# Application of Optimization Technique in Managing Labour Productivity for an Automotive Company

## Azlan, N.A.A.N., Mohamad, E., Salleh, M.R., Saptari, A.

*Abstract*: *Sustaining in the new industrial revolution 4.0 requires industries in Malaysia to be dynamic in all aspects towards handling the variations. One of the aspects is well managing their productivity throughout the changes. Four types of elements that can be looked up as measuring the productivity such as labor, capital, material and total factor productivity. While the labour productivity is among of three of the four types which typically important is assessing industry performance. It computes efficiency of the labour to process input into good value of output. Thus, accurate number of labour allocation is essential in producing high labour productivity. Hence, this paper is to provide alternative way to managers or decision makers on managing the labour allocation and analyzing result with the aid of optimization technique to enhance labour productivity. The application of the optimization technique is portrayed on an automotive company situated in Melaka, Malaysia that facing labour allocation issue. The flow of methodology is first by conducting problem identification using Pareto chart to target area of issue. Then, formulating the problem in linear programming (LP) model and finally solving the problem using Simplex method to generate the optimum number of labour based on the set constraints. The generated optimum number of labour is then loaded into the labour productivity formula and the outcome resulting to the betterment of percentage of labour productivity compared to the current approach. In this context, the labour productivity is measured by the unit of number of working hours per number of task perform. This application gives benefit to the industry in ensuring that involved teams in the company able to commit with the company's project timeline and due with consideration of all important constraints/ limitations occurred from that involved teams. Also, with the aid of this optimization technique, the company can foresee the result of the number of labour allocated without the need of utilizing actual resources in the actual arena.*

*Keywords*: *Labour productivity, linear programming problem, optimization technique, simplex method.*

## I. INTRODUCTION

The arrival of industrial revolution 4.0 has speed up the stimulation of collaboration between research and industry line [1]. This situation also has engulfed the Ministry of Energy, Science, Technology, Environment and Climate Change (MESTECC) to initiate Researcher-Industry Scientific Exchange (RISE) program in order to develop closer relationship between the researchers at public research agencies and the industry players [2]. One of the program's scope is to assist in solving problems of daily operation processes or to enhance current services.

As for industry, the problem of daily operation processes is constantly related to managing productivity. While studies on the effect of managing productivity has been a lifetime investigation in various fields' literature such as economic, construction and manufacturing industry [3]–[5]. Yet, it is found that, poor labour management is among of various factors that have been identified as some of the main factors influencing the productivity [6]–[8]. In industry, managing labour is about allocating an amount of human labour to yield industrial goods. Whereas for high usage of labour industries, the investment on labour is more crucial than the investment on manufacturing facilities [9]–[12]. Thus, a good labour productivity is vital which reflects on the efficiency of a company's labour force operates [13]–[15].

## II. RESEARCH BACKGROUND

### A. Optimization Technique

One of the way to control the productivity regardless of what factors is using optimization technique [16]. The optimization technique in manufacturing operation is getting a wide usage which mainly to stabilize the trade-off between constraints and resource available to attain the least project investment [17], [18]. Commonly, the stabilization of the trade-offs is to integrate the production constraints and resources to generate maximum profit and minimum cost and it can be said as finding optimal solution [19]. The optimal solution produced from the integration of the production constraints and resources is said to give benefit not just for one party but for all involved parties in the operation as every requirements and limits are taken into account [20]. These constraints and resources are said portraying a linear relationship, henceforth, linear programming (LP) model can be used to model the problem and further solve using Simplex method [21].

**Nor Asmaa Alyaa binti Nor Azlan**\*, Fakulti Kejuruteraan Pembuatan, Universiti Teknikal Malaysia Melaka, Melaka, Malaysia. Email: alyaanorazlan@gmail.com

**Effendi bin Mohamad**, Fakulti Kejuruteraan Pembuatan, Universiti Teknikal Malaysia Melaka, Melaka, Malaysia. Email: effendi@utem.edu.my

**Mohd Rizal bin Salleh**, Fakulti Kejuruteraan Pembuatan, Universiti Teknikal Malaysia Melaka, Melaka, Malaysia. Email: rizal@utem.edu.my

**Adi Saptari**, Faculty of Engineering, President University Campus, Bekasi, Indonesia. Email: adi.saptari@president.ac.id

3474

# Application of Optimization Technique in Managing Labour Productivity for an Automotive Company

The Simplex method able to determine the optimal solution by reaching from one point to another in a way of iterative calculation [22]. The good about Simplex method is that this method can be act as foundation for other extension either by adding, substituting or integrating with other methods for better accuracy and efficiency of computation at same time generating high quality of optimum solution [23], [24].

Hence, this paper will present on the scenario of a selected automotive company in Malaysia which facing labour allocation issue and the application of the optimization technique using Simplex method for the betterment of company's labour productivity.

## B. Overview of Selected Industry

The subject of this case study is an international manufacturing company from automotive industry situated in Melaka, Malaysia and has narrowed down the engineering group as the target group. There are six stages in its general project operations which starts with pre-CST (pre-Car Strategic Task), then goes to CST (Car Strategic Task), planning, development, trial and finally the stage ends at mass production, as shown in Fig. 1. The pre-CST stage is the initial cost study and market acceptance analysis that involves core groups such as sale and designer group. Whereas in the CST stage, the core groups involved are sale, designer and engineering group. These three core groups develop concept in deciding whether the project will be major, intermediate or minor conversion.
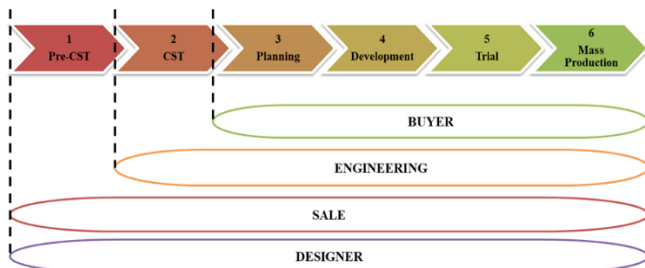


**Fig. 1. Positioning involvement of core group in stages of project development**

After the CST, the next stage is the planning whereby buyer group will join the other three core groups to specify all required activities and fit them into project's time allocation. As it goes, the development stage will realize the drawing unit into actual arena and all the four core groups will work concurrently until reaching the trial stage and ending at the mass production stage. The trial stage requires the core groups to evaluate and maturate the capacity and capability by the production to produce the unit before the project fit for the full capacity production during mass production stage.

