CHAPTER 5 CONCLUSION AND DISCUSSION

5.1 Conclusion

The VP EWMA control chart policy has shown to give substantially faster detection of most process shifts than the conventional control charts. In the dissertation, two topics have been considered. The first topic is considered the VP EWMA control chart, VP MEWMA control chart and VPSC EWMA chart. It is assumed that the amount of time the process remains in control has exponential distribution. The second topic considered is to develop the economic design of VP EWMA control chart, VP MEWMA control chart and VPSC MEWMA control chart to determine the values of the six test parameter of the chart by using genetic algorithm and sensitivity analysis such that the expected total cost , the hourly loss are minimized. The cost model of VP EWMA control chart is established by combining the cost function in Lorenzen and Vance (1986). The cost model of VP MEWMA control chart and VPSC MEWMA control chart are established by the cost function of Costa (2001), based on the Markov chain approach. An illustrative example is provided and the genetic algorithm (GA) is employed to search for the solution of the economic design. A sensitivity analysis is then carried out to study the effects of model parameters on the solution of the economic design. Based on the sensitivity analysis, the following results are observed for the illustrative example.

5.1.1 VP EWMA Control Chart

Before studying quality of VP MEWMA control chart and economic design of VP MEWMA control chart, we will considered VP EWMA control chart for only the value of the input variables are $G = t_4 = t_5 = \frac{5}{60}$ hours; $t_0 = \frac{45}{60}$ hours; $\frac{1}{\lambda} = 50$; $c_1 = 114.24$ \$/hour; $c_2 = 949.2$ \$/hour; $c_3 = c_4 = \$114.24$; $a = 0$; $b = \$4.22$; $\gamma_1 = 1,\ \gamma_2 = 0$. The economic performance of VP EWMA control chart in order to accomplish the optimization of the unit cost function, the following constraints were considered: $n_1 \le n_2$; $n_1 \ge 1$; $n_2 \ge 5$; $0.1 \le h_2 \le h_1$; $h_1 \ge 1$; $w_2 \le w_1$; $k_2 \le k_1$; k_1 and $k_2 \ge 1$. A nonlinear constrained optimization algorithm was applied to the cost function. We considered several shifts of the mean; $\delta = 0.5(0.5)2$, and $r = 0.05(0.05)0.95$.

The economic performance of VP EWMA control chart shown in the following: Table 4.1, the minimum value of $ECTU$ is 131.0285, where $r = 0.35,\ \delta = 3,\ n_1 = 2,\ n_2 = 5,$ $h_1 = 1,\ h_2 = 0.1,\ w_1 = 2.08,\ w_2 = 2.01,\ k_1 = 3.5,\ k_2 = 2.39$; average run length $ARL_0^1(k_1 = 3.4)$ is 9.35; Table 4.2, the minimum value of $ECTU$ is 136.4235, where $r = 0.5,\ \delta = 3,\ n_1 = 2,\ n_2 = 5,\ h_1 = 1,\ h_2 = 0.1,\ w_1 = 2.08,\ w_2 = 2.01,\ k_1 = 3.5,$ $k_2 = 2.39$; average run length $ARL_0^1(k_1 = 3.43)$ is 28.86. Table 4.3, the minimum value of $ECTU$ is 136.4047, where $r = 0.75,\ \delta = 3,\ n_1 = 2,\ n_2 = 5,\ h_1 = 1,\ h_2 = 0.1$ $w_1 = 2.08,\ w_2 = 2.01,\ k_1 = 3.5,\ k_2 = 2.39$; average run length $ARL_0^1(k_1 = 3.5)$ is 149.11.

5.1.2 VP MEWMA Control Chart

1. As the value of cost for inspected item (s) increases, the small sample size (n_1) leads to decrease.

2. As the value of process is operating in control state (V_0) increases, the small sample size (n_1) also increases.

3. As the value of the time to identify and correct the assignable cause (t_1) increases, the small sample size (n_1) also increases.

4. As the value of cost for inspected item (s) increases, the large sample size (n_2) lead to decrease.

5. As the value of process is operating in control state (V_0) increases, the large sampling size (n_2) also increases.

6. As the value of magnitude of the process shift (d) increases, the large sample size (n_2) also increases.

7. As the value of the time to identify and correct the assignable cause (t_1) increases, the large sample size (n_2) also increases.

