International Journal of Technical Innovation in Modern Engineering & Science (IJTIMES)
Impact Factor: 5.22 (SJIF-2017), e-ISSN: 2455-2585
Volume 5, Issue 03, March-2019

MECHANALYSIS OF LEAKAGES IN FIN-TUBE TYPE RADIATOR

Bhavin R. Patel[1], Dr. Vina D. Chauhan[2], Dhara P. Trivedi[3], Sunil D. Kininge[4]

[1]P.G scholar, [2]Professor, [3]Assistant Professor
Mechanical Engineering Department, Birla Vishvakarma Mahavidyalaya Engineering College, Vallabh Vidyanagar – 388120, Gujarat, India
[4]Deputy General Manager, Banco Products (India) ltd., Vadodara-391410, Gujarat, India

Abstract – ***In this paper, leakage analysis of radiator in manufacturing is conducted to identify defects. The fabrication of aluminium radiator assembly features high production efficiency and light weighted radiator have high heat dissipation. The quality of these radiators plays a key role in vehicle performance because it ensures the integrity of the engine and also it will cause significant mechanical complications in case of malfunction. Various types of leakage are identified in leakage analysis of radiator. Manufacturing defects can reduce the overall production rate so it is necessary to identify types of leakage occur in manufacturing for identification. Visual identification method & leakage testing methods are applied for identification of leakage. Leakage is elaborated with the help of cause-effect diagram to analyse the source of problem. Slot profile is analysed on profile projector. Rectification of leakage in radiator on the basis of identification of defect during manufacturing help to increase production rate.***

Keywords— Radiator leakage analysis, Heat exchanger leakage, Radiator manufacturing defects, Leakage testing of radiator

I. INTROUCTION

The radiator is a key component of an engine cooling system and play an important role by maintaining the operating temperature of the engine at optimal level to reduce damage due to rapid failure [1]. A number of studies have been performed in order to increase the heat transfer rate and to reduce the size and weight of radiator but compactness of design increase the complexity of manufacturing. Efficient design of fin-tube radiator can improve system performance [2]. Engine heat is absorbed by coolant circulates through it and then heated coolant moved to radiator. Heated coolant flow through tubes from top to bottom tank. Tubes and fins are assembled together and joined by brazing process. Air flow through the radiator, which absorbs the heat from outer body of radiator and reduce the temperature of radiator [3].
Radiator assembly consist following parts i.e. header plate, core channel, tubes, fins, pressure cap, drain cock, side frames, and fan & shrouding [4]. Aluminium alloy is most significant material used in manufacturing of radiator. Radiator tubes contains heated coolant during working condition which causes corrosion. Pressure cap works on fix range of pressure so it is necessary to manufacture defect free radiator. Leakage identification helps in rectification and root cause identification is necessary to reduce the particular types of leakage which reduce scrap and overall cost. Various types of leakage identified in further analysis.
A leak detection test is usually a quality control step to assure device integrity, and should preferably be a one-time non-destructive test, without impact on the environment and operators. Several leak-testing techniques are available for leakage detection, spanning from very simple approaches to systems that are more complex. The most commonly used non-destructive leak test methods are the underwater bubble test, bubble soap paint, pressure and vacuum decay test. Acceptance level is the main parameter to be considered when selecting the most suitable testing method or combination of methods. Several other factors have to be taken into account for a proper method selection [5]. Leak detection sensitivity graph shows the leak rate of different methods in fig. 1. Various factors i.e. Compactness of method, feasibility for particular application, cost of inspection is considered during selection of leakage detection method for inspection of product [6].
The basic functions of leak testing are detection of leakage, measurement of leak rate & location off leakage [7]. Various types of leakage identification testing methods are:

(i). Helium leak test
(ii). Thermal image processing
(iii). Dry leak test
(iv). Wet leak test
(v). Dye penetration test
(vi). Bubble test (soap painting)
(vii). Ultrasonic test

Dry leak test and wet leak test is most significant method in leak detection due to less time consumption, lower cost of test setup. Dry leak test detects the leakage availability in radiator and wet leak test used to identify the location of leakage from which leakage type is identified.