A limitation is set to guide the focus to which area will the application of the optimization technique to be conducted. Thus, a Pareto chart is constructed to separate the vital few and trivial many, so then the 80/20 rule will reveal the focus areas that must be prioritized and process of enhancements will be more effective if the vital few are addressed first. From Fig. 2, as the 80/20 rule marked, it reveals that the 80% of the project's accomplishment hours was owned by the 20% of the stages of the project. In this case, the 20% here are representing the two stages which are the development stage and planning stage.
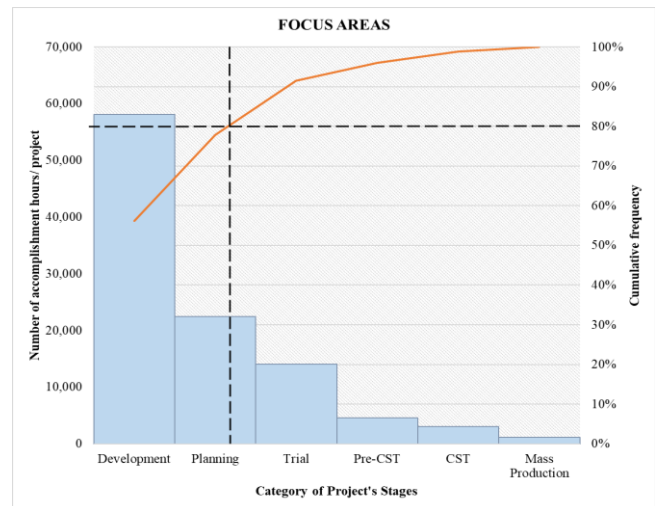


**Fig. 2. The Pareto Chart of focus areas of the case study**

The development stage appeared to be the highest stage that consuming 58,050 hours per project. This indicates that the development stage is demanding greatest commitments and must be comprised with mass of workloads in ensuring that development stage is executed accordingly. Yet, the development stage is involving all the core groups to be participated as this explains the massive number of hours consumed by the stage for each project performed.

In addition, planning stage is the subsequent stage that requiring about 22,437 hours for every time a particular project is conducted. Likewise, the planning stage also demanding sales, designers, engineering, and buyer group concurrent involvement in making sure the goals of planning stage is fulfilled. Thus, development and planning stage will be the focused areas for the application of the optimization technique.

## III. METHODOLOGY

The methodology of this research is comprising of three steps as shown in Fig. 3, whereby the first step is the problem identification, step two is the formulation of LP model and step three is the computation using Simplex algorithm. Further explanation for each of those steps were described in the next subheadings.
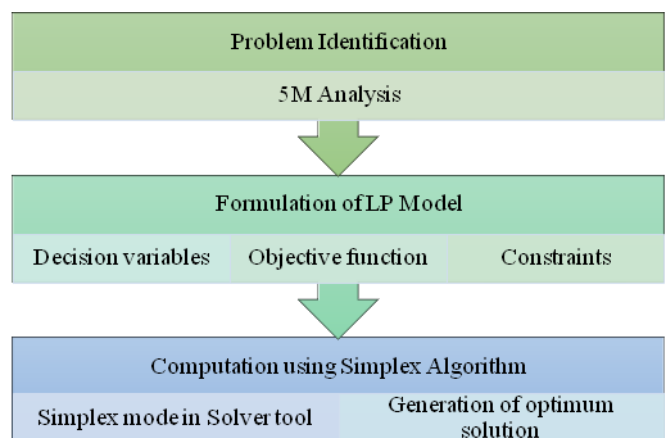


**Fig. 3. Steps in methodology**

### A. Step 1: Problem Identification

The identification of the problem in the engineering group is performed by taking into account the 5M elements which are Man, Method, Material, Machine and Management. In this case, the Man is referring to the people in the engineering group, Method is the standard of procedure (SOP) in the engineering group, while the Material is indicating the data, documents of car parts that required by the engineering group, the Machine is reflecting the facilities and tools that essential to the engineering group to perform their tasks.

Lastly, the Management is referring to the management in the engineering group. This case study has given a consent to perform the investigation involving the element of Man whereby the exploration of the case study is relating to labour issue in the engineering group. The other elements are not to be considered in the case study as those elements are containing massive of undisclosed data and information.

The engineering group facing labour allocation issue apart from their capability and competency in executing their tasks and responsibilities. Currently, their practice is based on the number of tasks that requiring each of the aspects of the engineering group to perform throughout the duration of the project.

