CHAPTER 6

CONCLUSION & RECOMMENDATION

6.1 Conclusion

The objective of this study is to develop the mathematical model that helps the company to balance its assembly line, in order to achieve the productivity and flexibility. The productivity is needed for the company to produce with the capacity utilization. The productivity is occurred when the optimal solution from the model is obtained. The flexibility is also needed when the changing occurred. Moreover, it will be beneficial to the company if it can spend less time as possible to balance the line in order to launch the new product model to the market to compete with the competitors especially in the high competitive market like hard disk industry.

After studying the existing system of the company, the idea of the balancing line is generated and the mathematical model is developed as following:

Objective function: Max **Final Output** $(\mathbf{d_n})$

S.T.

$$\mathbf{d_{i+1} \leq d_i} \qquad\qquad i = 1,2,\ldots\ldots\ldots\ldots,n\text{-}1$$

$$\mathbf{d_i} = \left(\frac{\mathbf{T_i}}{\mathbf{a_i + b_i}}\right) \times \left(\frac{\mathbf{\%Yield \times \%Efficiency}}{\mathbf{\%Sampling}}\right)_i \times \mathbf{m_i}$$

$$\mathbf{m_i} \leq \left(\frac{\mathbf{a_i + b_i}}{\mathbf{a_i}}\right) \times \mathbf{x_i}$$

$$\mathbf{s_i \geq s_i^o \times x_i}$$

$$\mathbf{s_i \geq s_i^m \times m_i}$$

$$\sum_{i=1}^{n} \mathbf{s_i} \leq 54$$

$0 \leq \mathbf{x_i} \leq$ number of operators available at operation i

$\sum_{i=1}^{n} x_i \leq$ Total operators available

$0 \leq m_i \leq$ number of tooling available at each operation

Where the list of variables are as following:

i ≡ number of operations ($i = 1, \ldots\ldots\ldots, n$)

- **Decision variables**

  x_i ≡ number of operators at operation i

  m_i ≡ number of tooling at operation i

- **Independent variables**

  a_i ≡ cycle time per operator at operation i

  b_i ≡ cycle time per tooling at operation i

  T_i ≡ total operating time at operation i

  s_i^o ≡ space factor of each operator at operation i

  s_i^m ≡ space factor of each tooling at operation i

- **Dependent variables**

  d_i ≡ output at operation i

  s_i ≡ space factor at operation i

After testing this proposed model, the data shows that the model can be used. The model can be used for balancing line that it shows the numbers of operators and tooling needed in each operation. The model can be used to predict productivity that it shows the numbers of output that can be produced in one line. With the constraints of space, numbers of operator and numbers of tooling, the model can compute for the optimal result that is the maximum final output. Besides, the model can gate for the bottleneck operation, which is the operation that produces the least numbers of output in the line.

However, when applying the real data into the proposed model, it can not conclude for better results than the existing method of the company. It is because this two method based on different objectives. The proposed model uses the objective of maximum output with the restriction of operators, tooling and space; while, the existing spreadsheet tries to use the minimum number of operators to produce the demanded output.

However, it can be seen that the proposed model has more applications. For example, the model can add more constraints to match the necessity situation. The constraints such as budget constraint may be added on.

$$\sum_{i=1}^{n} \$_i m_i \leq \text{Budget available} \qquad (\$_i = \text{cost for buy new tooling})$$

This constraint is considered when there is the case of new tooling required for setting up new product model line

Other constraints such as queueing equation, work in process (WIP) equation may be suitable to add on in the proposed model. Here is the example of equation for WIP:

$$WIP = \text{total output}_i - \text{total input}_{i+1} \qquad i = 1,2,\ldots\ldots\ldots\ldots,n-1$$

In conclusion, the proposed model can compute the same results as the existing method, however, it is more flexible to add on other constraints which make the model has more advance capability than the existing one.

6.2 Recommendation for Improvement

Based upon works covered under this study, the following recommendation for improvement is made:

- From the constraint number 2 in the proposed model: the relationship of the output with the operator and tooling, there are 3 cases in this function. It is suitable if there is no case occurred or every case can be written in one equation.

6.3 Recommendation for Further Study

Based upon works covered under this study, the following recommendations for further study are made:

- In the case of cycle time of tooling is more than the cycle time of operator, it should be beneficial to allow an operator to operate with more than one tooling. However, in present, the cycle time of tooling is not measured. Therefore, the recommendation for further study for the company is to measure the cycle time of tooling and use this cycle time to calculate for more optimal results in the proposed model.

- The LINDO program can solve the problem but it is too simple for the complicate equation such as

$$\mathbf{d}_{i+1} \leq \mathbf{d}_i \qquad i = 1,2,\ldots\ldots\ldots\ldots,n-1$$

The model needed to write likes:

d2 < d1

d3 < d2

d4 < d3

d5 < d4

:

:

d $_{n+1}$ < d n

Therefore, the recommendation for further study is to use the more powerful program that can solve such equation with in the least effort and time.

- Sensitivity Analysis

Actually, the mathematical optimal results do not suffice because the constant parameters from which they are derived. For example, the cycle time of each operator in the proposed model are almost never known with certainty at the time the model is solved. Maybe the change of one input variable controls everything. Maybe it could change dramatically with no impact to the results. The sensitivity analysis can indicate these things. It studies how results would vary with changes in parameter values, while the optimal solution simply provide a best choice of decision variables for one fixing of the inputs. Therefore, the recommendation for further study is to use sensitivity analysis to complete the whole picture of the company HGA assembly line.