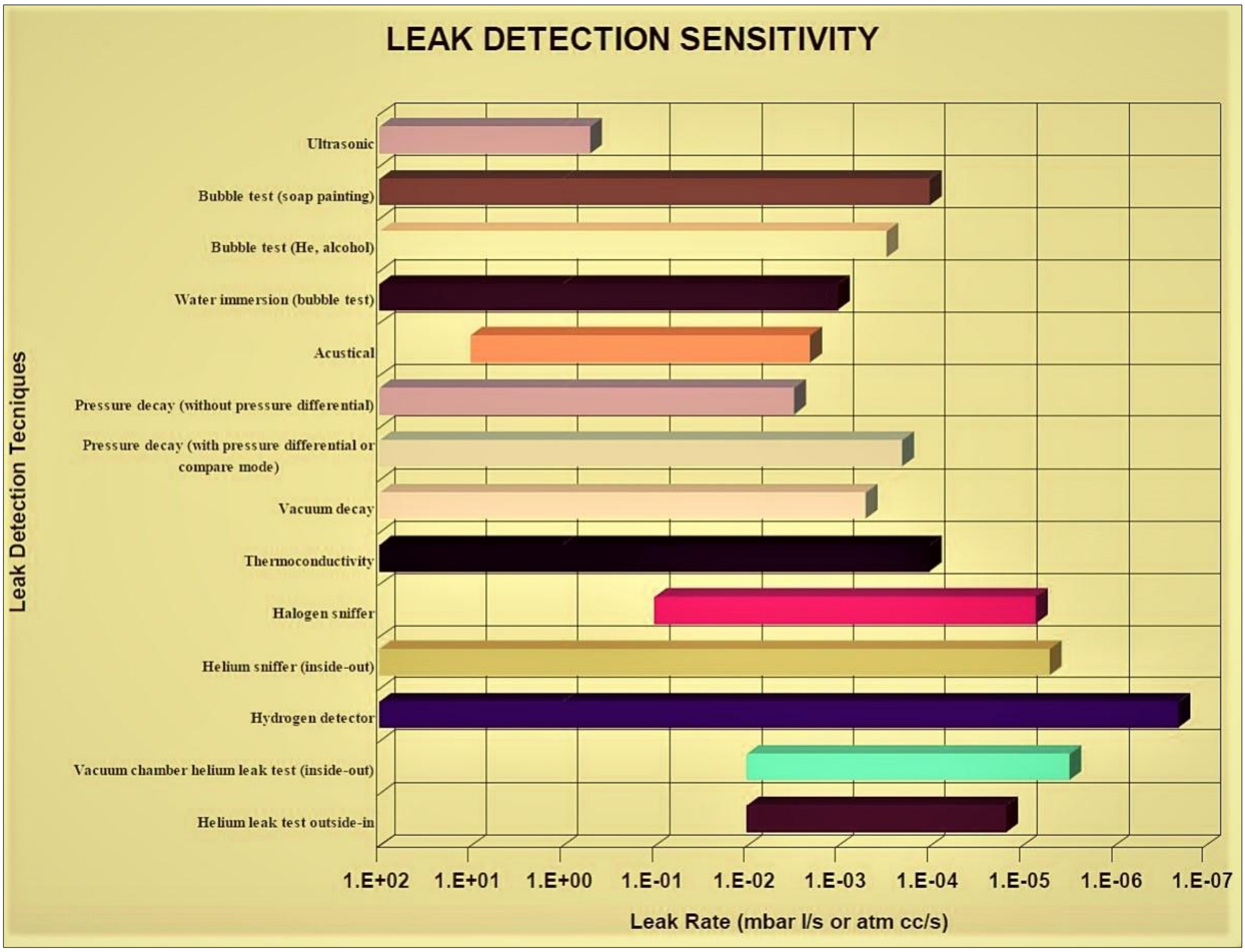

Figure 1 Leak detection sensitivity comparison of various leak detection techniques [5]

II. LEAKAGE IDENTIFICATION TEST

Dry leakage test and wet leakage test is conducted for identification of leakage. Visual inspection also carried out for identification of leakage. Dry leakage test is pneumatic test carried out by pressure of air. It is fast testing method; low-cost and non-corrosive substance are in contact with radiator due to this reason it is most preferable method for leakage testing of radiator. Primary advantage of dry leakage testing is speed in leakage testing at higher accuracy.