Hence, this practice is solely carrying out the labour allocation by considering the project's requirement from the individual functions in every aspects of the engineering group (Quality, Cost, Delivery, Specification Control and Certification team). Moreover, based on their past experiences, they had recognized that the impact from the practice was the occurrence of delay reporting activities which distressing them in executing their duties towards the project completion.
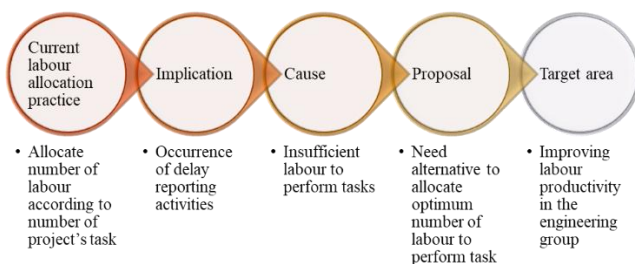


**Fig. 4. Flow of problem identification**

The occurrence of delay reporting activities is because of insufficient labour to perform certain tasks as shown in Fig. 4. Each team in the group has different target to be fulfilled. Such that, the Quality team is requesting a longer time to study defective items occurred. But, apparently the Delivery team is unable to spare some ample time for the Quality team to do the study since the team need to ensure that the targeted output is achieved. At the same time, the Cost team is reluctantly to allocate more expenses to assign outsource labour for assisting the Quality team to cope with the time constraint as the Cost team has secured the budget at initial phase of the project. Hence, the Quality team might need to work extra hour and delay their reporting activities as they have to investigate, combat the root cause and come up with a countermeasure to ensure the number of defective items can be reduced until reaching permissible amount. Thus, the delay reporting activities event reflects that the engineering group might need an alternative practice to allocate most

optimum number of labour to perform task, hence, to work on their labour productivity.

### B. Step 2: Formulation of Linear Programming Model

The idea of improving the current labour productivity is by assigning optimum number of labour for each engineering team. In order to do that, the problem is formulated first into the LP model and the optimum number of labour is then generated through the application of the Simplex algorithm. The LP model consisting of mathematical formulation to present the problem's attributes which are decision variables, objective function and constraints [25], [26]. Hence, the labour allocation requirement will be segregated into these three attributes. In overall, the planning and development stage consists of 13 and 8 level of tasks respectively as shown in Table I.

**Table- I: Task distribution for each team of the engineering group at planning and development stage of project**

| Project stage | Task level 1 | Team | | | | |
|---|---|---|---|---|---|---|
| | | Quality | Cost | Delivery | Specification Control | Certification |
| | | Sub-task for each team | | | | |
| Planning | Task 1 | Sub-task A1 Sub-task A2 | Sub-task B1 | Sub-task C1 | Sub-task D1 | Sub-task E1 |
| | Task 2 | Sub-task A3 Sub-task A4 | Sub-task B2 | Sub-task C2 | Sub-task D2 | Sub-task E2 |
| | Task 3 | Sub-task A5 Sub-task A6 | Sub-task B3 | Sub-task C3 | Sub-task D3 | Sub-task E3 |
| | Task 4 | Sub-task A7 Sub-task A8 | Sub-task B4 | Sub-task C4 | Sub-task D4 | Sub-task E4 |
| | Task 5 | Sub-task A9 Sub-task A10 | Sub-task B5 | Sub-task C5 | Sub-task D5 | Sub-task E5 |
| | Task 6 | Sub-task A11 | Sub-task B6 | Sub-task C6 | Sub-task D6 | Sub-task E6 |
| | Task 7 | Sub-task A12 Sub-task A13 | Sub-task B7 | Sub-task C7 | Sub-task D7 | Sub-task E7 |
| | Task 8 | Sub-task A14 Sub-task A15 | Sub-task B8 | Sub-task C8 | Sub-task D8 | Sub-task E8 |
| | Task 9 | Sub-task A16 Sub-task A17 | Sub-task B9 | Sub-task C9 | Sub-task D9 | Sub-task E9 |
| | Task 10 | Sub-task A18 | Sub-task B10 | Sub-task C10 | Sub-task D10 | Sub-task E10 |
| | Task 11 | Sub-task A19 | Sub-task B11 | Sub-task C11 | Sub-task D11 | Sub-task E11 |
| | Task 12 | Sub-task A20 Sub-task A21 | Sub-task B12 | Sub-task C12 | Sub-task D12 | Sub-task E12 |
| | Task 13 | Sub-task A22 | Sub-task B13 | Sub-task C13 | Sub-task D13 | Sub-task E13 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Development | Task 1 | Sub-task AA1 Sub-task AA2 | Sub-task BB1 | Sub-task CC1 | Sub-task DD1 | Sub-task EE1 |
| | Task 2 | Sub-task AA3 Sub-task AA4 | Sub-task BB2 | Sub-task CC2 | Sub-task DD2 | Sub-task EE2 |
| | Task 3 | Sub-task AA5 Sub-task AA6 | Sub-task BB3 | Sub-task CC3 | Sub-task DD3 | Sub-task EE3 |
| | Task 4 | Sub-task AA7 | None | Sub-task CC4 | Sub-task DD4 | Sub-task EE4 |
| | Task 5 | Sub-task AA8 | None | Sub-task CC5 | Sub-task DD5 | Sub-task EE5 |
| | Task 6 | Sub-task AA9 Sub-task AA10 | None | Sub-task CC6 | Sub-task DD6 | Sub-task EE6 |
| | Task 7 | Sub-task AA11 | None | Sub-task CC7 | Sub-task DD7 | Sub-task EE7 |
| | Task 8 | Sub-task AA12 | None | Sub-task CC8 | Sub-task DD8 | Sub-task EE8 |

Thus, the decision variable for the planning and development stage will have 13 and 8 variables respectively. and the information that needed were tabulated as shown in Table II. Since there are five teams in the engineering group, hence there will be 13 and 8 variables for each of the five teams and example of decision variables formulation for the Quality team for both planning and development stage are shown as follows,

