necessary schedule. This is used when the task at hand is a familiar one with subtasks that are of a known duration.

A. Qualitative Data from the Employee

The questionnaire that was distributed to the employee contains question on how the seasonal environment affect their daily plans and work; for instance the employee is not allowed to go for a vacation during this seasonal period. The questionnaire also covered issues such as how the employees plan their daily life especially during the seasonal period and during off-season period for purposes of comparison. The questionnaire also demands for suggestions from the employee on activities that could be done during the off-season period and also suggestions on how to improve their workmanship. Such information and data that are generated from the questionnaire was classified according to its' contribution the manufacturing's resources such as man, method, machine, material, and environment as shown in Figure 2.

B. The Information Weight

Due to the suggestions received from the questionnaire, the research has weighted the suggestions according to its priority by doing in depth case study by interviewing the selected employees. Information received from the interview is used as a measuring weight in constructing MDA. MDA is used to prioritize the activity received from the questionnaire due to it's' importance. The result from the in depth case study are shown in Table 2 and 3. In Table 2, the MDA is used to prioritize the importance of the manufacturing centre's resources (man, machine, method, material, and environment). The most weighted resources are identified and ranked based on its importance (man, machine, and method). These selected resources are believed to be the main contributor to the company success. The result will be used as the main parameter to be measured with value activities that soon are planned. In Table 3, the suggestions from the employees are weighted during the interview session and discussions with the selected employee. Another separate session of discussion with the top management is also held. From this interview and discussion, the weighted criteria are added to the MDA diagram in Table 4. The outcome of the analysis is to prioritize the most popular activities to be held during the off-season period. Data from Table 3 and Table 4 will be used in generating prioritizing MDA as in Table 5.

C. Prioritizing the Suggestions

With reference to Table 5, the employees have suggested that the machinery maintenance activity shall be the top priority of all the suggestion. The maintenance activity includes training of the employee on how to service, repair and maintain the machinery. Second most popular suggestion is the management shall allocate more time during this off-season period in training the employee on (other than work training) for example, safety training. The employees feel that more frequent fire-drill training is most suitable to be done during this off-season period. The third most weighted suggestion is to conduct short courses training such as Continuous Quality Improvement Program. This short course is able to improve the employees' knowledge and efficiency towards producing high quality product in future. The employees also suggested to the management to conduct supplier evaluation during this period. This is to prevent defective raw material be sent to the manufacturing centre in future. Another most weighted activity that could be done during this period of time is to do 'spring cleaning' or implement order and cleanliness program in the manufacturing centre. This is because during the seasonal period, it is hard to implement order and cleanliness throughout that time.

V. EMPIRICAL FINDINGS

The interviews were carried out with the aim of understanding the extent to which the various activities suggested by the employee to be applied in the manufacturing centre. As previously stated, the degree of adoption of each activity was measured by the carrying weight of each suggestion from the interviews and discussions with selected employee and the top management. The measured weight is used in MDA as discussed in Section 4.2 and 4.3.

A. Planning the Suggestions

The ranking of the selected activities and its' weight is given in Table 4. In general, the manufacturing centre has dedicated a great deal of attention to all the activities given in this activity (the activity suggested by the employee to be implemented during the off-season period). In particular, great effort has been done by the top management to implement every activities suggested. The final impressions, as a result of MDA, only top five suggestions were selected.