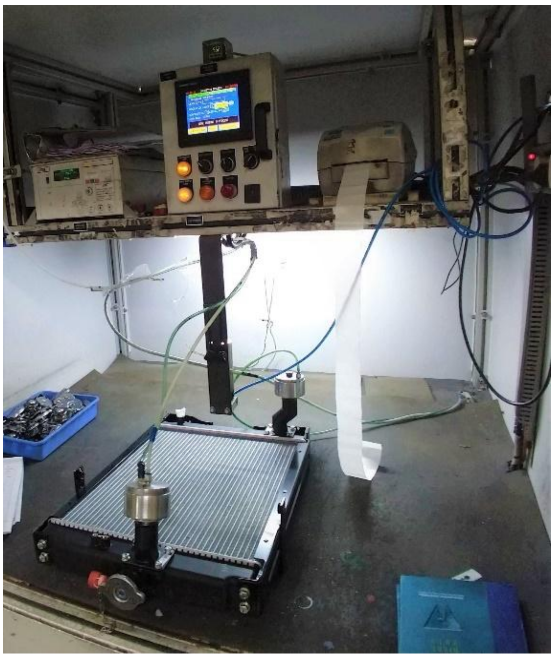

Figure 2 Dry leak test

Figure 3 Wet leak test

Wet leak test is used to identify location of leakage in leak radiator identified by dry leak test. It is based on the technique of submerging the part in the water that is stored in an immersion tank. Fig. 2 & fig. 3 shows testing setup of dry leak test and wet leak test.

From the following test, various kind of defects are identified during inspection of radiator in manufacturing are listed below.

- Header plate to tube joint leakage.
- Tube puncture
- Tube cut
- Gasket leakage
- Tank manufacturing defect
- Tank crack
- Drain cock leakage
- Radiator cap leakage

Various types of defects are identified in radiator from which header plate to tube joint leakage is higher as compare to other defects. So that further analysis is carried out on header plate to tube joint leakage to analyse the cause of leak.

Figure 4 Header plate to tube joint leakage

In brazing process, if header plate to tube joint is not brazed properly than this type of leakage is occur in radiator. If leakage is identified at furnace after completing brazing process than it will re-brazed to resolve leakage. If it will be left or visually not identified than it will identified at dry leakage test.

III. ANALYSIS OF LEAKAGE

A. Cause-effect diagram

Header plate to tube joint leakage is identified in wet leakage test. Discontinuity produced in brazing of header plate to tube joint, it does not mean that leakage occur due to improper brazing. so, it is necessary to elaborate the problem to resolve leakage. Cause effect diagram is used for quality defect prevention to identify potential factors causing an overall effect.

Main sources are elaborated from cause-effect diagram to discretise causes of header plate to tube joint leakage. Sources of variation are divided in sub categories to analyse cause effect diagram. Parameters relates with header plate to tube joint leakage are analysed in the cause-effect analysis.