$x_1 =$ Number of labour required by Quality team at planning stage for Task 1

$x_2 =$ Number of labour required by Quality team at planning stage for Task 2

$x_3 =$ Number of labour required by Quality team at planning stage for Task 3

$x_4 =$ Number of labour required by Quality team at planning stage for Task 4

$x_5 =$ Number of labour required by Quality team at planning stage for Task 5

$x_6 =$ Number of labour required by Quality team at planning stage for Task 6

$x_7 =$ Number of labour required by Quality team at planning stage for Task 7

$x_8 =$ Number of labour required by Quality team at planning stage for Task 8

$x_9 =$ Number of labour required by Quality team at planning stage for Task 9

$x_{10} =$ Number of labour required by Quality team at planning stage for Task 10

$x_{11} =$ Number of labour required by Quality team at planning stage for Task 11

$x_{12} =$ Number of labour required by Quality team at planning stage for Task 12

$x_{13} =$ Number of labour required by Quality team at planning stage for Task 13

$x_1 =$ Number of labour required by Quality team at development stage for Task 1

$x_2 =$ Number of labour required by Quality team at development stage for Task 2

$x_3 =$ Number of labour required by Quality team at development stage for Task 3

$x_4 =$ Number of labour required by Quality team at development stage for Task 4

$x_5 =$ Number of labour required by Quality team at development stage for Task 5

$x_6 =$ Number of labour required by Quality team at development stage for Task 6

$x_7 =$ Number of labour required by Quality team at development stage for Task 7

$x_8 =$ Number of labour required by Quality team at development stage for Task 8

Next, the objective function is then formed to set the contribution coefficients for each of the task level in the team

of the engineering group and example of objective function formulation for the Quality team for both planning and development stage are shown as follows,

Minimization of labour for Quality team at planning stage,
$$Z = 2x_1 + 2x_2 + 2x_3 + 2x_4 + 2x_5 + x_6 + 2x_7 + 2x_8 + 2x_9 + x_{10} + x_{11} + 2x_{12} + 2x_{13}$$

Minimization of labour for Quality team at development stage,
$$Z = 2x_1 + 2x_2 + 2x_3 + 2x_4 + 2x_5 + 2x_6 + 2x_7 + 2x_8$$

**Table- II: Total working hour per task and total number of task performed at planning and development stage**

| Task level | Quality | Cost | Delivery | Specification Control | Certification | Total working hour per task |
|---|---|---|---|---|---|---|
| | | | Team | | | |
| | | | Planning stage | | | |
| | | Working hour consumption per task (hour) | | | | |
| Task 1 | 1.28 | 0.75 | 0.50 | 0.25 | 0.25 | 3.04 |
| Task 2 | 1.36 | 0.75 | 0.50 | 0.25 | 0.25 | 3.11 |
| Task 3 | 1.18 | 0.75 | 0.50 | 0.50 | 0.25 | 3.18 |
| Task 4 | 1.17 | 0.75 | 0.75 | 0.50 | 0.51 | 3.68 |
| Task 5 | 1.18 | 1.00 | 0.75 | 0.50 | 0.51 | 3.95 |
| Task 6 | 0.95 | 1.00 | 0.75 | 0.50 | 0.51 | 3.71 |
| Task 7 | 1.24 | 1.00 | 0.75 | 0.75 | 0.51 | 4.26 |
| Task 8 | 1.34 | 1.00 | 1.00 | 0.75 | 0.51 | 4.60 |
| Task 9 | 1.12 | 1.00 | 1.00 | 0.75 | 0.51 | 4.39 |
| Task 10 | 0.89 | 1.00 | 1.00 | 1.00 | 0.51 | 4.40 |
| Task 11 | 0.80 | 0.75 | 1.00 | 1.00 | 0.51 | 4.06 |
| Task 12 | 1.19 | 0.75 | 1.00 | 1.00 | 0.51 | 4.45 |
| Task 13 | 0.38 | 0.75 | 1.00 | 1.00 | 0.51 | 3.64 |
| Total no. of tasks | 22 | 13 | 13 | 13 | 13 | |
| | | | Development stage | | | |
| | | Working hour consumption per task (hour) | | | | |
| Task 1 | 1.08 | 0.50 | 1.00 | 1.00 | 0.75 | 4.33 |
| Task 2 | 1.50 | 0.25 | 1.00 | 1.00 | 0.75 | 4.50 |
| Task 3 | 1.33 | 0.25 | 1.00 | 1.00 | 0.75 | 4.33 |
| Task 4 | 0.92 | 0.00 | 1.00 | 1.00 | 0.75 | 3.67 |
| Task 5 | 0.95 | 0.00 | 1.00 | 1.00 | 0.75 | 3.70 |
| Task 6 | 1.30 | 0.00 | 1.00 | 1.00 | 0.75 | 4.05 |
| Task 7 | 0.76 | 0.00 | 1.00 | 1.00 | 0.75 | 3.51 |
| Task 8 | 0.60 | 0.00 | 1.00 | 1.00 | 0.75 | 3.36 |
| Total no. of tasks | 12 | 3 | 8 | 8 | 8 | |
| Note: 1 = 10 hours of work per task | | | | | | |

The coefficients of the objective functions were decided based on the number of tasks that required to perform by the team at every task level of the stage, which adopted from Table III. While, the minimization problem is selected for the objective function to imply that the least number of labour required by the team to achieve better labour productivity.