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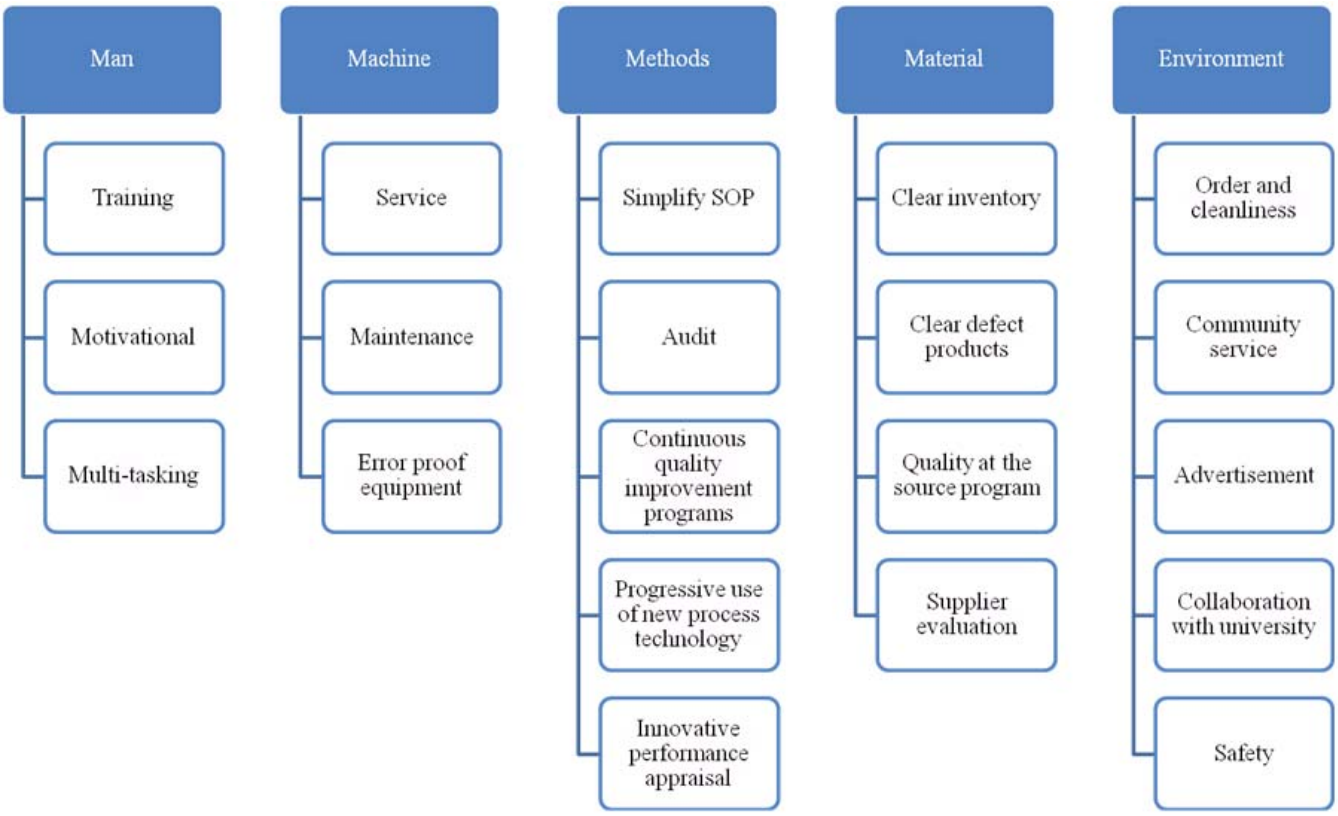

