PREVENTIVE MAINTENANCE SCHEDULING BASED ON SERVICE CENTER AND CUSTOMER'S PERSPECTIVE (CASE STUDY: CAR TYPE X OF COMPANY Y)

Yudha Prasetyawan[1], Mita Musoffa Asti [2]

Industrial Engineering, Faculty of Industrial Technology, Institut Teknologi Sepuluh Nopember (ITS) JL. Arief Rahman Hakim, Surabaya 60111
yudhaprase@yahoo.com , mitamusoffa@gmail.com

ABSTRACT

There is a difference between service centre and customer's perspective related to service cost. Based on service centre point of view, it is important to have effective cost from regular service activities. Therefore, they are including component replacement when regular service executed, regardless its reliability. On the contrary, customer wants a minimum maintenance cost by reducing the number of component replacement. The purpose of this research are to create the preventive maintenance schedule for component replacement, to calculate the total service cost based on customer and service centre's perspective until the period 100.000 km, and to make sensitivity analysis between reliability and total service cost. The maintenance scheduling begins with determining shape and scale parameter of the component, calculating reliability of the components, and creating algorithm for component replacement. In terms of total service cost, from customer perspective is more expensive at 472,430 rupiahs compared to the estimated total costs from service centre. To get the minimum total service cost, the component replacement scenarios are proposed. The scenarios are made by delaying and moving the replacement period forward. The result of sensitivity analysis between reliability and total service cost gives the information that reliability is directly proportional with total service cost. The higher component reliability, which is executed by moving the replacement period forward, will give the higher total service cost. On the contrary, the lower reliability will result in lower service cost.

***Keywords**: Preventive Maintenance, Algorithm for Component's Replacement, Sensitivity Analysis.*

1. INTRODUCTION

1.1. Background and Pupose

Automotive industries have been extremely growing recenty, especially for car. In indonesia, the sales of the car has increased 26,91% from 2011 to 2012 with the total sales of 1.116.000 units (Kompas, 2012). The highest sale was Car Type X of Company Y, which was 406.026 units and it was about 36% from the total sales in Indonesia 2012.

Mostly, the highest demand of car of Company Y is Car type X. According to Gabungan Industri Kendaraan Bermotor Indonesia (Gaikindo) 2012, the total sales of car type X was 192.146 units and it was 17,2% of total sales of car in Indonesia and successfully got the first place for Multi Purpose Vehicle (MVP) segment. In average, the total sale of car type X is 15.000 units per month (Amri, 2013). Based on this increasing sale of car in Indonesia, the after sales services of car are increasing as well.

Juehlin, et.al (2010) classified service in automotive industries into 3 categories: pre sales, sales, and after sales. The after sales services play the important role in the situation where the sale of cars is increasing. Based on Gaiardelli, et.al (2007) after sales market is four or five times larger than the sales product market.

Service Center Z is a service center that also provides the sale, maintenance, repair service and spare parts provider. Service Center Z is the main dealer of Company Y that dominates 70-80 % sales. There are 145 branches of sales of Service Center Z (SC Z) in Indonesia (Auto2000, 2013).

Nowadays, service is not considered as the "black box", yet a part of business activities design (Wu, 2011). Service center has the information of service cost such as replacement cost and service cost and also the parameter of replacement. According to Wu (2011), level of preventive maintenance is only known by the service centre. Customers only knows the amount of the service cost they have to pay. Based on this situation, there is knowledge gap between service centre and customer.

Generally, the outcome expected by the service center and customer is the car can operate well and perform its function as expected. Service activity is proportional to the service cost. In service center perspective, the service centers always recommend the components replacement, although the components are still reliable. In the customer perspective, the replacement of the components that are still reliable will cause the disadvantages. Customer expects the minimum maintenance cost and optimum lifespan of component. Most of customers choose this way because of the limited budget of customers.

With this knowledge gap between service centre and customer, it is possible to conduct the research about preventive maintenance scheduling based on the service centre and customer perspective. This research is conducted in one of the service centre of Company Y; it is in service centre Z Jemursari. SC Z in Jemursari has successfully sold 75 units car type X in average per month.

Patton J. (1980) in his research said that the after sales services is one of the product support services that aims to help and control the function of the product whether the product can perform its function or not in certain period of time. Some of after service services provided by SC Z are Home Service, work in service including booking and non-booking, and express maintenance. In average the UE per month of SC Z Jemursari in 2012 for work in service is 1332 dan for home service is 282 where 50 – 60% from the total UE per month, the service for car type X is about 600 – 800 units. Compared to unit sales of car type X, Unit Entry service of car type X is nine times larger than its unit sales.