**Table- III: Average of planned working hour for task must be delivered at planning and development stage**

| Task level | Quality | Cost | Delivery | Specification Control | Certification | Average of planned working hour |
|---|---|---|---|---|---|---|
| | | | Team | | | |
| | | | Planning stage | | | |
| | | No. of task must be delivered | | | | |
| Task 1 | 2 | 1 | 1 | 1 | 1 | 0.61 |
| Task 2 | 2 | 1 | 1 | 1 | 1 | 0.62 |
| Task 3 | 2 | 1 | 1 | 1 | 1 | 0.64 |
| Task 4 | 2 | 1 | 1 | 1 | 1 | 0.74 |
| Task 5 | 2 | 1 | 1 | 1 | 1 | 0.79 |
| Task 6 | 1 | 1 | 1 | 1 | 1 | 0.74 |
| Task 7 | 2 | 1 | 1 | 1 | 1 | 0.85 |
| Task 8 | 2 | 1 | 1 | 1 | 1 | 0.92 |
| Task 9 | 2 | 1 | 1 | 1 | 1 | 0.88 |
| Task 10 | 1 | 1 | 1 | 1 | 1 | 0.88 |
| Task 11 | 1 | 1 | 1 | 1 | 1 | 0.81 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Task 12 | 2 | 1 | 1 | 1 | 1 | 0.89 |
| Task 13 | 1 | 1 | 1 | 1 | 1 | 0.73 |
| Total no. of tasks | 22 | 13 | 13 | 13 | 13 | |
| Development stage | | | | | | |
| No. of task must be delivered | | | | | | |
| Task 1 | 2 | 1 | 1 | 1 | 1 | 0.87 |
| Task 2 | 2 | 1 | 1 | 1 | 1 | 0.9 |
| Task 3 | 2 | 1 | 1 | 1 | 1 | 0.87 |
| Task 4 | 1 | 0 | 1 | 1 | 1 | 0.92 |
| Task 5 | 1 | 0 | 1 | 1 | 1 | 0.92 |
| Task 6 | 2 | 0 | 1 | 1 | 1 | 1.01 |
| Task 7 | 1 | 0 | 1 | 1 | 1 | 0.88 |
| Task 8 | 1 | 0 | 1 | 1 | 1 | 0.84 |
| Total no. of tasks | 12 | 3 | 8 | 8 | 8 | |

Lastly, the constraints were set into four parameters whereby will be based on the working hour consumption per task performed and the average of planned working hour for the task must be delivered by the team at every task level for both planning and development stage as tabulated in Table II and Table III.

Constraints 1: Working hour consumption per task for Quality team at planning stage (hour):

$$
\begin{aligned}
\text{Task 1} &= & 1.28x_1 & \geq 2 \\
\text{Task 2} &= & 1.36x_2 & \geq 2 \\
\text{Task 3} &= & 1.18x_3 & \geq 2 \\
\text{Task 4} &= & 1.17x_4 & \geq 2 \\
\text{Task 5} &= & 1.18x_5 & \geq 2 \\
\text{Task 6} &= & 0.95x_6 & \geq 1 \\
\text{Task 7} &= & 1.24x_7 & \geq 2 \\
\text{Task 8} &= & 1.34x_8 & \geq 2 \\
\text{Task 9} &= & 1.12x_9 & \geq 2 \\
\text{Task 10} &= & 0.89x_{10} & \geq 1 \\
\text{Task 11} &= & 0.80x_{11} & \geq 1 \\
\text{Task 12} &= & 1.19x_{12} & \geq 2 \\
\text{Task 13} &= & 0.38x_{13} & \geq 1 \\
\end{aligned}
$$

Constraints 2: Working hour consumption per task for Quality team at development stage (hour):

$$
\begin{aligned}
\text{Task 1} &= & 1.08x_1 & \geq 2 \\
\text{Task 2} &= & 1.50x_2 & \geq 2 \\
\text{Task 3} &= & 1.33x_3 & \geq 2 \\
\text{Task 4} &= & 0.92x_4 & \geq 1 \\
\text{Task 5} &= & 0.95x_5 & \geq 1 \\
\text{Task 6} &= & 1.30x_6 & \geq 2 \\
\text{Task 7} &= & 0.76x_7 & \geq 1 \\
\text{Task 8} &= & 0.60x_8 & \geq 1 \\
\end{aligned}
$$

Constraints 3: Average of planned working hour for task must be delivered for Quality team at planning stage (hour):

$$
\begin{aligned}
\text{Task 1} &= & 2x_1 & \leq 0.61 \\
\text{Task 2} &= & 2x_2 & \leq 0.62 \\
\text{Task 3} &= & 2x_3 & \leq 0.64 \\
\text{Task 4} &= & 2x_4 & \leq 0.74 \\
\text{Task 5} &= & 2x_5 & \leq 0.79 \\
\text{Task 6} &= & x_6 & \leq 0.74 \\
\text{Task 7} &= & 2x_7 & \leq 0.85 \\
\text{Task 8} &= & 2x_8 & \leq 0.92 \\
\text{Task 9} &= & 2x_9 & \leq 0.88 \\
\text{Task 10} &= & x_{10} & \leq 0.88 \\
\text{Task 11} &= & x_{11} & \leq 0.81 \\
\text{Task 12} &= & 2x_{12} & \leq 0.89 \\
\text{Task 13} &= & x_{13} & \leq 0.73 \\
\end{aligned}
$$

Constraints 4: Average of planned working hour for task must be delivered for Quality team at development stage (hour):

$$
\begin{aligned}
\text{Task 1} &= & 2x_1 & \leq 0.87 \\
\text{Task 2} &= & 2x_2 & \leq 0.90 \\
\text{Task 3} &= & 2x_3 & \leq 0.87 \\
\text{Task 4} &= & x_4 & \leq 0.92 \\
\text{Task 5} &= & x_5 & \leq 0.92 \\
\text{Task 6} &= & 2x_6 & \leq 1.01 \\
\text{Task 7} &= & x_7 & \leq 0.88 \\
\text{Task 8} &= & x_8 & \leq 0.84 \\
\end{aligned}
$$

