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Condition Based Maintenance of Automotive Air Conditioners

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ABSTRACT

The usage of air conditioners is common these days in the automobiles and theseare 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.

I 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 decease 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 maintenanceneeds 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.

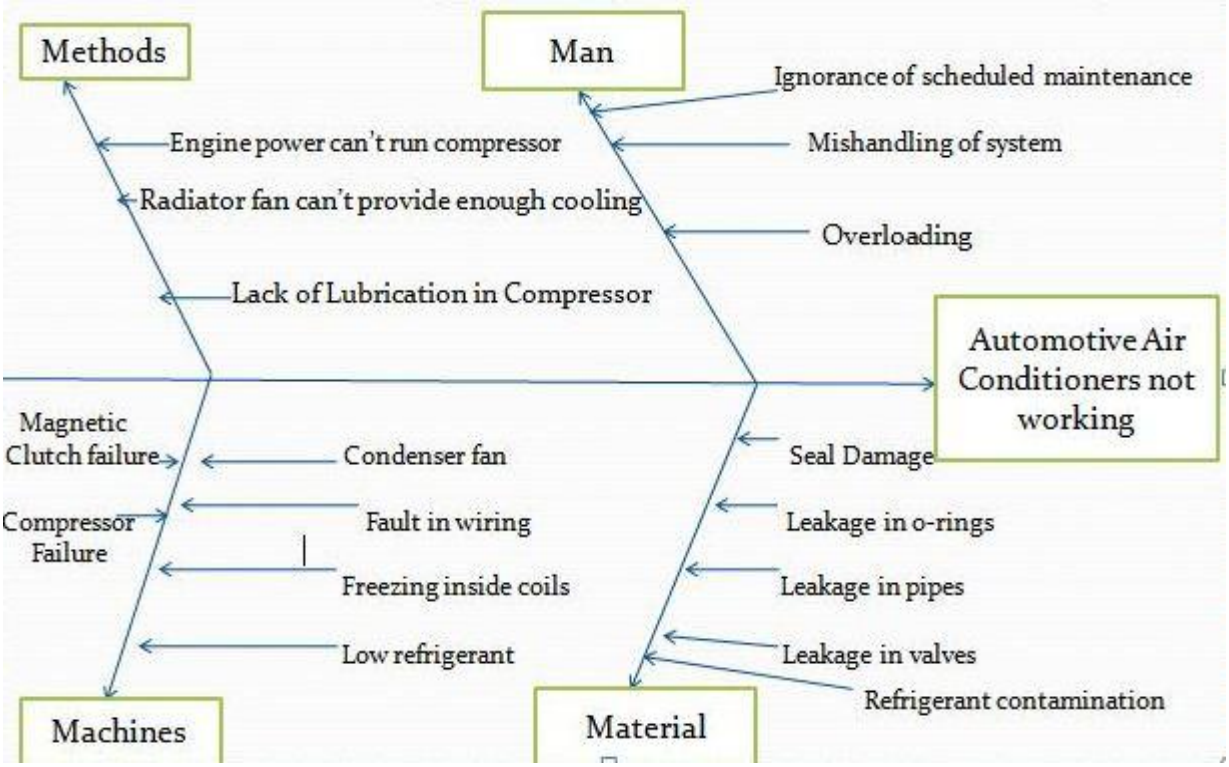

Fig1: Fish bone diagram expressing the fault in automotive air conditioner

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 MagalhaesSobrinho 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.

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