CHAPTER 6
CONCLUSION

6.1. Conclusion

From the research that is done in PT. Purinusa Ekapersada to get interval of preventive maintenance based on cost minimization, the conclusion are:

1. Optimum interval preventive maintenance for hotplate part is 24 hour with Rp 196 and reduce cost 76.2 %
2. Optimum interval preventive maintenance for mechanical repair is 23 hour with Rp 45 and reduce cost 92.4%

6.2. Suggestion

1. Corrective maintenance change into preventive maintenance to reduce cost.
2. Detail for down machine record must be increased, for daily data convert into hour data.

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Attachment 1 Detail of Maple Software for Hotplate Weibull Distribution

```
ctp:=evalf((1422988/(24*60)*0.19));        } Cost of Preventive Maintenace
     ctp := 10870.04722
ck:=44946+ctp                              } Cost of Corrective Maintenace
     ;ck := 55816.04722
mean:=54.7;                                } Mean
     mean := 54.7
be:=19;                                    } Beta
     be := 19
al:=0.542;                                 } Alpha
     al := .542
fung:=(al*(be^(-al))*((t-23.8)^(al-1))*
     (exp(-((t-23.8)/be)^al)));            } Cumulative Distribution Function
     fung := .1098790345/(t-23.8)^.458*
          exp(-(1/19*t-1.252631579)^.542)
Rt:=(int(fung,t=tp..infinity));            } Reliability
     Rt := int(.1098790345/(t-23.8)^.458*exp(-(1/19*t-
1.252631579)^.542),t = tp .. infinity)
ft:=(1-Rt);          Probability Distribution Function
     ft := 1-int(.1098790345/(t-23.8)^.458*exp(-
(1/19*t-1.252631579)^.542),t = tp .. infinity)
cost:=((ctp*Rt)+(ck*ft));                  } Total Cost
     cost := -44946.00000*int(.1098790345/(t-
23.8)^.458*exp(-(1/19*t-1.252631579)^.542),t = tp ..
infinity)+55816.04722
cycle1:=((tp)*Rt);
     cycle1 := tp*int(.1098790345/(t-23.8)^.458*exp(-
(1/19*t-1.252631579)^.542),t = tp .. infinity)
et:=(int((t-23.8)*(fung),t=23.8..tp));
```

```
     et := int(.1098790345*(t-23.8)^.542*exp(-(1/19*t-
1.252631579)^.542),t = 23.8 .. tp)
cycle2:=((et)*(ft));
     cycle2 := int(.1098790345*(t-23.8)^.542*exp(-
(1/19*t-1.252631579)^.542),t = 23.8 .. tp)*(1-
int(.1098790345/(t-23.8)^.458*exp(-(1/19*t-
1.252631579)^.542),t = tp .. infinity))
cycle:=(cycle1+cycle2)+23+0.19;
     cycle := tp*int(.1098790345/(t-23.8)^.458*exp(-
(1/19*t-1.252631579)^.542),t = tp ..
infinity)+int(.1098790345*(t-23.8)^.542*exp(-(1/19*t-
1.252631579)^.542),t = 23.8 .. tp)*(1-
int(.1098790345/(t-23.8)^.458*exp(-(1/19*t-
1.252631579)^.542),t = tp .. infinity))
Cpu:=(cost/cycle);
     Cpu := (-44946.00000*int(.1098790345/(t-
23.8)^.458*exp(-(1/19*t-1.252631579)^.542),t = tp ..
infinity)+55816.04722)/(tp*int(.1098790345/(t-
23.8)^.458*exp(-(1/19*t-1.252631579)^.542),t = tp ..
infinity)+int(.1098790345*(t-23.8)^.542*exp(-(1/19*t-
1.252631579)^.542),t = 23.8 .. tp)*(1-
int(.1098790345/(t-23.8)^.458*exp(-(1/19*t-
1.252631579)^.542),t = tp .. infinity)))
dCpu:=diff(Cpu,tp);
     dCpu := 4938.623085/(tp-23.8)^.458*exp(-(1/19*tp-
1.252631579)^.542)/(tp*int(.1098790345/(t-
23.8)^.458*exp(-(1/19*t-1.252631579)^.542),t = tp ..
infinity)+int(.1098790345*(t-23.8)^.542*exp(-(1/19*t-
1.252631579)^.542),t = 23.8 .. tp)*(1-
int(.1098790345/(t-23.8)^.458*exp(-(1/19*t-
1.252631579)^.542),t = tp .. infinity)))-(-
```