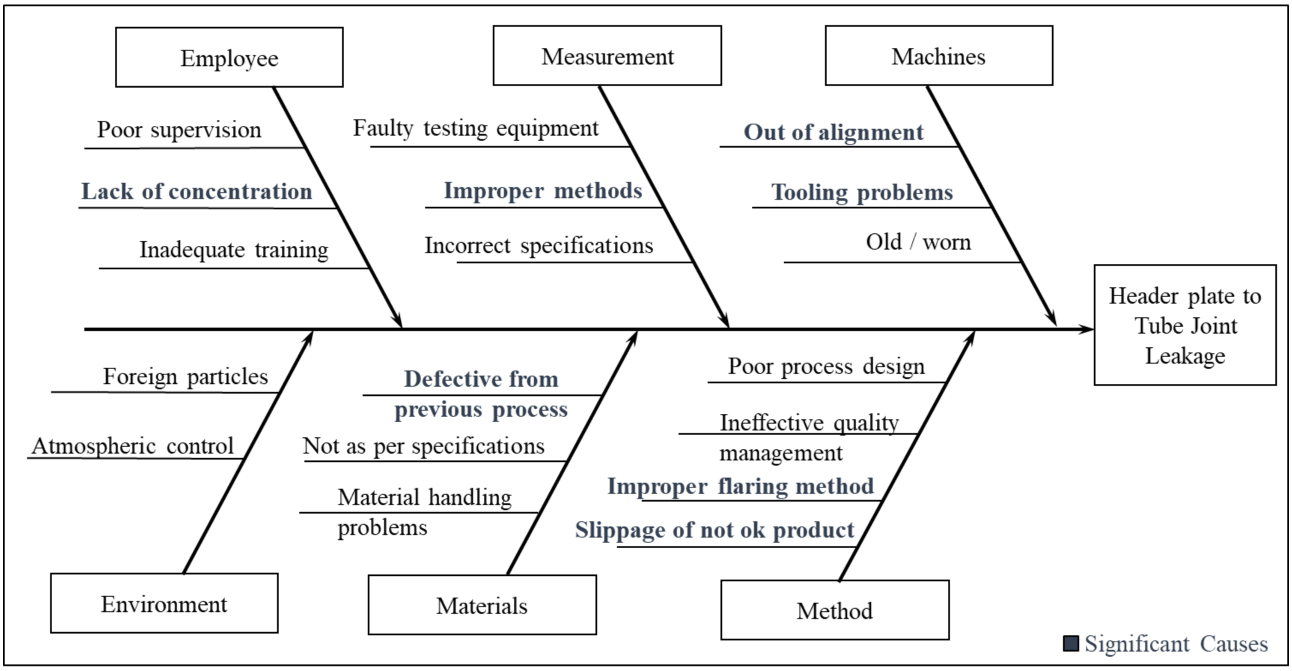

Figure 5 Cause-effect diagram of header plate to tube joint leakage

Thickness of tube & header plate is different but if braze clade material of both the parts are same than it is more suitable for brazing joint due to melting temperature. Melting temperature difference of header plate and tube material needs to identify for brazing compatibility. The temperature is provided to radiator core by furnace is compared with design temperature of furnace for brazing to analyse the variation. If flux jam in furnace or heat loss occur in furnace than variation occur in temperature provided to core and design temperature which will cause discontinuities in joint. Temperature at every phase of furnace is observed and no variation found in it. suitable brazing temperature of header plate and tube material is compared with design temperature and it is found ok.

Gap allowed between header plate and tube is 0.05 mm to 0.12 mm for braze joint fillet formation due to capillary action. Larger gap between header plate and tube reduces capillary action while smaller gap may restrict filler metal flow causing discontinuities in joint [8]. Gap is increased due to tube deformation so that flaring process is used to minimize the gap between header plate and tube.

B. Visual inspection

Header plate observed visually with the help of magnification glass and heavy burr found on slot of header plate. Heavy burr on slot profile of header plate shown in fig.6.

Figure 6 Heavy burrs on slots of header plate

C. Slot profile analysis on profile projector

Slot profile of header plate is analysed on profile projector at 10X zoom for better visualization of slot profile. Dents and rough cut of slot profile found on profile projector. It states the availability of heavy burr on header plate slots. There is no fix pattern of damaged slot found in observation of multiple samples of header plate slot profile which can states the damage available in particular slot punching die. But various slots of header plate found damaged so it means slot punching die needed maintenance to remove burr from slot profile. Dents occurs due to burr and rough cut on Slot profile found at top radius, bottom radius and sides of slot. Fig.7 shows profile of header plate slots.