To compose the maintenance schedule for car, the first step is identifying the components of the car that can be seen from its block diagram. The block diagram of the car is used to identify the configuration of the component or its network, whether parallel or series network.

Generally, car type X comprises two functions; they are engine and chassis or body. These two functions, engine and chassis body is configured with the series network. The engine and the chassis body are dependent; when the engine is broken, then the chassis body cannot be operated. The engine will not work as well if the body or chassis is broken. System Reliability of car type X is also configured in series network, between chassis and the engine.

Engine has function as motor and consists of ignition system, combustion system and emission control, and cooling system and filing system. The structure of the engine is shown in the figure below:

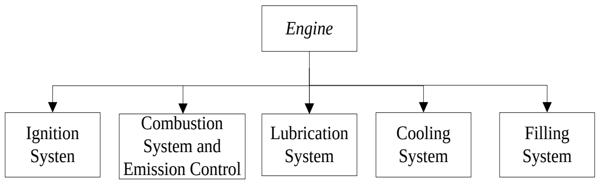

Figure 1. *Engine* Structure and Its Components

Chassis & body has a function to give a shape of the car that consists of the motion system, brake system, lighting system, and others. Sstructure of the and its components is shown in the figure below:

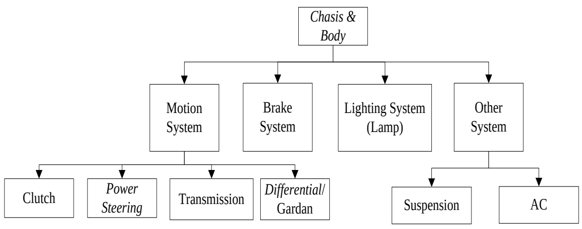

Figure 2. *Chasis & Body* Structure and Its Components

From each component of engine and chasis & body system shown in Figure 1 and 2, the complete components configuration can be identified. Below is the block diagram of the car type X, which is shown in the figure 3 and 4.

Service activity now is not the business service center only, but it is also the business of customer to decide the whether a certain components should be replaced or not in that service activity. To get the information of the customer budget for service activities, the random respondents were taken and interviewed. The result is; customer is classified into two groups in case of service costing until 100.000 km period. The first group is the medium-to-high customer with the estimation total budget of 30 million rupiahs. Second group is the medium-to-low customer with the estimation total budget of 15 million rupiahs. This estimation total budget will be the comparison between real total service cost spent by the customer and estimated total service cost budgeted by the customer, wheter it is affordable or not.

2. RESEARCH METHOD

The research method in this research is composed from the seven phases, they are:

1. Identifying the Block Diagram
   This step is executed by identifying the configuration or the network whether series or parallel.
2. Reliability Calculation of the Component
   The reliability calculation is done to find the replacement parameter, so the period of replacement can be known. This reliability calculation is based on the weibull 2-parameter (etha and beta), which parameters can be obtained from the failure fitting distribution in Weibull ++6 software.
3. Design of Algorithm for Component's Replacement
   After calculating the reliability, the Algorithm for Component's Replacement is then developed.
4. Penentuan Jadwal Penggantian Komponen
   Based on the Algorithm for Component's Replacement, the maintenance scheduling is then composed based on the customer and service center perspective.
5. Total Service Cost Calculation
   Based on the component replacement schedule, the total service cost can be calculated.
6. Component Scenario Replacement
   To find the minimum total service cost (approximating the service center's cost estimation), then the component replacement scenario can be composed.
7. Sensitivity Analisys between Total Service Cost and Reliability
   The last phase of this research methodology is conducting the sensitivity analysis between the Total service cost and reliability.

3. RESEARCH ELABORATION

3.1. Reliability Calculation

In this reliability calculation, parameter of etha (η) and beta (β) of each component are required. This parameter can be found by fitting TTF into the failure fitting distribution process. There two TTF data; the first TTF is based on the hystorical failure data and another is the TTF based in the routine service schedule. The exact value of ethat and beta can be found by failure fitting distribution using software Weibull ++6. After the parameter of etha and beta are found, the reliability of the component can be calculated by using the formula of the weibull 2 parameter blow [9]:

$$R(t) = e^{-\left(\frac{t}{\eta}\right)^{\beta}} \quad (1)$$

Where:
e = 2.718281
t = period (km)
β = betha value
η = etha value

To identify when or in what period the component should be replaced, the threshold value should be stipulated. This threshold value is the limit of the reliability for replacement that has been stipulated by the manufacturer. The result of the reliability calculation based on the routine service is 0.367 and so thi value will be the threshold value for replacement. If the reliability of the component is under 0.367, the component should be replaced.

