Reducing the High Temperature of Water Radiator Dump Truck (HD 785-7 Type) by Making Special Tool

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Abstract. The high temperature of the engine in the dump truck vehicle will cause a decrease in the performance. Therefore, it is necessary to monitor and analysis the causes high temperature by creating a program called Intelligence Availability. This program is monitor and control the critical engine conditions and to make sure the engine coolant temperature can’t exceed 85 °C. In March 2018, 50 units HD 785-7 type have temperature above 85 °C. The main cause is the dirty core of the radiator and the absence of tools to clean the cores, so it is necessary to make a special tool to clean the radiator cores by flushing method. This flushing method can reduce the high temperature to be normal.

1. Introduction

Dump trucks are generally used for materials from medium to long distances, where the material transported can be filled by excavators, wheel loaders, or shovels [1] [2]. In this research, dump trucks manufactured by KOMATSU are used to transport solid objects in the form of top soil and overburden and liquids (water tanks or oil tanks). To support the coal production process, coal mining equipment is needed in excellent performance. Intelligent Availability (IA) is a program created to measure capability and maintain equipment availability by using knowledge and technical expertise (Skill). Thus IA becomes a parameter in the productivity of the unit [3].

In this mining area the achievement of program maintenance has not been maximally and still focused on short-term corrective & preventive activities. The use of predictive tools (VHMS-Vehicle Healthy Monitoring System- & LAP-Lubricant Analysis Program-) has not been used optimally in maintaining equipment availability. Exploration from the predictive side of maintenance still needs improvement, and data-based decision making. [4] [5]

IA (Intelligence Availability) has several assessment variables that will continue to be monitored according to that units. Variable in HD785-7 units are engine oil temperature, coolant temperature, blow by pressure, EGT sensor, boost pressure, and oil temperature transmission. IA data retrieval process can be taken from downloading VHMS, LAP Engine, LAP Final drive. This research is intended to increase IA units to be able to produce maximally. [6] [7] [8] [9] [10]

2. Methodology
Observation in the field has been a very significant decrease in IA so that it needs to be improved to its original target event though if it is possible to exceed the target set. The method used is the corporate culture approach where this research is conducted, which has known continuous improvement. The process starts from the data that is available then analyzed and compared with the targets that have been set. If based on that results of the data below the target set, it is necessary to analyze why until it is below the target, then find the root of the problem using the tool management fishbone analysis. After finding the root of the problem, the improvement process is carried out by involving all stakeholders so that the same mistakes will not occur in the future. [11] [12] [13] [14] [15] [16]

3. Background Data

Based on data in Heavy Equipment Plant 1, the HD785-7 is the most populated units with a total 323 units (March 2018), and the 323 units are divided into several parts, 243 units as Hauler dump trucks, 56 units dump trucks ex remanufacturing, 17 units of tailgate dump truck and 17 units as water tank.

![Figure 1. Unit's population (March 2018)](image)

Site observations indicate that the achievement of IA for HD 785-7 units from January to March 2018 is as follows:

![Figure 2. Trend Data IA HD 785-7 from January - March 2018. The vertical axis is achievement (%) and horizontal axis is months (January – March).](image)

Data at figure 2, that HO target (head office) for IA is 75% while the target of the site is 80%. The actual achievement is still below the target. Observations at the workshop showed that there were 50...
units of HD 785-7 that had critical coolant high temperature problems and having small lifetime engines while compared to the engine lifetime overhaul limit at 36,000 HM (Hour Meter).

4. Result and Discussion

Based on table 1, then the improvement was chosen based on consideration of effectiveness, processing time and costs for making improvements so that the chosen solution could solve the existing problems. For this reason, the cheapest and most effective solution is to make radiator core flushing tools

| NO | ROOT CAUSES | SOLUTION ALTERNATIVE | EFFEC TIVENESS | TIME | COST | REMARK |
|----|-------------|----------------------|----------------|------|------|--------|
| MAN | The numbers of New mechanics at PHE 1 | Training to all new mechanics equally to increase the competency of maintenance regarding the HD 785-7 | Effective | Too long | Expensive | Training to new mechanics, it is expected that the mechanics' individual competence will get some level |
| MATERIAL | There is not program for Rehose Cooling System | A hose cooling system program is held for HD 785-7 | Effective | Too long | Expensive | In terms of cost, it is expensive, but by doing rehose can improve the quality of the hose |
| MACHINE | There is no tool to clean the core radiator | Making a Flashing Core Radiator's Tool | Effective | Too long | Cheap | With the flashing core radiator's tool it can clean the dirt inside the core, without having to split the core |
| METHODE | The radiator cleaning program is not standardized | Maintenance of radiator every PS 2000 is done by spraying using water | Effective | Faster | Cheap | With fast time and low costs, radiator maintenance can be done at any Periodic Service setup Periodic Service |

After number of feeding trials, a tool was obtained as shown in figure 3.
Figure 3. Flushing Tool Core Radiator’s scheme.