Cycle Time

```
44946.00000*int(.1098790345/(t-23.8)^.458*exp(-(1/19*t-
1.252631579)^.542),t = tp ..
infinity)+55816.04722)/(tp*int(.1098790345/(t-
23.8)^.458*exp(-(1/19*t-1.252631579)^.542),t = tp ..
infinity)+int(.1098790345*(t-23.8)^.542*exp(-(1/19*t-
1.252631579)^.542),t = 23.8 .. tp)*(1-
int(.1098790345/(t-23.8)^.458*exp(-(1/19*t-
1.252631579)^.542),t = tp ..
infinity)))^2*(int(.1098790345/(t-23.8)^.458*exp(-
(1/19*t-1.252631579)^.542),t = tp .. infinity)-
.1098790345*tp/(tp-23.8)^.458*exp(-(1/19*tp-
1.252631579)^.542)+.1098790345*(tp-23.8)^.542*exp(-
(1/19*tp-1.252631579)^.542)*(1-int(.1098790345/(t-
23.8)^.458*exp(-(1/19*t-1.252631579)^.542),t = tp ..
infinity))+.1098790345*int(.1098790345*(t-
23.8)^.542*exp(-(1/19*t-1.252631579)^.542),t = 23.8 ..
tp)/(tp-23.8)^.458*exp(-(1/19*tp-1.252631579)^.542))
solve (dCpu=0,tp);
    Error, (in solve) cannot solve expressions with,
int(219758069/2000000000/(t-119/5)^(229/500)*exp(-
(1/19*t-1252631579/1000000000)^(271/500)),t = tp ..
infinity), for, tp
```

Attachment 2 Detail of Maple Software for Hotplate Weibull Distribution with Numeric Method

```
ctp:=evalf((1422988/(24*60)*0.19));
     ctp := 10870.04722
ck:=44946+ctp                          } Cost of Corrective
     ;ck := 55816.04722                } Maintenace
mean:=54.7;                            } Mean
     mean := 54.7                      }
be:=19;                                } Beta
     be := 19                          }
al:=0.542;                             } Alpha
     al := .542                        }
fung:=(al*(be^(-al))*((t-23.8)^(al-1))*
     (exp(-((t-23.8)/be)^al)));        } Cumulative
     fung := .1098790345/(t-23.8)^.458* } Distribution
          exp(-(1/19*t-1.252631579)^.542) } Function

for tp from 24 by 1 to 264 do tcoba:=tp;} Numeric method
Rt:=evalf(int(fung,t=tp..infinity));  } Reliability
ft:=evalf(1-Rt);   } Probability Distribution Function
cost:=evalf((ctp*Rt)+(ck*ft));  } Total Cost
cycle1:=evalf((tp)*Rt);
et:=evalf(int((t-23.8)*(fung),t=23.8..tp));
cycle2:=evalf((et)*(ft));
cycle:=evalf(cycle1+cycle2)+23+0.19; } Cycle Time
Cpu:=evalf(cost/cycle);
od;
```

