

Condition Based Maintenance of Automotive Air Conditioners

Anurag Jha^{1*}, Shweta Bisht², Mahesh Pandey¹

¹Department of Mechanical Engineering, GLBTM, Greater Noida, UP, India

²Department of Mechanical Engineering, Manav Rachna International University, Haryana, India

ABSTRACT

The usage of air conditioners is common these days in the automobiles and these are subjected to various type of failure. Such failures can be minimized by implementing suitable maintenance strategy, which will ensure smooth working thus would reduce the chances of failures and increase availability of the entire system. The paper aims to study the implementation of Condition Based Maintenance in the automotive air conditioners.

Key words:Automotive air conditioners, Condition based maintenance, fishbone diagram, maintenance.

INTRODUCTION

Air Conditioning is a process by which air is cooled, cleaned and circulated. It means quantity, quality; temperature, humidity and volume of air are controlled in a given situation. Because of extensive use of the automobile, automobile air conditioning play an important role in promoting the comfort, health and safety of travelers. The principle of air conditioning is quite interesting to understand. In the process of refrigeration, the compressor absorbs the gas from the evaporator, compresses vapour in high temperature, and high pressure then sends them to the condenser. At the meantime, the temperature of the refrigeration vapor is higher than the temperature outside the car. The refrigerant will spread out the heat of the condenser. The gas refrigerant becomes liquid to flow into the dryer. It is dried and filtered. The liquid refrigerant volume will increase rapidly to become liquid-fog mixtures, which come into the evaporator in the low temperature and low-pressure state. The liquid-fog refrigerant absorbs the heat in the evaporator to make the air temperature decrease when the car circulating air is flowing through the evaporator. Finally, the cooled air is sent into the car through the air-blower. The next circulating begins while the vaporized refrigerant vapor is absorbed again into the compressor.

The various faults, which can occur in Automotive Air Conditioners, are given as follows:

- i. Shortage of refrigerant charge
- ii. Expansion valve jammed
- iii. Expansion valve fully closed
- iv. Membrane leakage of expansion valve
- v. The hole of expansion valve too small
- vi. Electromagnetic valve cannot open
- vii. Filter valve blocked of liquid pipe
- viii. Output valve of R/D bottle does not open fully

- ix. Liquid pipe blocked
- x. Cooling of condenser not enough
- xi. Cooling of condenser too much
- xii. Air exists in the condenser
- xiii. Refrigerant too much
- xiv. Expansion valve stick on the open position
- xv. Expansion valve with wrong adjustment
- xvi. Capacity of evaporator too large
- xvii. Load distribution of evaporator not uniform
- xviii. The distribution of the refrigerant is not uniform
- xix. Refrigerant oil gather in the evaporator
- xx. Air return valve of compressor blocked
- xxi. Actuator overload
- xxii. Low pressure control valve too high
- xxiii. High pressure control valve too low
- xxiv. Compressor valve cracked
- xxv. Leakage of low pressure valve
- xxvi. Compressor bearing cannot rotate
- xxvii. Compressor movable element cannot action
- xxviii. Compressor oil pump damage
- xxix. Compressor oil pipe blocked
- xxx. Compressor capacity controller damage
- xxxi. Compressor over reduce load
- xxxii. Compressor piston or link damage
- xxxiii. Fuse burn down
- xxxiv. Short circuit of control board
- xxxv. Switch control element burn out or dusty
- xxxvi. Wire terminal loose
- xxxvii. Magnetic clutch not engaging the compressor
- xxxviii. Temperature control switch failure
- xxxix. Instrument damage

The faults occurring in the automotive air conditioners are here shown by using Fishbone diagram or Ishikawa diagrams. Ishikawa diagrams also called fishbone diagrams, herringbone diagrams, cause-and-effectdiagrams, or Ishikawa were created by Kaoru Ishikawa. This diagram shows the causes of a specific event.

Condition based maintenance (CBM) is a maintenance strategy that monitors the actual condition of the asset to decide what maintenance needs to be done. Condition based maintenance (CBM) is a management philosophy that takes repair or replacement decisions on the current or future condition of assets. The main objective of CBM is to ensure that assets fulfill their mission in the most cost effectively manner.

There are also various levels of condition monitoring:

- (a) Detection- To detect the problem and criticality of the situation.
- (b) Diagnosis-To determine the problem and condition monitoring techniques need to be used.
- (c) Prognosis- To determine the severity of the problem.