This tool can remove dirt particles from the radiator core so that there is no blockage in the radiator tube core, which can cause engine coolant heat exchanger processes to be hampered. The principle of this tool is to pump coolant into the radiator core then filter it using a filter with a capability of 10 micrometers. Pump discharge is 350 liters/minute. The testing process was carried out on 28 units of HD 785-7 that overheating. The results are in the following table 2.

Table 2. Result of this Tool Applied to HD 785-7 Units

| NO | CN UNIT | TEMPERATURE BEFORE | TEMPERATURE AFTER |
|----|---------|-------------------|------------------|
| 1  | DT3606  | 87                | 85               |
| 2  | DT3584  | 87                | 82               |
| 3  | DT3888  | 86                | 85               |
| 4  | DT3837  | 88                | 84               |
| 5  | DT3746  | 86                | 76               |
| 6  | DT3914  | 90                | 82               |
| 7  | DT3586  | 88                | 84               |
| 8  | DT3276  | 86                | 77               |
| 9  | DT3506  | 87                | 78               |
| 10 | DT3619  | 86                | 83               |
| 11 | DT3823  | 89                | 85               |
| 12 | DT3837  | 86                | 81               |
| 13 | DT3666  | 87                | 85               |
| 14 | DT4118  | 88                | 80               |
| 15 | DT3531  | 87                | 76               |
IA's Intelligence Availability period January – June 2018 has increased, in March IA's achievement was only 68%, after this improvement there was an increase of 83.9% and had reached the target from Head Office and Plant Heavy Equipment 1 Department (figure 4).

![Figure 4](image)

**Figure 4.** Flushing Tool Core Radiator’s scheme[3]. The vertical axis is achievement (%) and horizontal axis is June16-30.

The High Temperature Coolant’s trend in the period January – June 2018 has decreased in March 2018 there are 50 units with coolant abnormal temperature and in June 2018 it has decrease to 27 units. This is an effect on IA achievement because the percentage coolant temperature to IA achievement is 17% (figure 5).

![Figure 5](image)

**Figure 5.** Achievement of IA (Intelligence Availability)[3]. The vertical axis is quantity.
5. Benefit Using this Tool

If using this tool, the potential losses that can be saved are:

a. Radiator Unit.
   If there are 50 radiator’s to be replaced cause Coolant High temperature
   Core Radiator No.1 (Part Number 561-30-81640) = 50 pcs x @ 70,877,408 IDR = 3,543,870,400 IDR
   Core Radiator No.2 (Part Number 561-30-81650) = 50 pcs x @ 54,970,648 IDR = 2,748,532,416 IDR
   Core Radiator No.3 (Part Number 561-30-81630) = 50 pcs x @ 70,877,408 IDR = 3,543,870,400 IDR
   Core Radiator No.4 (Part Number 561-30-81630) = 50 pcs x @ 70,877,408 IDR = 3,543,870,400 IDR
   Total = 13,380,143,000 IDR

b. Engine Unit.
   In early 2017, engine lifetime’s target to be remanufacturing is 33,000 HM (Hour Meter). Whereas
   in 2018 the target changed to 38,000 HM. With this flushing program, the target can be achieved. The
   difference of lifetime’s engine that can be saved is 5000 HM for each unit. If cost per hour = 25,999
   IDR, for 50 units: 50 x 5000 HM x 25,999 IDR = 6,499,767,000 IDR.
   The total cost that can be saved from the components are: radiator component cost + engine
   component cost = 13,380,143,000 IDR + 6,499,767,000 IDR = 19,879,910,353 IDR

c. Cost of Loss Due to Lead Time
   If 50 units having coolant high temperature problem are replaced, all of them will become
   Unscheduled Breakdown. The lead time processing is 18 hours. 1 hour HD 785-7 can transport coal as
   much as 2 rotations. If 1 rotation can transport 45 bcm (bank cubic meter) then in 18 hours it transports
   1620 bcm. The price of OB is 1 bcm, 2 USD. (1 USD = 13,888 IDR at that time), the cost wasted is
   44,997,120 IDR. If there are 50 units, the total lost is 2,249,856,000 IDR

