Dry Testing Method for Heat Exchangers

Diana L. Cotoros, *Member IAENG*, Mihaela I. Baritz, Constantin M. Opran

***Abstract*— The paper deals with a new and modern technology used to test the tightness of the vehicles radiators or heat exchangers. This technology involves a dry testing method, different from the present one, which requires huge amounts of water and afterwards drying devices, that lead to increased costs of the product and environmental damage. We intend to propose a new testing possibility and prove its advantages in comparison to the one used at the present moment.**

***Index Terms*— radiators, tightness, dry testing, pressure**

I. Introduction

All cars, trucks or other types of vehicles are set in motion by internal combustion engines that develop high temperatures while they operate. The heat from the controlled ignition inside the cylinders needs to be safely dissipated in order to prevent the overheating. This is where the cooling system of the vehicle steps in by passing the cooling liquid through the radiator whose geometry should be suitable to acquire the dissipation of a huge amount of heat. The core of the cooling system is of course the vehicle radiator, which should provide a reliable tightness in order to work properly and with the best efficiency.

The manufacturers are compelled to check the tightness of their products before delivery and the technology they use stipulates submerging of the radiator in a water basin, at a pressure of 0,8 at. The possible lacks of tightness are observed by the worker in the form of air bubbles in the water. This method has a lot of disadvantages, among which we can remind of the following:

- after the testing, an additional drying operation is required, usually in some special furnaces, in order to prepare the surfaces before dyeing, as well as repairing the small imperfections (if necessary);
- the automation of the control operations is not possible, as a human operator is always required to observe the faults, fact that leads to some lack of objectivity or attention
- the working conditions are difficult, due to high humidity and bulky outfits
- increased consumption of water and energy
- possible environmental pollution due to the huge amounts of liquid wastes used during the tests.

The new dry testing technology removes the disadvantages presented above, due to the fact that instead of water we use a determined volume of air, at a pressure of 1 at that remains enclosed in the radiator for 1 minute. The faults are exposed by dropping of the air volume pressure and this event is signalized both optic and acoustic.

After the prescribed time, in case the pressure remains unchanged (meaning the radiator is tight) the air is evacuated and the test starts for the next radiator.

If during the test, the pressure does not reach 1 at (meaning we are dealing with severe defects) or if during the period of 1 minute the pressure drops under the value of 1 at (the case of small defects) we need to locate the exact position of the faults, so the wet test is performed. But the number of radiators subjected to the wet test will be much smaller than before, representing around 3 to 4% of the entire number of products.

II. Dry testing equipment

From theoretical point of view the dry testing equipment should contain tight connecting sleeves between the equipment and the radiator, used to apply the air volume under the required pressure, by help of pressure stabilizers and pneumatic distributors, pressure gauges with inductive proximity transducers meant to observe the pressure drop during the test period and a control and optical-acoustical signal block, which calls the attention upon the faulty products and also automates the testing procedure, except for the radiator connection to the equipment.

Practically, the equipment used for dry testing is designed of two parts: a pneumatic part and an electrical one (used for optic and acoustic signalization), see fig.1. Of course, the pneumatic part is controlled by the electrical part.

The pneumatic diagram consists of two circuits:

- the control circuit including the stabilizer ST2, the pneumatic distributor DP2, the control pressure gauge with inductive proximity transducer (sensor), adjusted for 1 at, M2 and the pneumatic driven connection sleeves, which assure the tight joint to the tested product CR;
- the tightening circuit consisting of the tap R, the stabilizer ST1, pneumatic distributor DP1, pressure gauge M1 to control the tightening pressure (between 3 and 5 at) and the connection sleeves CR.

Manuscript received March 20, 2008.

D.L. Cotoros is with the Department of Mechanics, Transilvania University of Brasov, Romania (corresponding author to provide phone: 0040722960509; fax: 0040268410525, e-mail: dcotoros@unitbv.ro).