3.2. Design of Algorithm for Component's Replacement

The purpose of developing this algorithm is for choosing the optimum alternative of replacement schedule, where the total service cost spent by the customer is in the minimum cost. Developing tis algorithm refers to the scheduling algorithm developed by Yudha Prasetyawan (2011), Scheduling based in the reliability perspective. Fgure 5 describes the algorithm for component's replacement for car:

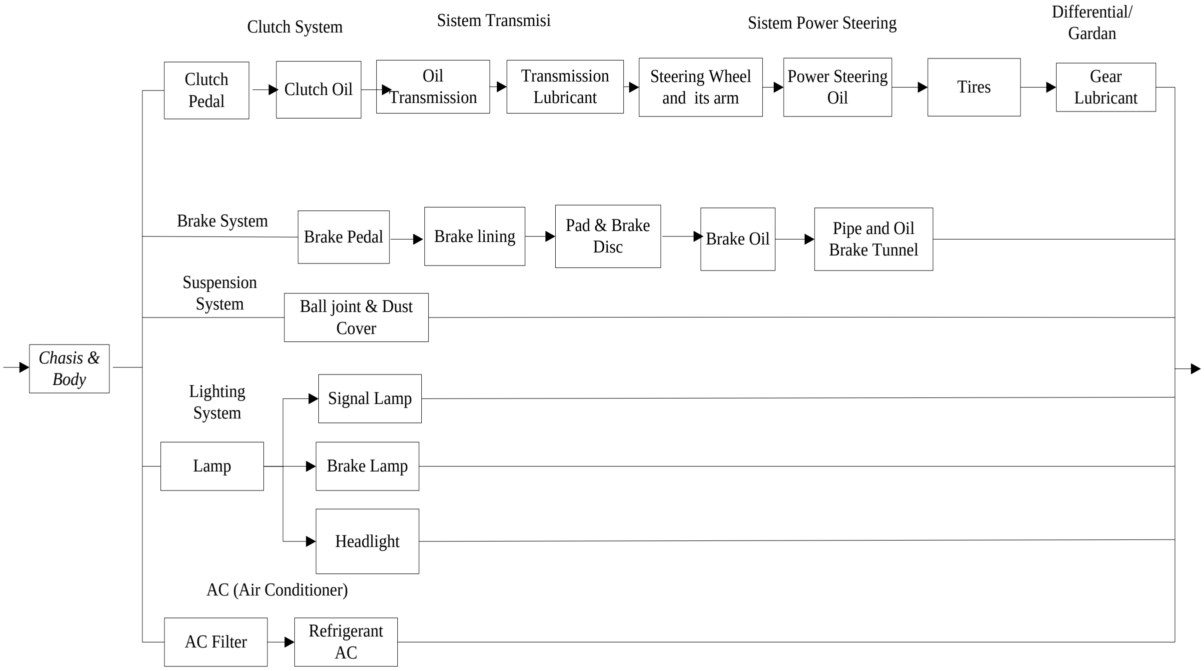

Figure 3. *Block Diagram* Function *Chassis & Body*

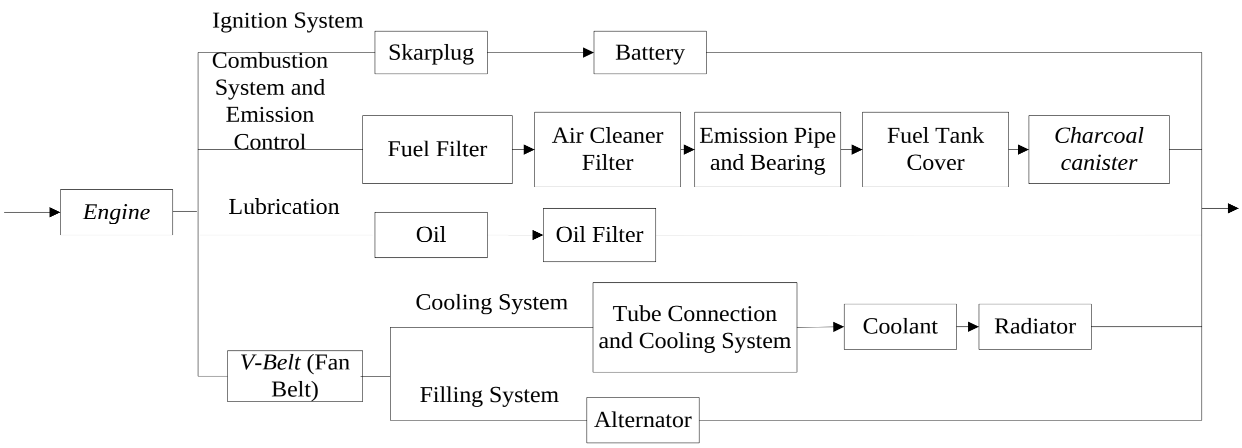

Figure 4. *Block Diagram* of *Engine*

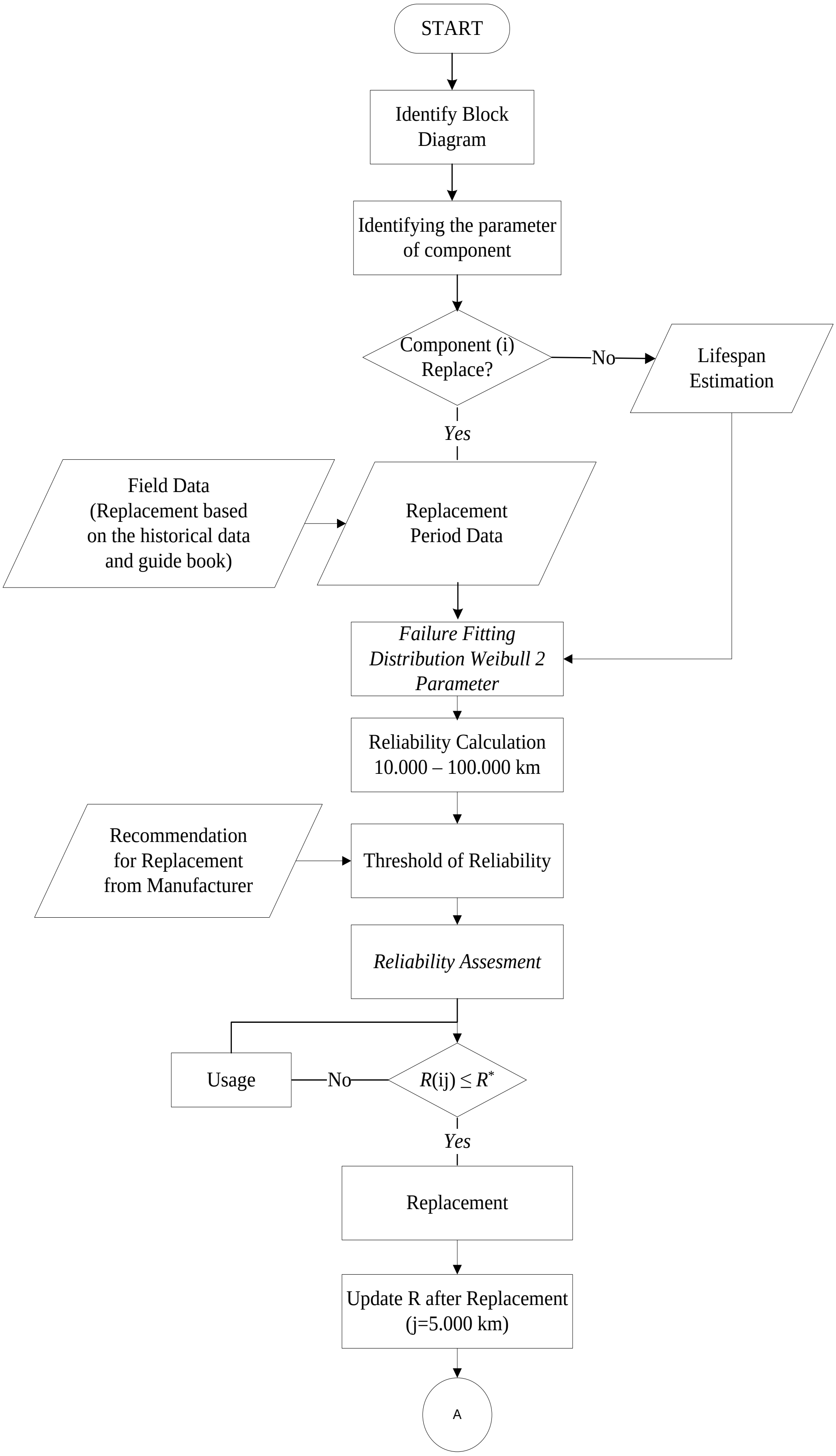

Figure 5. Algorithm for Component’s Replacement