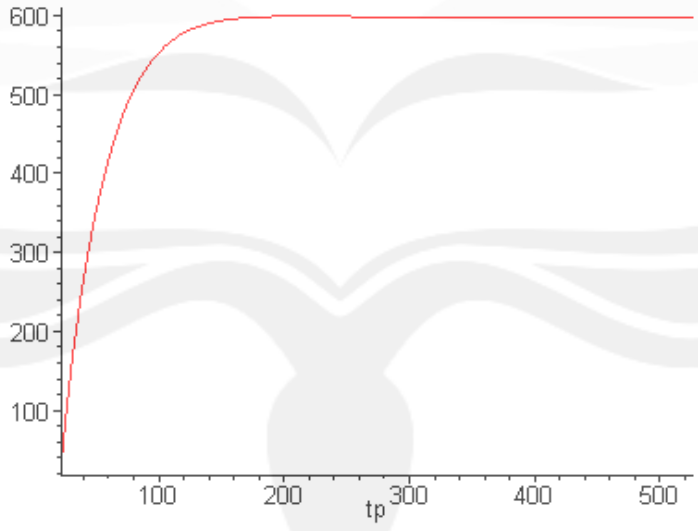
Attachment 3 Detail of Maple Software for Hotplate Lognormal Distribution with Numeric Method

```
ctp:=evalf(1422988/(24*60)*0.19);
     ctp := 187.7553611
ck:=(44946+ctp);
     ck := 45133.75536
mean1:=59.6;
     mean1 := 59.6
sd1:=530;
     sd1 := 530
mean:=ln((mean1^2)/(sqrt((sd1^2)+(mean1^2))));
     mean := 1.896150966
sd:=sqrt(ln(((sd1^2)+(mean1^2))/(mean1^2)));
     sd := 2.093563760
fung:=(1/(sd*(t-23)*sqrt(2*3.14)))*exp(-(ln(t-23)-
mean)^2/(2*(sd^2)));
     fung := .1906048671/(t-23)*exp(-.1140768763*(ln(t-
     23)-1.896150966)^2)
for tp from 24 by 1 to 264 do
tcoba:=tp;
rt:=int(fung,t=tp..infinity);
ft:=1-rt;
cost:=(ctp*rt)+(ck*ft);
cycle1:=(tp)*rt;
et:=evalf(int((t-23)*(fung),t=23..tp));
cycle2:=(et)*(ft);
cycle:=cycle1+cycle2+23+0.19;
mincost:=(cost/cycle);
od;
```

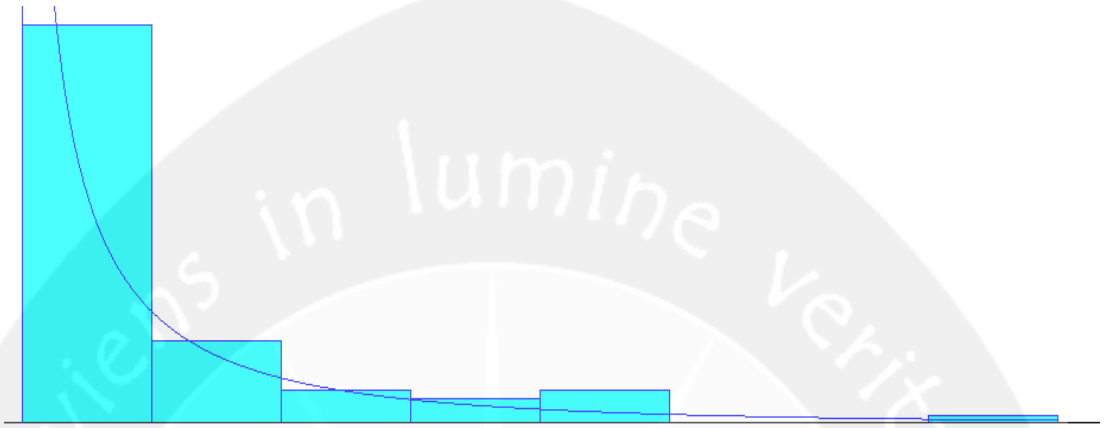
Attachment 4 Detail of Maple Software for Mechancal Repair Exponential Distribution

```
ctp:=evalf(1422988/(24*60)*1.2617);
     ctp := 1246.794416
ck:=(44946+ctp);                    } Cost of Corrective
     ck := 46192.79442              } Maintenace
mean:=55.3;                         } Mean
     mean := 55.3                   }
fung:=1/mean*exp(-(t-22)/mean);
     fung:=.1808318264e-1*exp(-.1808318264e-
1*t+.3978300181)                    Reliability
Rt:=int(fung,t=tp..infinity); }
     Rt := exp(-.1808318264e-1*tp+.3978300181)
ft:=1-Rt;} Probability Distribution Function
     ft := 1-exp(-.1808318264e-1*tp+.3978300181)
cost:=(ctp*Rt)+(ck*ft); } Probability Distribution Function
     cost:=-44946.00000*exp(-.1808318264e-
1*tp+.3978300181)+46192.79442
cycle1:=(tp)*Rt;
     cycle1:=tp*exp(-.1808318264e-1*tp+.3978300181)
et:=evalf(int((t-22)*(fung),t=22..tp));
     et:=-1.*tp*exp(-.1808318264e-1*tp+.3978300181)-
     33.30000000*exp(-.1808318264e-
     1*tp+.3978300181)+55.30000000
cycle2:=(et)*(ft);
     cycle2:=(-1.*tp*exp(-.1808318264e-
1*tp+.3978300181)-33.30000000*exp(-.1808318264e-
1*tp+.3978300181)+55.30000000)
*(1-exp(-.1808318264e-1*tp+.3978300181))
cycle:=cycle1+cycle2+22+1.2617;
```

```
     cycle:=tp*exp(-.1808318264e-1*tp+.3978300181)+
(-1.*tp*exp(-.1808318264e-1*tp+.3978300181)-
33.30000000*exp(-.1808318264e-
1*tp+.3978300181)+55.30000000)*
(1-exp(-.1808318264e-1*tp+.3978300181))+22
Cpu:=evalf(cost/cycle);
     Cpu:=(-44946.00000*exp(-.1808318264e-
1*tp+.3978300181)+46192.79442)/(tp*exp
(-.1808318264e-1*tp+.3978300181)+(-1.*tp*exp
(-.1808318264e-1*tp+.3978300181)-33.30000000*
exp(-.1808318264e-1*tp+.3978300181)+55.30000000)*(1.-
1.*exp(-.1808318264e-1*tp+.3978300181))+22.)
solve(dCpu=0,tp);
     -2.266313005+34.01789361*I
plot(Cpu,tp=22..527);
```