M.I. Baritz is with the Department of Precision Mechanics and Mecathronics, Transilvania University of Brasov, Romania (phone: 0040744984077, e-mail: mbaritz@unitbv.ro).

C.M. Opran is with the Department of Manufacturing Technology, Politechnica University of Bucharest, Romania (phone: 0040744500417, fax: 0040214029930, e-mail: constantin.opran@ltpc.pub.ro).

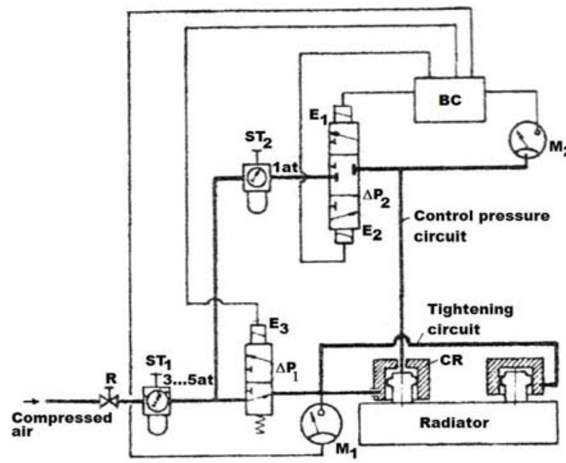
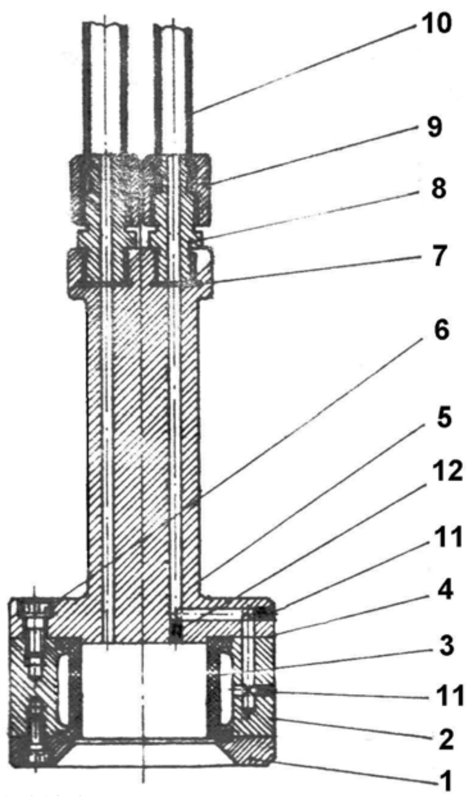


Fig.1 Dry testing equipment

In order to achieve a perfectly sealed connection between the test equipment and the radiator we need two connection sleeves (as shown before), whose design is very important for assuring a reliable test. The solution we come up with is presented in fig.2, where the consisting parts are the following:

1. Cap made of OLC45
2. Sleeve body also made of OLC 45
3. Circumferential joint made of rubber using a special die
4. Rubber ring
5. Handle with two passages, one of them sealed
6. Screw
7. Copper sealing
8. Nipple made of OLC 45
9. Cap nut
10. Hose
11. Brass threaded cap



12. Brass threaded cap

The threaded caps are plugging some of the passages in the body sleeve and in the handle because they are strictly technological, while others remain uncovered. A pressure test is required for (2) and (5) in order to check their sealing.

In order to check the tightness, we introduce compressed air through the passage covered with a brass threaded cap, the air will be forced through the sleeve body and from here through the sealing cavity (circumferential joint 3), which will mould upon the radiator joint, accomplishing this way the perfectly sealed connection.

To make the test the air is forced under a 1at pressure inside the uncovered passage, to the inside of the heat exchanger, where it should be kept for 1 minute.

The electric diagram for optic and acoustic signalizing is mainly including the control pressure gauge M2, the control and signalization block BC and electromagnets E1, E2, and E3. In order to support the luminous and acoustic signalization we use three signalization lamps and an alarm horn.