ISSN : 1978-774X

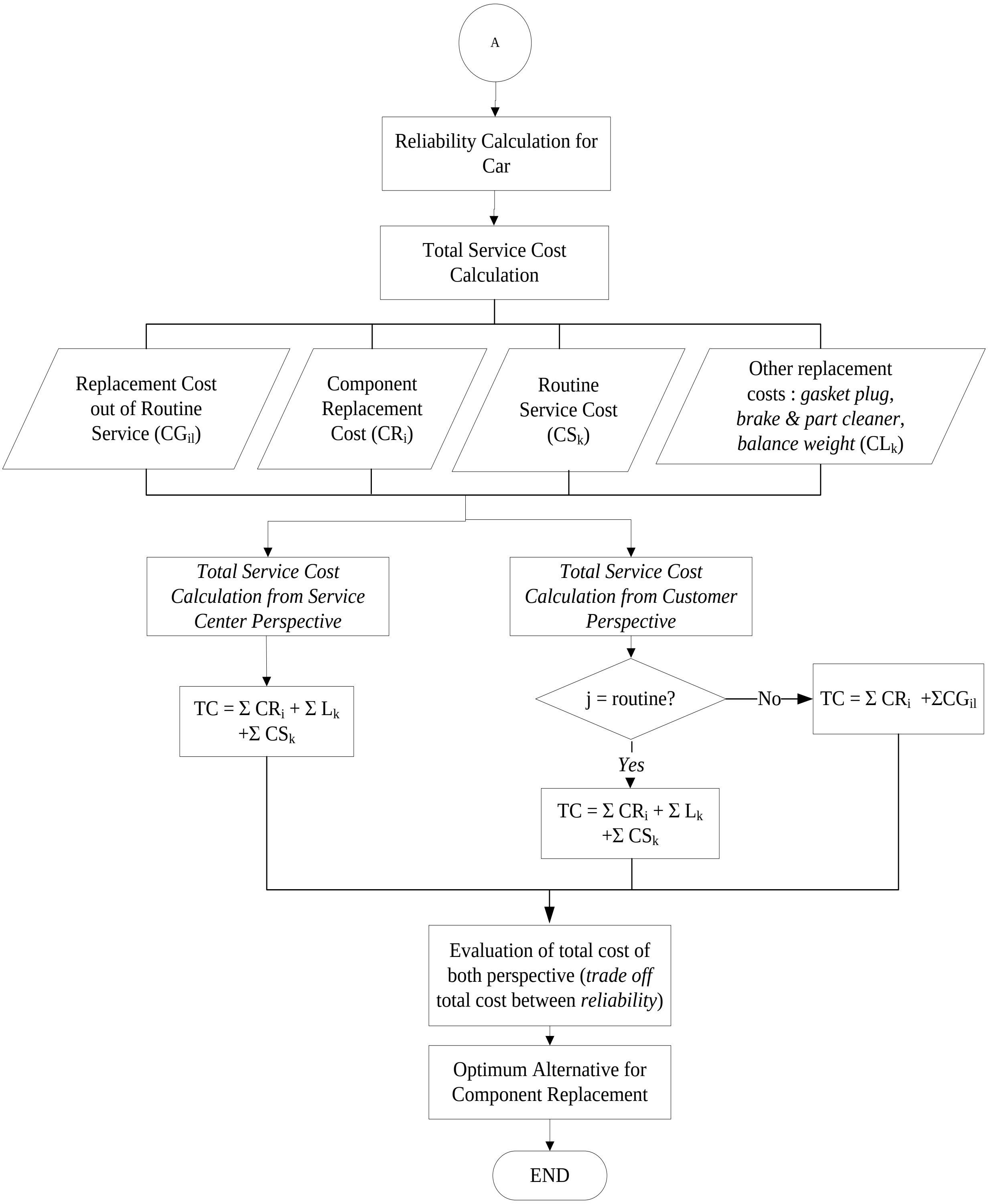

Figure 5. Algorithm for Component's Replacement (continuation)

3.3. Replacement Schedule

After reliability calculation of each component, the estimation of the replacement period can be made. The table 1 below shows the component replacememt schedule based on the service center perspective:

ISSN : 1978-774X

Table 1 Component Replacement Schedule based on the Service Center Perspective

No	Component	Condition (km)							
		1000	5000	10000	15000	20000	25000	30000	35000
1	Sparkplug	M	M	M	M	R	M	M	M
2	Battery	M	M	M	M	M	M	M	M
3	V Belt	M	M	M	M	M	M	M	M
4	Fuel Filter	M	M	M	M	M	M	M	M
5	Air Filter	M	M	M	M	M	M	M	M
6	Oil	M	M	R	M	R	M	R	M
7	Oil Filter	M	M	R	M	R	M	R	M
8	Clutch Lubricant	M	M	M	M	M	M	M	M
9	Brake Lining	M	M	M	M	M	M	M	M
10	Brake Pad	M	M	M	M	M	M	M	M
	Brake Pad (*matic*)	M	M	M	M	M	M	M	M
11	Brake Oil	M	M	M	M	M	M	M	M
12	Transmission Oil	M	M	M	M	M	M	M	M
13	Automatic Transmission Oil	M	M	M	M	M	M	M	M
14	Tire	M	M	M	M	M	M	M	M
15	*power steering oil*	M	M	M	M	M	M	M	M
16	Gardan	M	M	M	M	M	M	M	M
17	AC Filter	M	M	M	M	M	M	M	M

Tabel 1 Component Replacement Schedule based on the Service Center Perspective (Continuation 1)

No	Component	Condition (km)						
		40000	45000	50000	55000	60000	65000	70000
1	Sparkplug	R	M	M	M	R	M	M
2	Battery	M	M	R	M	M	M	M
3	V Belt	M	M	M	M	M	M	M
4	Fuel Filter	M	M	M	M	M	M	M
5	Air Filter	R	M	M	M	M	M	M
6	Oil	R	M	R	M	R	M	R
7	Oil Filter	R	M	R	M	R	M	R
8	Clutch Lubricant	R	M	M	M	M	M	M
9	Brake Lining	M	M	M	M	M	M	R
10	Brake Pad	M	M	M	M	M	M	M
	Brake Pad (*matic*)	M	M	R	M	M	M	M
11	Brake Oil	R	M		M	M	M	M
12	Transmission Oil	R	M	M	M	M	M	M
13	Automatic Transmission Oil	M	M	M	M	M	M	M
14	Tire		M	M	M	M	M	M
15	*power steering oil*	R	M	M	M	M	M	M
16	Gardan	R	M	M	M	M	M	M
17	AC Filter	M	M	M	M	R	M	M

Tabel 1 Component Replacement Schedule based on the Service Center Perspective (Continuation 2)

No	Component	Condition (km)						Replacement Frequency up to 100.000 km
		75000	80000	85000	90000	95000	100000	
1	Sparkplug	M	R	M	M	M	R	5
2	Battery	M	M	M	M	M	R	2
3	V Belt	M	M	M	M	M	R	1
4	Fuel Filter	M	R	M	M	M	M	1
5	Air Filter	M	R	M	M	M	M	2
6	Oil	M	R	M	R	M	R	10
7	Oil Filter	M	R	M	R	M	R	10
8	Clutch Lubricant	M	R	M	M	M	M	2
9	Brake Lining	M	M	M	M	M	M	1
10	Brake Pad	M	M	M	M	M	R	0
	Brake Pad (*matic*)	M	M	M	M	M	R	2
11	Brake Oil	M	R	M	M	M	M	2
12	Transmission Oil	M	R	M	M	M	M	2
13	Automatic Transmission Oil	M	R	M	M	M	M	1
14	Tire	M	M	M	M	M	R	1
15	*power steering oil*	M	R	M	M	M	M	2
16	Gardan	M	R	M	M	M	M	2
17	AC Filter	M	M	M	M	M	M	1
Estimation of Replacement up to 100.000 km								**47**

Note :

M = Maintain

R= Replace

The replacement scenario based on the customer perspective is:

Tabel 2 Component Replacement Schedule based on the Customer Perspective

No	Component	Condition (km)							
		1000	5000	10000	15000	20000	25000	30000	35000
1	Sparkplug	M	M	M	M	R	M	M	M
2	Battery	M	M	M	M	M	M	M	M
3	V Belt	M	M	M	M	M	M	M	M
4	Fuel Filter	M	M	M	M	M	M	M	M
5	Air Filter	M	M	M	M	M	M	M	M
6	Oil	M	M	R	M	R	M	R	M
7	Oil Filter	M	M	R	M	R	M	R	M
8	Clutch Lubricant	M	M	M	M	M	M	M	M
9	Brake Lining	M	M	M	M	M	M	M	M
10	Brake Pad	M	M	M	M	M	M	M	M
	Brake Pad (*matic*)	M	M	M	M	M	M	M	M
11	Brake Oil	M	M	M	M	M	M	M	M
12	Transmission Oil	M	M	M	M	M	M	M	M
13	Automatic Transmission Oil	M	M	M	M	M	M	M	M
14	Tire	M	M	M	M	M	M	M	M
15	*power steering oil*	M	M	M	M	M	M	M	M
16	Gardan	M	M	M	M	M	M	M	M
17	AC Filter	M	M	M	M	M	M	M	M

Tabel 2 Component Replacement Schedule based on the Customer Perspective (Continuation 1)

No	Component	Condition (km)							
		40000	45000	50000	55000	60000	65000	70000	75000
1	Sparkplug	R	M	M	M	R	M	M	M
2	Battery	M	M	R	M	M	M	M	M
3	V Belt	M	M	M	M	M	M	M	M
4	Fuel Filter	M	M	M	M	M	M	M	M
5	Air Filter	R	M	M	M	M	M	M	M
6	Oil	R	M	R	M	R	M	R	M
7	Oil Filter	R	M	R	M	R	M	R	M
8	Clutch Lubricant	M	R	M	M	M	M	M	M
9	Brake Lining	M	M	M	M	M	R	M	M
10	Brake Pad	M	M	M	M	M	M	M	M
	Brake Pad (*matic*)	M	M	R	M	M	M	M	M
11	Brake Oil	M	R	M	M	M	M	M	M
12	Transmission Oil	M	R	M	M	M	M	M	M
13	Automatic Transmission Oil	M	M	M	M	M	M	M	M
14	Tire	M	M	R	M	M	M	M	M
15	*power steering oil*	M	M	M	M	R	M	M	M
16	Gardan	M	M	R	M	M	M	M	M
17	AC Filter	M	M	M	M	M	M	M	R

Tabel 2 Component Replacement Schedule based on the Customer Perspective (Continuation 2)

No	Component	Condition (km)					Replacement Frequency up to 100.000 km
		80000	85000	90000	95000	100000	
1	Sparkplug	R	M	M	M	R	5
2	Battery	M	M	M	M	R	2
3	V Belt	M	M	M	M	R	1
4	Fuel Filter	R	M	M	M	M	1
5	Air Filter	R	M	M	M	M	2
6	Oil	R	M	R	M	R	10
7	Oil Filter	R	M	R	M	R	10
8	Clutch Lubricant	M	M	R	M	M	2
9	Brake Lining	M	M	M	M	M	1
10	Brake Pad (manual)	M	M	M	M	M	0
	Brake Pad (*matic*)	M	M	M	M	R	2
11	Brake Oil	M	M	R	M	M	2
12	Transmission Oil	M	M	R	M	M	2
13	Automatic Transmission Oil	R	M	M	M	M	1
14	Tire	M	M	M	M	R	2
15	*power steering oil*	M	M	M	M	M	1
16	Gardan	M	M	M	M	R	2
17	AC Filter	M	M	M	M	M	1
Estimation of Replacement up to 100.000 km							**47**

Note :
M = Maintain
R= Replace

3.4. Total Service Cost Calculation

Based on the schedule component replacement, the total service cost can be calculated. Total service cost calculation is done by summing the component replacement cost, in every service period with mark 'R'. Based on the result of the total service cost, there is a difference amount of the cost, which is 472.430 rupiahs between total service cost from customer and service center perspective (up to 100000 km). This may happen because in the customer perspective, some replacements are executed out of routine service interval such as the replacement of clutch lubricant, oil brake, transmission oil, brake lining, and AC filter. This will make the total service cost up to 100.000 km from the customer perspective higher than the service center perspective because customer should pay additional cost for service cost if the replacements are executed out of the routine replacement schedule based on the service center perspective.

3.5. Component Replacement Scenario

These scenarios are only for the replacement that is executed out of the routine service. The scenarios are made by moving the replacement schedule forward or backward. The replacement schedule that is out of the routine schedule will be moved into the routine service schedule. The first scenario is moving the schedule forward into the recommended schedule. This scenario is applied to clutch lubricant, brake oil, and transmission oil, which replacement schedule is in 45.000 km at first and it is moved to 40.000 km. The second scenario is moving the schedule backward into the recommended schedule. This is usually applied to brake lining.