Figure 2 Affinity Diagram

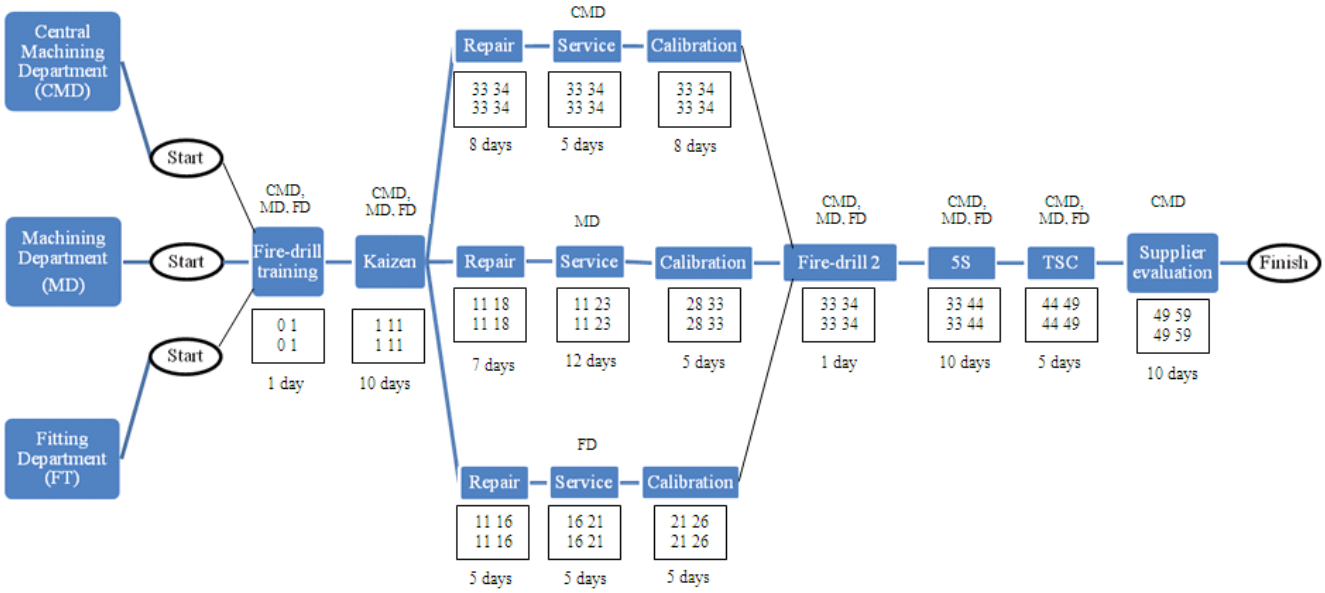

Figure 3 The Activity Network Diagram

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Table 2 Ranking the criteria

	Man	Method	Machine	Material	Environment	Row Totals (% of grand total)
Man		10	5	1	5	**0.37**
Method	10		5	1	1	**0.30**
Machine	5	5		0.2	0.1	**0.18**
Material	1	1	0.2		0.1	**0.04**
Environment	5	1	0.1	0.1		**0.11**
Column Total	**21.0**	**17.0**	**10.3**	**2.3**	**6.2**	**56.8**

1 Equally important
5 Significantly more important
10 Exceedingly more important

0.2 Significantly less important
0.1 Exceedingly less important

Table 3 Ranking option by criteria

	A	B	C	D	E	F	G	H	I	J	K	Row Totals (% of grand total)
A		10	10	5	10	5	0.1	0.2	5	0.1	5	**0.091**
B	10		10	10	5	10	0.2	5	10	0.1	5	**0.124**
G	0.1	0.2	0.2	5	5	0.2		10	5	0.2	10	**0.080**
H	0.2	5	5	5	10	5	10		10	0.2	0.1	**0.102**
I	5	10	10	5	10	0.2	5	10		0.1	10	**0.124**
J	0.1	0.1	0.1	0.2	0.2	0.1	0.2	0.2	0.1		10	**0.025**
K	5	0.2	5	0.2	5	10	10	0.1	10	10		**0.124**
Column Total	**40.4**	**35.9**	**55.3**	**40.6**	**55.4**	**50.5**	**35.7**	**45.5**	**55.3**	**11.2**	**55.3**	**445.2**

Legend
A Training
B Machine Maintenance
C Simplify SOP
D Continuous Quality Improvement
E Progressive Use of New Process Technology
F Clear Defect Products
G Quality at the Source Program
H Order and Cleanliness
I Community Service
J Supplier Evaluation