## C. Step 3: Computation Using Simplex Algorithm

After formulating the problem into the LP model, it is computed using Simplex algorithm to generate the optimum number of labour for each of the team in the engineering group at both planning and development stage. Basically, the flow of Simplex algorithm is as depicted in Fig. 5 whereby it comprising with initialization, iterative calculation and termination stage.
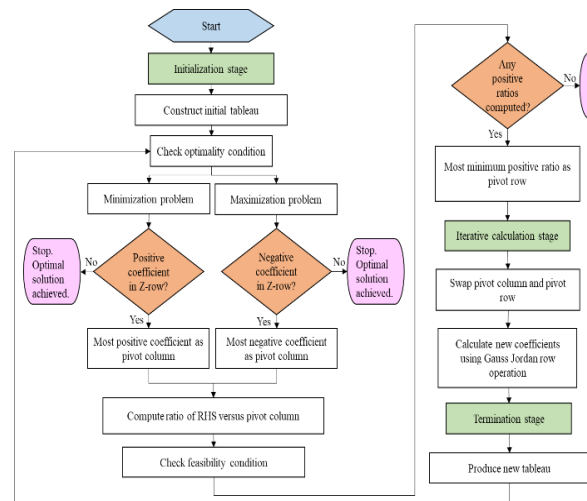


**Fig. 5. Flow of Simplex algorithm**

The Simplex algorithm is also available in the Solver of Microsoft Excel as one of the options in the solving method list which the formulated LP problem will be loaded in and computed to generate the optimum solution. This computation using Simplex algorithm will be calculated individually for each team of the engineering group with the same four parameter of constraints but different coefficients according to their working hour consumption per task and the average of planned working hour for the task must be delivered for both planning and development stage.

## IV. RESULT AND DISCUSSION

### A. Labour Productivity at Planning Stage

The result of the labour productivity at planning stage for all the task level of the engineering group is computed and tabulated in Table IV. Based on the result, by using the current practice, the Quality team has been allocated 14 labours with the percentage of labour productivity of 63.64%. However, with the application of the optimization technique,

the Quality team is suggested to be allocated of 19 labours with better labour productivity of 86.36%. As for the Cost team, the current practice allocated 11 labours for the team with 84.62% of labour productivity.

**Table- IV: Comparison of labour productivity at planning stage between current practice and optimization technique**

| Team | No. of task performed | Current practice | | Optimization technique | |
|---|---|---|---|---|---|
| | | Labour allocation | Labour productivity (%) | Labour allocation | Labour productivity (%) |
| Quality | 22 | $14.07 \approx 14$ | 63.64 | 19 | 86.36 |
| Cost | 13 | $11.25 \approx 11$ | 84.62 | 12 | 92.31 |
| Delivery | 13 | $10.50 \approx 10$ | 76.92 | 12 | 92.31 |
| Specification Control | 13 | $8.75 \approx 8$ | 61.54 | 10 | 76.92 |
| Certification | 13 | $5.91 \approx 5$ | 38.46 | 11 | 84.62 |

Yet, from the optimization technique, the Cost team is expected to achieve 92.31% of labour productivity with the number of labour allocation of 12. While the Delivery team, the current practice generated about 76.92% of labour productivity with the number of labour allocation of 10. Despite that, the Delivery team can achieve labour productivity up to 92.31% with the number of labour allocation of 12 by implementing the optimization technique.

Whereas the current practice has made the Specification Control team achieving only 61.54% of labour productivity with being allocated about 8 labours. Nevertheless, the team can achieve higher labour percentage by applying the optimization technique which is up to 76.92% with the number of labour allocation of 10. On the other hand, the Certification team can achieve much better labour productivity with the application of the optimization technique that is up to 84.62% with the number of labour allocation of 11. This is a huge gap of percentage when compared with the current practice that allocating only 5 labours that generated about 38.46% of labour productivity.

This has showed that the application of the optimization technique generating better labour productivity at the planning stage for each of the team of the engineering group. The optimization technique is suggesting for the planning stage to allocate the least number of labour allocation that is optimum with the consideration of the four constraints and objective function that set individually for each team. The set objective function and constraints from the formulation of LP problem model have made the Simplex algorithm to run and produce the optimum solution within those circumstances at the planning stage.

**B. Labour Productivity at Development Stage**

The result of the labour productivity at development stage for all the task level of the engineering group is computed and tabulated in Table V. Based on the result, with the usage of the current practice, the Quality team has been allocated 8 labours with the percentage of labour productivity of 70.36%. However, with the application of the optimization technique, the Quality team is recommended to be allocated of 10 labours with better labour productivity of 83.33%. While the Cost team has achieved only 33.33% of labour productivity via the current practice that has allocated only 1 labour to perform 3 tasks. Instead, with the application of the optimization technique, the Cost team able to be allocated 3 labours which eventually generate 100.00% of labour productivity.

**Table V: Comparison of labour productivity at development stage between current practice and optimization technique**

| Team | No. of task performed | Current practice | | Optimization technique | |
|---|---|---|---|---|---|
| | | Total no. of working hour per task (Note: 1 = 10 hours of work per task) | Labour productivity (%) | Total no. of working hour per task (Note: 1 = 10 hours of work per task) | Labour productivity (%) |
| Quality | 12 | $8.44 \approx 8$ | 70.36 | 10 | 83.33 |
| Cost | 3 | $1.00 \approx 1$ | 33.33 | 3 | 100.00 |
| Delivery | 8 | $8.00 \approx 8$ | 100.00 | 8 | 100.00 |
| Specification Control | 8 | $8.00 \approx 8$ | 100.00 | 8 | 100.00 |
| Certification | 8 | $6.01 \approx 6$ | 75.15 | 8 | 100.00 |

Whereas, the current practice has already generated 100.00% of labour productivity for both Delivery and Specification Control team with both teams have been allocated the same number of labour which is 8 labours. While the optimization technique is also generating the same number of labour allocation that is 8 labours with 100.00% labour productivity. This situation implies that, with all the set objective function and constraints from the formulation of LP problem model, both teams are permitted to have full allocation of labour whereby each of the labour is assignable to focus on one task at one time. On the other hand, the Certification team is also capable to achieve 100.00% of labour productivity with also full allocation of labour in spite of the current practice that producing 75.15% of labour productivity with the number of labour allocation of 6 labours.