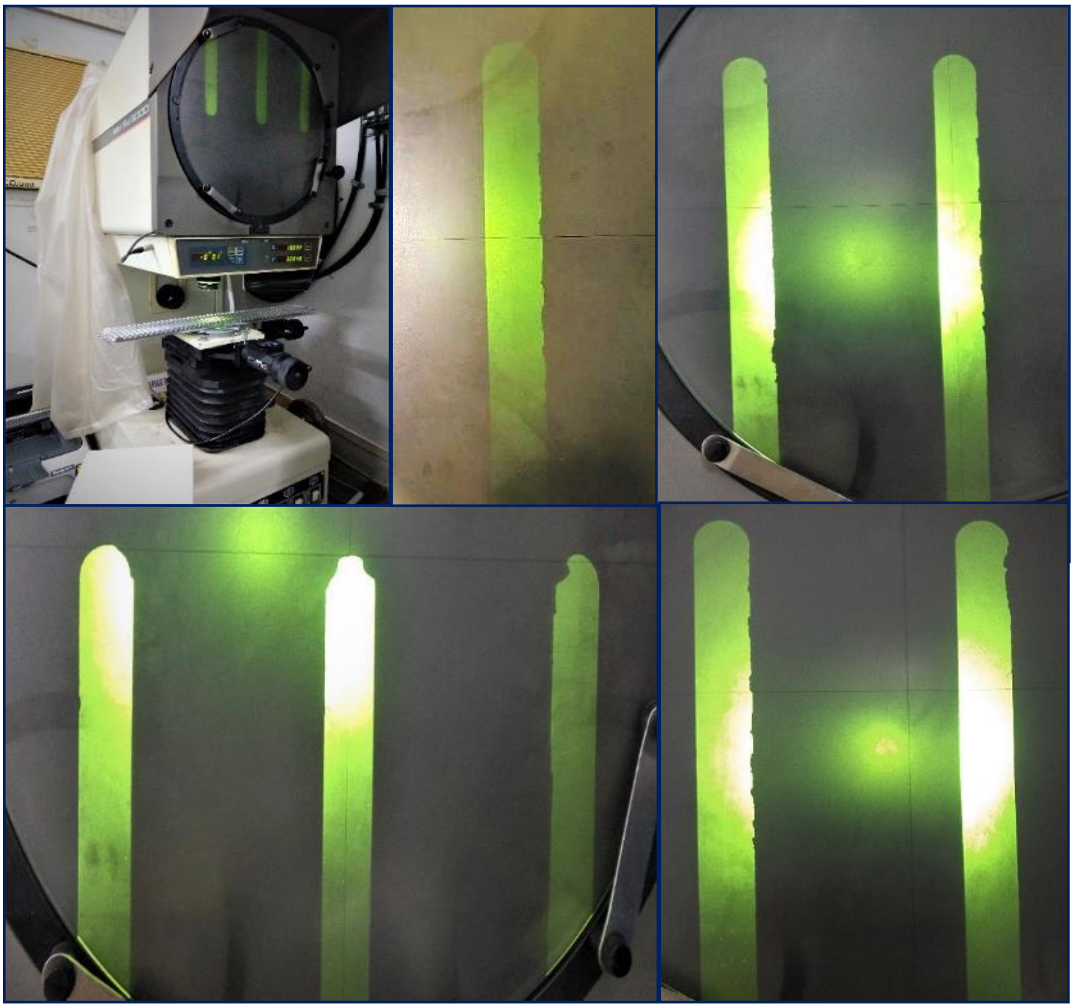

Figure 7 Slot profile analysis on profile projector

IV. RESULTS AND DISCUSSION

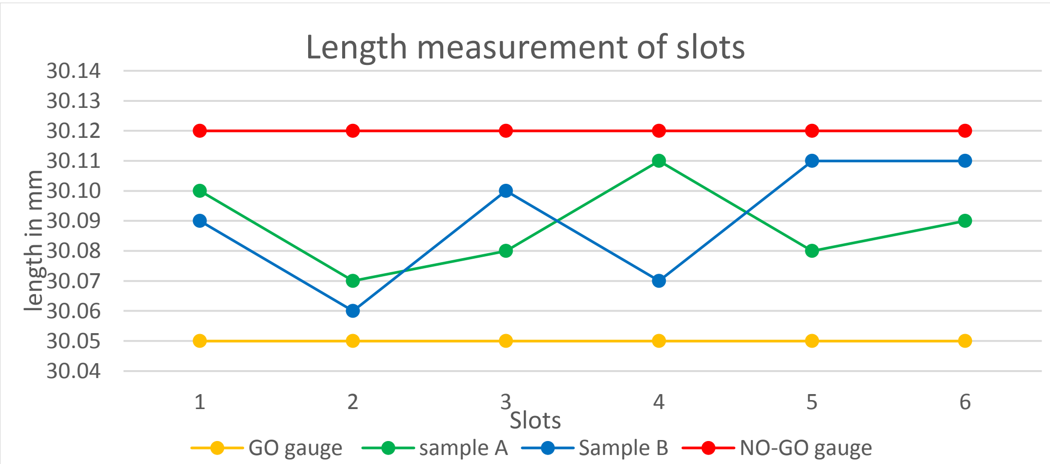

Figure 8 Length measurement of slots

Header plate to tube joint leakage is higher in radiator than other types of defects. Leakage is identified in radiator at wet leakage testing. So that header plate slots are measured. Length (major axis) of six slots of header plate are measured with Vernier calliper and inspected with go gauge and no-go gauge. After measurement and inspection, slot length is between 30.06 mm to 30.11 mm, it is found acceptable is shown in fig.8.