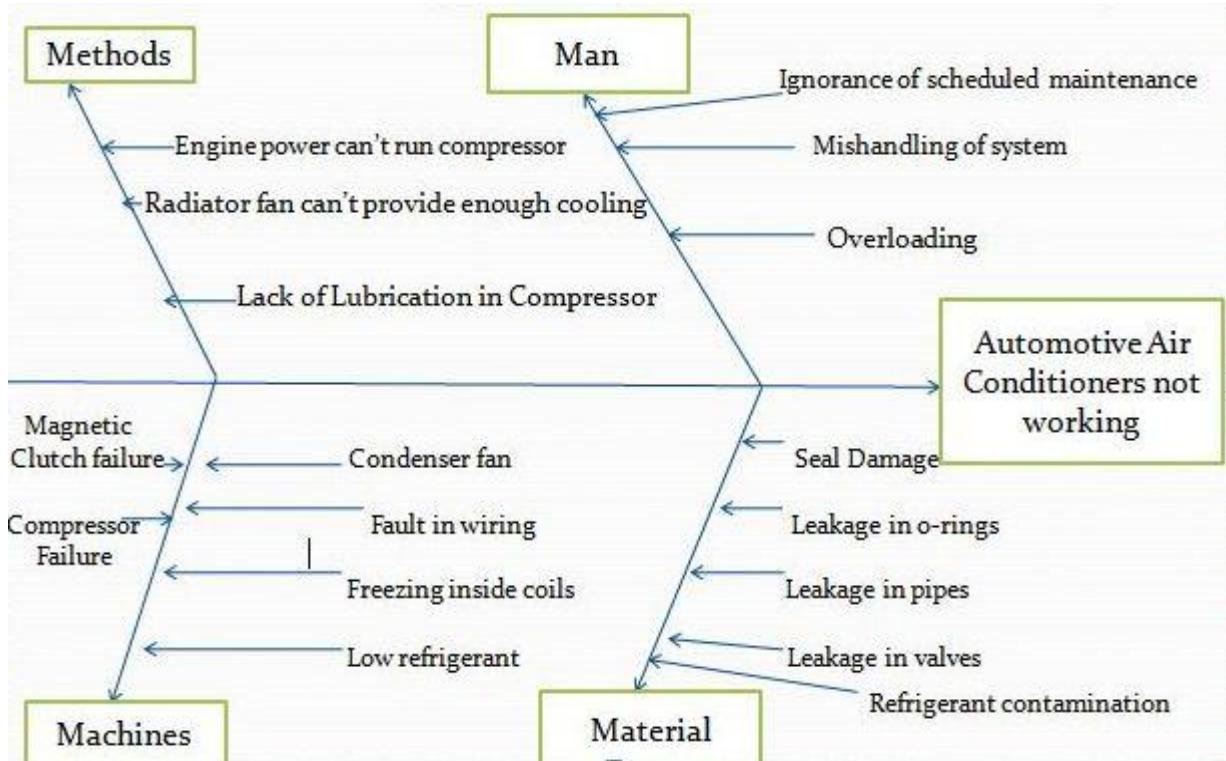


Fig1: Fish bone diagram expressing the fault in automotive air conditioner

Condition Based Maintenance uses all available diagnostic, process and performance data, maintenance histories, operator logs and design to make timely decisions about maintenance requirements for the system. Condition based maintenance can be deployed as a means of determining the needs of machine maintenance, and is normally used in combination with scheduled maintenance to extend the maintenance cycle and reduce the maintenance time of routine overhauls. Condition monitoring system has the potential to achieve cost savings associated with reduced operational failures and reduced routine maintenance.

Davide Di Battista et al. [1] presented a mathematical model of the A/C system, starting from its single components: compressors, condenser, expansion valve and evaporator. The model considered off-design behavior of components, being this system often at partial load operating conditions. **QuanshengZhang** [2] used an H1 filter based FDI method which was applied to an automotive A/C system using model-based approaches. An MBM A/C model was built using first principles, for the first time, which served as a control-oriented model for distinguishing faults. **B.B. Popovic et al.** [3] analyzed the causes and modes of failure of air conditioner and Automotive DC Electro-ventilator as parts of Automotive air conditioning machine using the method of Fault Tree Analysis (FTA). The causes and modes of failure of air conditioners and automotive DC electro-ventilator, as part of automotive air conditioning system were analyzed and detected. **Mahdi Mohammad Tehrani et al.** [4] used the traditional method of linear regression and artificial neural network for prediction. The empirical data was retrieved and a new method for predictive maintenance illustrated using HVAC system was developed. **Miaozhong Sun et al.** [6] designed and implemented a testing system for Automotive Air conditioning. Twelve channel signals of air conditioning performance parameters were acquired

and analyzed simultaneously. The positions where sensors are used in the automotive air conditioning were designed. **Pedro Magalhaes Sobrinho et al.** [7] performed an experimental analysis on an air conditioning system, and evaluated the influence of relative air humidity on system performance. **Muhammad Aftab et al.** [8] discussed a fundamental problem of optimizing the trade-off between the battery lifetime and the effectiveness of HVAC remote control in the presence of uncertain (even adversarial) fluctuations in room temperature. **Jungwoo Lee et al.** [9] determined the effect of each component of the air-conditioning system on the fuel consumption of a conventional gasoline engine vehicle operating at various engine speeds. It was determined that air-conditioning operation increased the fuel consumption by 90% maximum compared with the operation without air-conditioning during the idling condition. **Ingolf Kruger et al.** [10] proposed an improved development process for car diagnostics that better supports the architecture of modern cars and discussed modeling techniques that abstract components implementations.