Fig.2 Connection sleeve

The first lamp will indicate the presence of voltage in the circuit, the second will show the finish of the normal checking cycle of 1 minute, while the third will signalize a pressure decrease (meaning a tightness problem for the checked product) and the alarm horn will signalize in the acoustic way, the same problems.

III. Using the Dry Test Equipment

After connecting to power, the first thing is opening the tap R to allow the compressed air to circulate towards the required circuits. We also manipulate the switches of the control panel that will act by help of electromagnet E3, on the distributor DP1, so that the air supply towards the control circuit and the tightening one is interrupted. The connection sleeves are fixed on the radiator and then the electromagnet E3 will be uncoupled. The compressed air from the stabilizer ST1 will pass through the tightening circuit connecting this way the radiator to the test equipment and assuring the connection tightness.

By help of the control panel we start electromagnet E2, allowing the compressed air from the stabilizer ST2 to pass through the distributor DP2 in the control circuit. When the 1 at pressure in the control circuit and inside the radiator will be reached, the M2 pressure gauge due to the inductive proximity transducer (adjusted for 1 at) sends a signal to the control block to uncouple E2. This way, the distributor DP2 accomplishes the tight closing of the air volume in the control circuit, including the radiator.

Starting from this moment, a timing relay from the control panel is measuring 1 minute and then, if the pressure does not drop below 1 at, it sends a command towards the electromagnet E1 in order to unload the control circuit. If the pressure drops within the 1 minute time interval, the inductive transducer on the pressure gauge M2 sends a signal to the control panel, which gives optic and acoustic warning on the defect presence. In case they are so significant that the pressure is unable to reach 1 at, another timing relay from the

ISBN:978-988-17012-3-7

control panel, that limits the air supply time, sends a signal to the control panel in 10 s in order to announce the malfunction.

IV. Testing efficiency

The radiators used for testing the new procedure and equipment came from a vehicles radiators company, which produces radiators for the Dacia type cars, see fig.3.

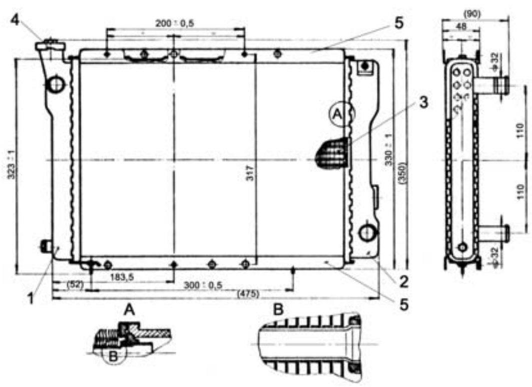


Fig.3 Tested radiator

In order to prove the benefits of using the new testing technology, we performed studies to determine the number of work hours, the number of necessary workers and last but not least the work efficiency, comparing the classic technology with the new one.

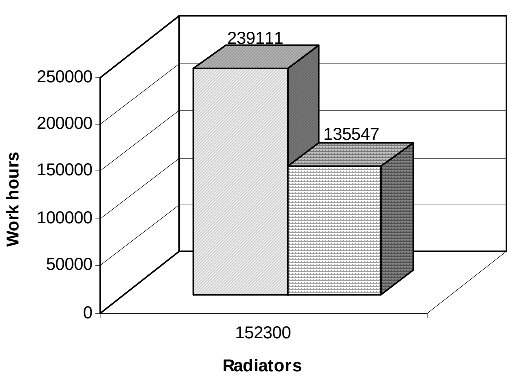


Fig.4 Diagrams of necessary work hours

The results are presented by comparison in fig.4-6. The results for the classic technology are expressed by the hachured blocks, while the results for the new technology are represented by horizontal bricks blocks.