8. As the value of time to identify and correct the assignable cause (t_1) increases, the hourly loss $(E(L))$ also increases.

5.1.3 VPSC MEWMA Control Chart

1. As the value of exponential distribution (λ) increases, the long sampling interval (h_1) leads to decrease.

2. As the value of magnitude of the process shift (d) increases, the long sampling interval (h_1) also increases.

3. As the value of small sampling size (n_1) increases, the long sampling interval (h_1) also increases.

4. As the value of quality characteristic (p) increases, the long sampling interval (h_1) also increases.

5. As the value of average amount of time exhausted searching for the assignable cause when the process is in-control (t_0) increases, the long sampling interval (h_1) also increases.

6. As the value of exponential distribution (λ) increases the short sampling interval (h_2) leads to reduce.

7. As the value of small sampling size (n_1) increases, the short sampling interval (h_2) also increases.

8. As the value of magnitude of the process shift (d) increases, the short sampling interval (h_2) also increases.

9. As the value of quality characteristic (p) increases, the short sampling interval (h_2) also increases.

10. As the value of magnitude of the process shift (d) increases, the hourly loss $(E(L))$ leads to decrease.

11. As the value of the hourly profit earned when the process is operating in control state (V_0) increases, the hourly loss $(E(L))$ also increases.

5.2 Discussion

For this research, we aimed to search for the appropriated parameter for minimizing hourly loss of VP MEWMA control chart and VPSC MEWMA control chart and to find $ECTU$ of VP EWMA control chart. These control charts are suitable for detection of small changes. In some factories, with small changes it can lead to incredible damage. On the other hand, the $\overline{X}$ control chart is suited for use in the factories that produce non-restricted goods and by using this control chart in such a factory it would help to reduce the unnecessary cost. Conclusively, these three control charts are suitable to be used in different types of factories and products. Therefore, selection of appropriated parameter and control chart is recommended in order to reduce the unnecessary cost.

We are able to determine the appropriated values of parameter and $ECTU$ of VP EWMA control chart. For VP EWMA control chart, the minimum value of $ECTU$ is 131.0285,where $r = 0.35,\ \delta = 3,\ n_1 = 2,\ n_2 = 5,\ h_1 = 1,\ h_2 = 0.1,\ w_1 = 2.08,\ k_2 = 2.01$; average run length ARL_0^1 $(k_1 = 3.5)$ is 9.35.

We found that the minimum loss of VP MEWMA control chart $(E(L))$ is 0.018 where value of independent variables are: $r = 0.1,\ d = 2,\ s = 10,\ C_0 = 250, C_1 = 50,\ V_0 = 500,$ $V_1 = 100,\ t_0 = 5,\ t_1 = 10,\ \lambda = 0.01$ and $p = 2$; value of dependent variables are $n_1 = 27,$ $n_2 = 33,\ h_1 = 2$ and $h_2 = 1$.

We found that the minimum loss of VPSC MEWMA control chart $(E(L))$ is 53.748 where values of independent variables are: $n_1 = 5,\ s = 5,\ C_0 = 250,\ C_1 = 500,\ V_0 = 250,$ $V_1 = 100,\ t_0 = 5,\ t_1 = 1,\ \lambda = 0.01$ and $p = 3$; values of dependent variables are $n_2 = 6,\ h_1 = 46.317$ and $h_2 = 46$.

5.3 Suggestion

By studying Genetic algorithm in this research, we obtained the optimal variable and minimum hourly loss. Our suggestion is as follow:

1. *The short sampling interval and long sampling interval did not depend on* any parameter model, so the future work for the economic design for variable parameter of MEWMA control chart with variable parameters by fixed sampling interval, should be studied.

2. The sample size of my study varies for the most minimizing hourly loss, but we can reduce the sample size as small as possible but we cannot increase because the hourly loss will be less than zero.

5.4 Future Work

Genetic algorithm is one of optimization techniques, but in future work we will use other optimization techniques to optimal the integrated model by MEWMA control chart with variable parameters which in-control, has other distribution such as, Weibull distribution or other control chart.