Table 4 Ranking option by all criteria

Evaluation	Man	Method	Machine	Row totals (% of grand total)
A) Training	0.034	0.042	0.023	0.116
B) Machine Maintenance	0.046	0.043	0.027	0.136
C) Simplify SOP	0.034	0.026	0.025	0.100
D) Continuous Quality Improvement	0.046	0.042	0.022	0.129
E) Progressive Use of New Process Technology	0.042	0.026	0.014	0.096
F) Clear Defect Products	0.029	0.026	0.012	0.079
G) Quality at the Source Program	0.038	0.034	0.016	0.103
H) Order and Cleanliness	0.046	0.026	0.016	0.103
I) Community Service	0.009	0.010	0.005	0.028
J) Supplier Evaluation	0.046	0.026	0.022	0.110
Column Total	**0.370**	**0.301**	**0.182**	**0.0.853**

Ranking
1. Machine Maintenance
2. Training
3. Continuous Quality Implementation Program
4. Supplier Evaluation
5. Order and Cleanliness
6. Quality at the Source Program

Table 5 The rank of activities

Rank	Activities	Weight
1	Machine Maintenance	0.136
2	Training	0.129
3	Continuous Quality Improvement Program	0.116
4	Supplier Evaluation	0.110
5	Order and Cleanliness	0.103
6	Quality at the Source Program	0.103
7	Simplify SOP	0.100
8	Progressive Use of New Process Technology	0.096
9	Clear Defect Products	0.079
10	Community Service	0.028

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The planning stage begins with identifying the duration for each activity. The Activity Network Diagram in Figure 3 shows the schedule and the duration for the top five selected activities.

B. Utilization of Resources

In reference to Figure 3, an analysis has been made on the level of utilization of the manufacturing centre's resources (employee, machinery, and method). In the analysis, the time factor (days during the off-season period) is the independent variable, while the resources is the dependent variable. The results from the analysis received are shown in Figure 4.

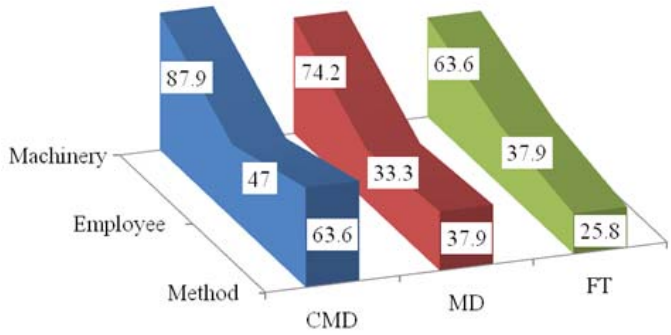

Figure 4 Utilization of resources

In reference to Figure 4, the block diagram includes the interrelationship between the resources (employee, machinery, and method) and the departments in the manufacturing centre respectively.
The time factor (working days during the off-season period) is used as a measuring weight in this diagram, has been translated into percentage in measuring the utilization of the resources. From the diagram, there is a significant improvement in utilizing the time of their employees during this off-season period in the range of 64.6 to 87.9 percent. The involvement of the machinery during this off-season period range between 33.3 to 47 percent and the activities for improving the methodology are 25.8 percent with respect to each department. This has shown that the value added activities, which has planned in Figure 4, has increased the utilization of resources in the manufacturing centre during this off-season period.

VI. Conclusion

Management extrapolated the result presented in Figure 4 to the entire Activity Network Diagram (as shown in Figure 3) and estimated that the total utilization in manufacturing resources is 59 days from 66 days during the off-season period. Another benefit would be gained by the manufacturing centre is the increment of the morale amongst the employees in the centre. During this planned activities, the management has arranged trainings for the employees to improve their working skills, safety, continuous improvement, order and cleanliness in the working area. The management also has used the opportunity during the fire-drill training to address the employee in the manufacturing centre statutory. Therefore, the planned activities have benefited the manufacturing centre in handling the manufacturing waste (the off-season period).

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