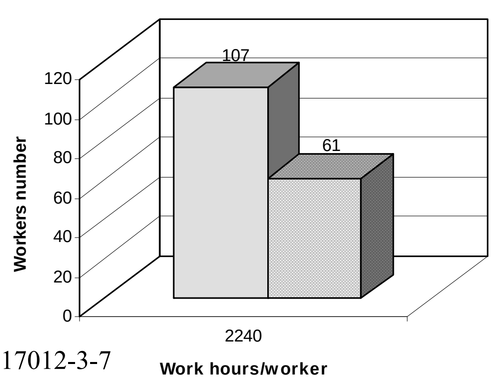


Fig.5 Diagram of workers number

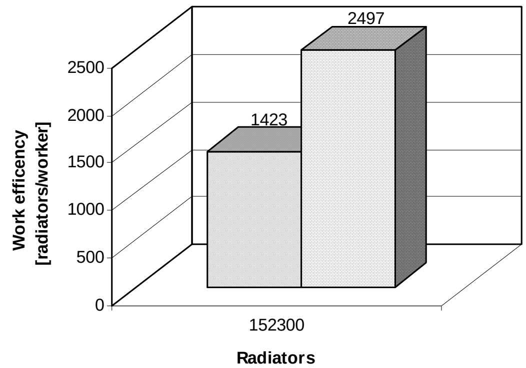


Fig.6 Diagram of work efficiency

Analyzing the diagrams, it becomes obvious that the new technology involves less work hours, less workers and of course increases with almost 50% the work efficiency, as the required actions are diminished, by comparison to the classic approach.

V. Conclusions

The present paper chose to modernize the testing technology for a type of radiator with the largest series of manufacturing in our country, concentrating upon some operations that require a relatively large amount of work and energy, involving procedures which are common for more types of similar products.

As we mentioned before, the use of radiators dry testing presents several benefits in comparison to the classic wet testing technology. The most important benefits are:

- the tightness test is done in a dry state, avoiding the drying operation required after the wet testing. Thus, we are able to save the energy consumed by the drying furnaces and also a tremendous amount of labour
- we may automate the tightness control, the only task of the human operator being the supply and evacuation of the products and also to start the testing cycle
- the radiators control operation productivity will be considerably increased due to the possibility of using a single operator to monitor several testing equipments
- the water consumption is also considerably decreased, as the submerging in a liquid environment remains necessary only for determining the exact location of the defects on the faulty products
- the operator’s working conditions are significantly improved, not only because of a lighter protection equipment, but also due to avoiding the wet and dirty environment

- the quality of the product is also improved by eliminating the liquid remnants between the interspaces and the cooling body
- less pressure upon the environment by eliminating the potential amounts of polluted water resulted from the wet tests

Of course, we have not exhausted all the possibilities of diminishing the consumptions in energy, materials or human resources or all the environmental threats, but the researches will continue in this respect.

References

[1] Kays, W.M. – *Compact Heat Exchangers*, McGraw – Hill Book Company, New York, 1977

[2] Whitaker, S., - *Fundamental Principles of Heat Transfer*, Pergamon Press, New York, 1977

[3] Schnabel, E., - *Contributii teoretice si experimentale la realizarea schimbatoarelor de caldura cu geometrie variabila din aluminiu*, Ph.D. thesis, Timisoara, 1980

[4] Cotoros, D., Popescu, I., - *Instalatie de incercare uscata a etanseitatii radiatoarelor pentru autovehicule*, Patent no. 94822/1988, Bucharest

[5] Shah, J., - *Fundamentals of heat exchanger design*, Lavoisier Librairie, France, 2003

[6] Carson, I., - *Living with the car*, The Economist, 1996, p.4-18

[7] Saunders, E.A.D., *Heat Exchangers: Selection Design and Construction*, John Wiley & Sons, New York, 1988

[8] Wong, J.Y., *Theory of Ground Vehicles, 2nd. Ed.*, John Wiley & Sons, New York, 1993

[9] Cotoros, D., - *Heat Exchangers for High Powered Engines*, Proceedings EE&AE, Rousse, Bulgaria, 2004