This has showed that the application of the optimization technique generating better labour productivity at the development stage for each of the team of the engineering group. At the same time, this optimization technique can be looked up as a tool to confirm a decision as what situation happens to the Delivery and Specification Control team. Yet, the optimization technique is suggesting for the development stage to allocate the least number of labour allocation that is optimum with the consideration of the four constraints and objective function that set individually for each team. The set objective function and constraints from the formulation of LP problem model have made the Simplex algorithm to run and produce the optimum solution within those circumstances at the development stage.

## V. CONCLUSION

Labour productivity is one of all-important factor that will portray on the ability of a company to undertake their target which manoeuvre with optimum expenditure of resources. While the optimization technique can be seen as one of available methods that manager or decision maker can play with to foresee impact of particular suggestions towards the company's operations without biased and in an optimal way. Thus, in this paper, the application of the optimization technique has assisted the engineering group in allocating number of labour for each teams (Quality, Cost, Delivery, Specification Control and Certification). The steps in the optimization technique were framed in three steps which are the problem identification, formulation of LP model and computation using Simplex algorithm. The result has showed that the application does contribute to the enhancement of the percentage of the labour productivity compared to their current practice.

## ACKNOWLEDGEMENT

## REFERENCES

1. Nasiibah, R. and Zinatul, A.Z., "University-Industry Collaboration: Entrepreneurial University Catalyst Towards," Prosceeding PERKEM VIII, vol. 3, pp. 1227–1233, 2013.
2. MESTECC, "Researcher-Industry Scientific Exchange (RISE) Programme," 2019.
3. Kapelko, M., Lansink, A.O. and Stefanou, S.E., "Effect of Food Regulation on the Spanish Food Processing Industry: A Dynamic Productivity Analysis," PLoS One, vol. 10, no. 6, pp. 1–16, 2015.
4. Ohueri, C.C., Enegbuma, W.I., Wong, N.H., Kuok, K.K. and Kenley, R., "Labour Productivity Motivation Framework For Iskandar Malaysia," Built Environment Project Asset Management, vol. 8, no. 3, pp. 293–304, 2018.
5. Siu, M.F.F., "Resource Budget For Workface Planning In Industrial-Construction," Facilities, vol. 37, no. 5–6, pp. 292–312, 2019.
6. Chaturvedi, S., Thakkar, J.J. and Shankar, R., "Labor Productivity in The Construction Industry: An Evaluation Framework for Causal Relationships," Benchmarking, vol. 25, no. 1, pp. 334–356, 2018.
7. Mahamid, I., "Contractors Perspective Toward Factors Affecting Labor Productivity in Building Construction," Engineering, Construction and Architectural Management, vol. 20, no. 4, pp. 446–460, 2013.
8. Ghoddousi, P., Alizadeh, B.T., Hosseini, M.R. and Chileshe, N., "Implementing The International Benchmarking Labour Productivity Theoretical Model," Benchmarking, vol. 21, no. 6, pp. 1041–1061, 2014.
9. Shahidul, M.I., and Shazali, S.T.S., "Dynamics of Manufacturing Productivity: Lesson Learnt From Labor Intensive Industries," Journal Manufacturing Technology Management, vol. 22, no. 5, pp. 664–678, 2011.
10. Ugulu, R.A. and Allen, S., "Using The Learning Curve Theory In The Investigation Of On-Site Craft Gangs' Blockwork Construction Productivity," Built Environment Project Asset Management, vol. 8, no. 3, pp. 267–280, 2018.
11. Islam, S. and Shazali, S.T.S., " Determinants Of Manufacturing Productivity: Pilot Study On Labor-Intensive Industries," International Journal Production. Performance Management, vol. 60, no. 6, pp. 567–582, 2011.
12. Tang, C.F., "The Non-Monotonic Effect Of Real Wages On Labour Productivity: New Evidence From The Manufacturing Sector In Malaysia," International Journal Social Economy, vol. 39, no. 6, pp. 391–399, 2012.
13. Iqbal, N., Ahmad, M., Allen, M.M.C. and Raziq, M.M., "Does E-HRM Improve Labour Productivity? A Study Of Commercial Bank Workplaces In Pakistan," Employee Relations, vol. 40, no. 2, pp. 281–297, 2018.
14. Yang, J. and Chen, H., "Can Rewards Incentives Of Non-State-Owned Enterprises Realize Co-Win Cooperation Of Workers, Enterprises And The Society?: From The Perspective Of Labor Productivity, Profit And Labor Absorption," Nankai Business Review International, vol. 10, no. 2, pp. 179–206, 2019.
15. Enshassi, A., Mohamed, S., Mayer, P. and Abed, K., "Benchmarking Masonry Labor Productivity," International Journal Production Performance Management, vol. 56, no. 4, pp. 358–368, 2007.
16. Anggoro, B.S.R., Rosida, M., Mentari, A.M., Novitasari, C.D. and Yulista, I., "Profit Optimization Using Simplex Methods On Home Industry Bintang Bakery In Sukarame Bandar Lampung," Journal Physics: Conference Series, vol. 1155, no. 1, 2019.
17. Salama, T. and Moselhi, O., "Multi-Objective Optimization For Repetitive Scheduling Under Uncertainty," Engineering, Construction and Architectural Management, vol. 0217, no. 2, pp. 1294–1320, 2019.
18. Ugulu, R.A., Arewa, A. and Allen, S., "Project-Specific Constraints Influencing Productivity Of Tradespeople In The Nigerian Construction Industry," Built Environment Project and Asset Management, pp. 1-14, 2019.
19. Aulia, M.R., Putra, D.N., Murniati, S., Mustahiroh, M., Octavia, D., and Budiasih, Y., "Maksimalisasi Keuntungan Dengan Pendekatan Metode Simpleks Studi Kasus pada Pabrik Sendai X di Ciputat, Tangerang Selatan," Liquidity, vol. 2, no. 2, pp. 144–150, 2018.
20. Saleh, S.A., and Latif, T.I., "Solving Linear Programming Problems By Using Excel ' s Solver," Tikrit University جامعة تكريت," vol. d, no. April, 2019.
21. Sriwidadi, T. and Agustina, E., "Analisis Optimalisasi Produksi Dengan Linear Programming Melalui Metode Simpleks Teguh Sriwidadi," Binus Business Review, vol. 4, no. 2, pp. 725–741, 2013.
22. Hussain, M.R., Qayyum, M. and Hussain, M.E., "Effect Of Seven Steps Approach On Simplex Method To Optimize The Mathematical Manipulation," International Journal Recent Technology Engineering, vol. 7, no. 5, pp. 34–43, 2019.
23. Febres, G.L., "A Space Decomposition-Based Deterministic Algorithm For Solving Linear Optimization Problems," Axioms, vol. 8, no. 3, 2019.
24. Nadar, D. K., "Some Applications of Simplex Method," RIET-IJSET International Journal Science Engineering Technology, vol. 2, no. 2, p. 171, 2015.
25. Azlan, N.A.A.N., Saptari, A. and Mohamad, E. "Augmentation of Simplex Algorithm for Linear Programming Problem to Enhance Computational Performance," Journal Advanced Manufacturing Technology -Special Issue Symposium 2017, vol. 11, no. November, pp. 31–46, 2017.
26. Tesfaye, G., Berhane, T., Zenebe, B. and Asmelash, S., "A Linear Programming Method to Enhance Resource Utilization Case," International Journal for Quality Research, vol. 10, no. 2, pp. 421–432, 2016.