I. Koronaki [11] evaluated the possibilities of reducing the refrigerant leakages. The objective of this research work was to describe the European state of the art on refrigerant leakage in refrigerating system. The leakage reduction is accomplished by prevention by providing proper training to the relevant professionals according to established standardized procedures. **Byron A. Ellis** [12] analyzed condition based maintenance by reviewing various research work done in this area. **Poggi F et al.** [13] described and evaluated the possibilities of charge reduction in refrigerating systems and heat pump. **Navarro-Esbri J. et al.** [14] applied the fault detection technique for on-line refrigerant leakage detection. The authors discussed how the vapour compression system variables are affected by the fault. The suction pressure was selected as output variable for the methodology.

S.A. Tassou et al. [15] described the development of a fault diagnosis and refrigerant leak detection system based on artificial intelligence and real-time performance monitoring. This system was developed to distinguish between faulty and fault free operation, steady-state and transient operation, leakage and over charge conditions.

Laura Swanson et al. [16] discussed and provided information regarding the characteristics and use of Computerized based Maintenance Management System.

II CONCLUSION

A brief of automotive air conditioner, it's functioning, various faults occurring in it, and the possible maintenance strategy adopted have been discussed in the paper. The review work is to identify different failures in the system and the methodology of Condition Based Maintenance. The conclusion can be summarized as follows:

- (1) The failures occurring in the given system can be pre-diagnosed with the help of various online monitoring techniques.
- (2) Based on various states of the system determined, the condition of the system can be analyzed and accordingly maintenance plan can be prepared.
- (3) This will result in reducing the failure rates and saving of maintenance cost.

So that appreciable improvements in the performance together with possible reduction in the emissions related to leakageso as to make the process eco- friendly.

International Conference on Computational and Experimental Methods in Mechanical Engineering

**G.L. Bajaj Institute of Technology and Management, Greater Noida (U.P) India ICCEMME-2017
8th- 9th December 2017, www.conferenceworld.in ISBN: 978-93-86171-85-6**

REFERENCES

- [1] Davide Di Battista et al, High efficiency air conditioning model based analysis for the automotive sector, International Journal of refrigeration, International Journal of refrigeration, 28(5), 680-688, International *Journal of refrigeration*, 28(5), 680-688, Volume-64, 2016, 108-122 .
- [2]Quashing Zhang et al, Fault Detection and Isolation of automotive Air Conditioning systems using first principle models,*Control Engineering Practice* 43, 2015, 49-58.
- [3]B.B. Popovic et al, Analysis of causes and modes of failure of air conditioner and Automotive DC Electro-ventilator as parts of Automotive air conditioning machine, *Control EngineeringPractice* 43,2015, pages 49-58
- [4]Mahdi Mohammad Tehrani et al , A Predictive Preference Model for Maintenance of a Heating Ventilating and Air Conditioning System , IFAC-Papers OnLine,Volume48, Issue 3, 2015, Pages 1-2444 .
- [5]Syed Muztuza Ali et al ,Thermodynamicmodelling and performance study of an engine waste heat driven adsorption cooling for automotive air-conditioning , *Applied Thermal Engineering, Elseveir*, 2015, (54-63).
- [6]Miaozhong Sun et al , Design and Implementation of a Testing System of Automotive Air Conditioning Based on Delphi , *International Journal of Control and Automation,Vol.7, No.5, 2014, pp.227-234.*
- [7]Pedro MagalhaesSobrinho et al ,Experimental research on the influence of the air humidity conditions in an air conditioning system , vol. 49, pp. 152-159, *Experimental thermal and fluid science*, (2013)
- [8]Muhammad Aftab et al. ,Smart Air-Conditioning Control by Wireless Sensors: An Online Optimization Approach , Proceedings of the fourth international conference on Future energy systems, Pages 225-236, ISBN: 978-1-4503-2052-8, (2013)
- [9]Jungwoo Lee et al ,Effect of the air-conditioning system on the fuel economy in a gasoline engine vehicle ,*Journal of Automobile Engineering January, Part -D,2012, 66-77.*
- [10]Ingolf Kruger et al , Improving the Development Process for Automotive Diagnostics , *International Conference on Software and System Process*, pages-63-67, (2012)
- [11]I. Koronaki et al ,Refrigerant emissions and leakage prevention across Europe - Results from the Real Skills Europe project , Energy 4s , Elseveir, (2012)
- [12]Byron A. Ellis , Condition Based Maintenance , *TJP*,2008, pp. 1-5 .
- [13]Poggi F et al , A. Refrigerant charge in refrigerating systems and strategies of charge reduction ,*International Jounal of Refrigeration, Elseveir*, 31(2008)
- [14]Navarro-Esbrí, J. et al ,A vapour compression chiller fault detection technique based on adaptative algorithms. Application to on-line refrigerant leakage detection ,*International Journal of refrigeration* 29(2006),716-723, Elseveir (2006)
- [15]S.A. Tassou et al ,Fault diagnosis and refrigerant leak detection in vapour compression refrigeration systems" *International Journal of refrigeration*, 28(5),2005, 680-688 .
- [16]Laura Swanson et al *Production and Inventory Management Journal* 38.2,1997, pgs 11-15 .