Based on the total service cost comparison between existing and scenario, it is found that the total service cost up to 100.000 km will be more effective and economical if the replacement schedule is based on the recommendation of the service center.

3.6. Sensitivity Analysis between Total Service Cost and Reliability

This sensitivity analysis is applied to the brake lining only because according to the reliability calculation, brake lining is the only component which replacement schedule can be moved forward or backward. Based on the sensitivity analysis, it is found that along with the degradation of the reliability value, the total service cost is getting higher. If the brake lining is replaced, the reliability of the system will be higher and the total cumulative service cost will be higher as well.

4. CONCLUSION

The conclusions of this research are:

1. This research has composed the sechduling maintenance based on the customer and the service center peerspective. The threshold value of the reliability for replacement is 0.3679 for each component.
2. There is no significant gap of total service cost between customer and service center perspective. The total service cost up to 100.000 km based on the service center perspective is 15.593.360 rupiahs for matic car type X and 14.393.360 rupiahs for manual car type X. The total service cost up to 100.000 km based on the service center perspective is 16.065.790 rupiahs for matic car type X and 14.865.790 rupiahs for manual car type X.
3. From the sensitivity analysis between reliability and total service cost by using some scenarios of brake lining replacements, it is known that reliability of the component is more sensitive to brake lining replacements than the reliability of brake system, chasis & body, and the reliability of car. The total cumulative service cost is sensitive to the replacement, which is out of the recommended routine service.

The improvement suggestions are:

1. The approximation to find the failure historical data should be classified into two groups; they are failure historical data for customer who is always on the recommended schedule and customer who is not on schedule. By doing so, *reliability* calculation and the total service cost calculation can be more effective and accurate.
2. Updating service cost should be done because the service cost is always getting higher over the time.

5. REFERENCES

(a) Kompas. (2012, January 4). *Kompas.com*. retrieved from Kompas Otomotif : http://otomotif.kompas.com/read/2012/01/04/306/Penjualan.Mobil.2011.Sudah.Mencapai.893.420.unit.

(b) Amri, A. B. (2013, January 15). *Berita Industri*. retrieved from Berita Industri Otomotif: http://industri.kontan.co.id/news/ini-daftar-20-mobil-terlaris-di-2012/2013/01/15BPS. 2011.

(c) Juehlin, E., Torney, M., Hermann, C., & Droeder, K. (2010). Integration of Automotive *Service* and Technology Strategies. *CIRP Journal of Manufacturing Science and Technology, III*, 1-9

(d) Gaiardelli, P., Saccani, N., & Songini, L. (2007). Performance measurement of the after-sales *service* network—Evidence from the AUTOmotive industry. *Computers in Industry*, 1.

(e) Auto2000. (2013, January 7).*Sekilas AUTO2000*. Retrieved January 7, 2013, from Sekilas AUTO2000: http://livebeta.auto2000.co.id/page/sekilas_auto2000

(f) Wu, S. (2011). Assessing Maintenance Contracts when Preventive Maintenance is Outsourced. *Reliability Engineering and System Safety*, 66-72.

(g) Patton, J. (1980). *Maintainability and Maintenance Management.* North Carolina-USA: The Instrument Society of America.

(h) Lewis, E. (1987). *Introduction to Reliability Engineering.* Canada: John Wiley & Sons.

(i) Prasetyawan, Yudha, (2011), "Penjadwalan Pemeliharaan Sederhana Berdasarkan Prinsip *Preventive Maintenance", Prosiding Seminar Nasional Teknologi Industri XV,* Teknik Industri ITS, Surabaya.

AUTHOR BIOGRAPHIES

Yudha Prasetyawan is a lecturer in Department of Industrial Engineering, Faculty of Industrial Technology, Institut Teknologi Sepuluh Nopember, Surabaya. He received his Master in Advanced Manufacturing Technology from Swinburne University of Technology, Australia in 2005. His research interests are in the area of Computer Integrated Manufacturing, Automated Quality Control System and Manufacturing System Design. He is a member of the Manufacturing System Laboratory in Industrial Engineering Department. His email address is <yudhaprase@ie.its.ac.id>

Mita Musoffa Asti is a former student in Department of Industrial Engineering, Faculty of Industrial Technology, Institut Teknologi Sepuluh Nopember, Surabaya. She received her Bachelor of Industrial Engineering from this department in 2013. Her research interests are in the area of Quality Management, Reliability and Maintenance. Her email address is mitamussofa@gmail.com