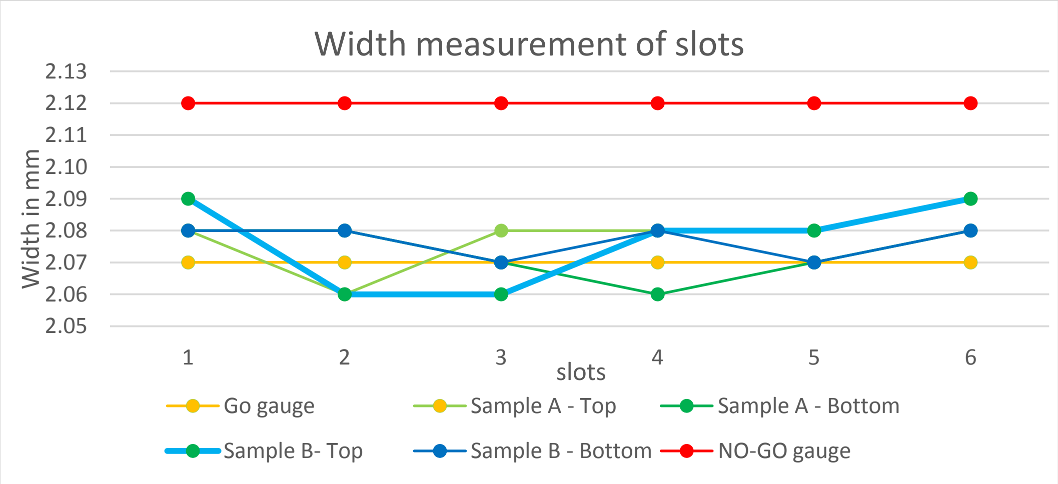

Figure 9 Width measurement of slots

Width (minor axis) of six slots of header plate are measured with Vernier calliper and inspected with go gauge and no-go gauge. After measurement and inspection, slot width is between 2.06 mm to 2.09 mm, it is found acceptable is shown in fig.9.

Heavy burr visualised in visual inspection with the help of magnification glass on the slot profile of header plate. Slot profile analysis is conducted on profile projector and found that the heavy burr on slot profile can damage tube which causes header plate to tube joint leakage.

V. CONCLUSIONS

Radiators are tested for leakage detection by various leakage testing methods. Each method has different capacity of leakage detection and own significance. Some methods are not feasible for leakage detection of radiator due to many aspects i.e. time duration of inspection, economically, more precision required, safety factor, etc. Dimension of major axis and minor axis of slot in header plate are found acceptable in dimensional measurement. Tube dimension is also measured and found acceptable. No dimensional errors are found in dimension analysis so that dimensional error is not reason for header plate to tube joint leakage. In visual inspection, heavy burr found on slot profile can damage tube which causes header plate to tube joint leakage. Dents (rough surface) on slot profile are found in slot profile analysis conducted on profile projector to analyse the slot profile of header plate. It is found that the die used for slot punching operation is damaged and heavy burr occur on slot due to it.
After observing various models for leakage analysis, various possible causes of header plate to tube joint leakage are identified. Cause-effect diagram is used to analyse the parameters concern with header plate to tube joint leakage. Flaring of tubes after core assembly is needed due to deformation of shape in assembly operation. Causes concluded from leakage analysis are:

- Burr on header plate slot (inside & outside burr)
- Improper flaring
- Tube cut by flaring punch or at core builder during assembly (at tube & header plate periphery)

REFERENES

[1] S. S. Mohtasebi, A. Taheri-Garavand, H. Ahmadi and M. Omid, “An intelligent approach for cooling radiator fault diagnosis based on infrared thermal image processing technique,” *Applied Thermal Engineering*, vol. 87, pp. 434-443, 2015.

[2] R. Senthilkumar, A. J. D. Nandhakumar and S. Prabhu, “Analysis of natural convective heat transfer of nano coated aluminium fins using Taguchi method,” *Heat Mass Transfer*, vol. 49, pp. 55-64, 2013.

[3] R. Jadar, K.S.Shashishekar and S. R. Manohara, “Nanotechnology Integrated Automobile Radiator,” *Materials Today: Proceedings(elsevier)*, vol. 4, no. 11, pp. 12080-12084, 2017.

[4] S. T. K. R. K.Sainath, “Experimental and computational analysis of radiator and evaporator,” *Materials today: Proceedings (ELSEVIER)*, vol. 2, pp. 2277-2290, 2015.

[5] Manual of VTech cool innovation, *VTECH LEAK DETECTION*, VTech cool innovation, 2006.

[6] R.S. Bhosale, P.P. Kumbhar, K.S. Mahajan, A.K. Yachkal and Anil Katarkar, "Study on Leak Testing Methods," *International Journal for Scientific Research & Development*, vol. 5, no. 1, pp. 1618-1621, 2017.

[7] D. Dabholkar, D. shenvi, N. Anekar and O. Joshi, "Design of Wet Leak Test Machine for Radiators: A Study," *International Journal of Current Engineering and Technology*, no. 4, pp. 343-346, 2016.

[8] M. Ainali, "cuprobraze Brazing Handbook," luvata, 2006, pp. 67-70.