Attachment 5 Distribution Summaries for Hotplate part with *Arena Input Analyzer*



Distribution Summary of Weibull Distribution

Distribution: Weibull
Expression: 23 + WEIB(19, 0.542)
Square Error: 0.003651

Data Summary

Number of Data Points	= 70
Min Data Value	= 23.8
Max Data Value	= 264
Sample Mean	= 54.7
Sample Std Dev	= 45.2

Distribution Summary of Lognormal Distribution

Distribution: Lognormal

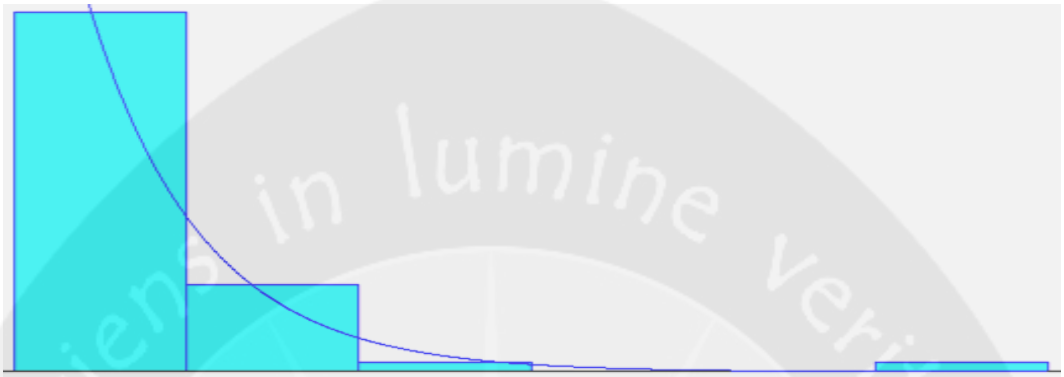
Expression: 23 + LOGN(59.6, 530)

Square Error: 0.007722

Data Summary

Number of Data Points	= 70
Min Data Value	= 23.8
Max Data Value	= 264
Sample Mean	= 54.7
Sample Std Dev	= 45.2

Attachment 6 Distribution Summary for Mechanical Part with *Arena Input Analyzer*



Distribution: Exponential

Expression: 22 + EXPO(55.3)

Square Error: 0.001160

Data Summary

Number of Data Points	= 48
Min Data Value	= 22.8
Max Data Value	= 527
Sample Mean	= 77.3
Sample Std Dev	= 84

Attachment 7 Corrugator Machine