## AUTHORS PROFILE

**Nor Asmaa Alyaa binti Nor Azlan** is a PhD student from Universiti Teknikal Malaysia Melaka (UTeM) that taking Competitive Manufacturing course under Faculty of Manufacturing Engineering. Prior to this, she worked in Honda Malaysia Sdn. Bhd. as an executive engineer which attached in Mass Production Delivery Department of Procurement Division and trainee in Project Management and Quality Department of Muehlbauer Technologies Sdn. Bhd. She received her master's degree in Industrial Engineering after completed her Bachelor's degree in Manufacturing Engineering (Management) from UTeM. Her interest of studies are comprising of academic institution-industries collaboration in Malacca, Malaysia in various field, for instance, facilities layout planning, simulation and optimization technique applications.

*Retrieval Number: A4935119119/2019©BEIESP*
*DOI: 10.35940/ijitee.A4935.119119*
*Journal Website: www.ijitee.org*

*Published By:*
*Blue Eyes Intelligence Engineering*
*& Sciences Publication*

3480

# Application of Optimization Technique in Managing Labour Productivity for an Automotive Company

**Effendi bin Mohamad** has been serving Faculty of Manufacturing Engineering in Universiti Teknikal Malaysia Melaka (UTeM) as a lecturer since 2005. Prior to his involvement as an academician, he worked in NEC Semiconductors Sdn Bhd, Perodua Sales Sdn Bhd and ST Microelectronics Sdn Bhd in various engineering capacities such as industrial engineer and process engineer. He received his Bachelor's degree in Manufacturing Engineering from University Malaya Kuala Lumpur and Master's degree in Manufacturing Management from Coventry University United Kingdom. He completed his Doctoral course in Intelligent Structures and Mechanics Systems Engineering in University of Tokushima, Japan. He has also served as a visiting professor/scholar at various institutes including, Tokushima University, Japan and University Brawijaya, Indonesia. Currently, he is Associate Professor in Faculty of Manufacturing Engineering, UTeM and is actively involved in consultation and research work with various manufacturing organizations.

**Mohd Rizal bin Salleh** is one of associate professor of Faculty of Manufacturing Engineering in Universiti Teknikal Malaysia Melaka (UTeM). He received his Diploma in Mechanical Engineering from Suzuka National College of Technology, Japan and Advance Diploma in Mechanical Engineering, Universiti Teknologi MARA, (UiTM). He then completed his Master Engineer in Mechanical Engineering from University of Tokushima, Japan and Doctoral course from Brunel University London, United Kingdom in System Engineering. Among of his interest are lean manufacturing, industrial engineering, metrology, manufacturing process, measurement uncertainly, and agile manufacturing.

**Adi Saptari** is previously had been serving Faculty of Manufacturing Engineering in Universiti Teknikal Malaysia Melaka (UTeM) as a lecturer and later migrated to serve for President University Campus, Bekasi, Indonesia under Faculty of Engineering. Prior to his involvement as an academician in UTeM, he was attached under Department of Manufacturing Management in the area of expertise such as optimization linear and non-linear programming, human factors (ergonomics) and technology management. He received his Bachelor's degree from Teknologi Bandung Institute, Jakarta, Indonesia and Master's degree from Ohio University, United States. He then completed his Doctoral course from Case Western Reserve University, United States. Among of his teaching interest are introduction to industrial engineering, operations technology based innovation, management of innovation technology, lean manufacturing, research methodology, facilities design and engineering statistics.