d. Man Hour Cost.
   The number of mechanics for the repair process per unit is 3 peoples and the lead time is 18 hours. If
   a man hour is paid USD 25, then the mechanical cost for repairs per unit is 18 x 3 x (25 USD) x 13,888
   = 18,748,800 IDR. For 50 units, the total man hour cost is 937,440,000 IDR.
   The total potential loss if it is not use this tool for 50 units are: Cost due to component damage +
   Costs due to loss of lead time + cost of loss to pay man-hour = 23,067,206,000 IDR.
   Total cost of producing tool is 53,821,030 IDR and the lead time of flushing per unit 9 hours with
   number of mechanics of 2. Thus for 50 units of flushing costs are 277,760,000 IDR. The total cost that
   can be saved for 50 units are 23,067,206,000 IDR - 331,581,030 IDR = 22,735,625,000 IDR

6. Conclusion

By using this tool, the coolant temperature HD 785-7 can be normal according to the standard of the
manufacturer. The flushing process can save component damage to 22,735,625,000 IDR.

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References

[1] komatsu Ltd, Shop Manual Komatsu HD 785-7, Japan: Komatsu Ltd, 2011.
[2] k. Ltd, Operation and Maintenance Manual Komatsu HD785-7, Japan: Komatsu Ltd, 2011.
[3] PAMA, Pamawebproud/apps/Mamadata/Default/785-7/IA (Inteligence Availability),
    Jakarta: PAMA, 2018.
[4] Vuko A T Manurung, Yohanes Wibowo, Muhammad Ramadlan, "Oil Flushing Method to Avoid Unscheduled Breakdown Final Drive Components at Komatsu Dump HD 465-7R in PT ATP," in ICETASIA, Solo, 2018.

[5] Vuko A T Manurung, Yohanes Wibowo, Muhammad Ramadlan, "Oil Flushing to Avoid Unscheduled Breakdown Final Drive Components at Komatsu Dump HD465-7R in PT ATP," in ICETASIA, SOLO, 2018.

[6] Michel J Maron, Haword N Saphiro, fundamental of Engineering Thermodynamics, England: John Wiley & Son Inc., 2006.

[7] F. Justin Dhiraviam1, V. NaveenPrabhu, T. Suresh, "Improved Efficiency in Engine Cooling System by Repositioning of Turbo Intercooler," Applied Mechanics and Materials, vol. 787, pp. 792-796, 2015.

[8] S. Bennett, Heavy Duty Truck System, vol. 3, USA: Beaverton: Ringgold Inc., 2016.

[9] Mavropoulos, Georgios C, Katsanos, Christos, Knecht, Walter, "Mavropoulos, Georgios C, Katsanos, Christos, Knecht, Improvement of bottoming cycle efficiency and heat rejection for HD truck applications by utilization of EGR and CAC heat," vol. 53, no. 1, pp. 19-32, 2012.

[10] Gilles, Tim, Automotive Service Inspection, Maintenance, Repair, vol. 86, USA: Delmar, 2012, pp. 2632-2643.

[11] M. Thomas, Truck and Trailer Systems, USA: MacGrow-Hill, 2014.

[12] Liao, Yidai, Zhuo, et al, Liao, Yidai, Zhuo, et al, Heat Flow Characteristics of a Newly-Designed Cooling System with Multi-Fans and Thermal Baffle in the Wheel Loader, Applied Science, 2017.

[13] Mavropoulos, Georgios C, Katsanos, et al, "Mavropoulos, Georgios C, Katsanos, et al, Improvement of bottoming cycle efficiency and heat rejection for HD truck applications by utilization of EGR and CAC heat," Mavropoulos, Georgios C, Katsanos, et al, Improvement of bottoming cycle efficiency and heat rejection for HD truck Energy Conversion & Management, vol. 53, pp. 19-32, 2012.

[14] Chong, Kok-Keong, Tan, Woei-Chong, "Study of automotive radiator cooling system for dense-array concentration photovoltaic system," Solar Energy, vol. 86, no. 9, pp. 2632-2643, 2012.

[15] M. Thomas, Truck and Trailer Systems, USA: McGrow-Hill, 2014.

[16] Hountalas, Dimitrios T, Mavropoulos, Georgios C, Katsanos, Christos, Knecht, Walter, "Hountalas, Dimitrios T, Mavropoulos, Georgios C, Katsanos, Christos, Knecht, Walter, Improvement of bottoming cycle efficiency and heat rejection for HD truck applications by utilization of EGR and CAC heat," Energy Conversion & Management, vol. 53, no. 1, pp. 19-32, 2012.

[17] Gilles, Tim, Automotive Service Inspection, Maintenance, Repair, USA: Delmar, 2012.