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DEVICE FOR DETERMINING ANTIFREEZE FREEZING POINT

The results of the development of the device for experimental measurement of antifreeze freezing point are provided. The device applies a direct measurement of antifreeze temperature upon its cooling to the freezing point using a thermoelectric module. An optimized heat exchange system, which has contributed to the development of a compact inexpensive device, available both to ordinary car enthusiasts and entrepreneurs dealing with car maintenance services, is used in the device design.

Key words: antifreeze, tosol, tester, freezing temperature.

Introduction

Urgency of an issue. Antifreeze is a coolant, and along with engine oil, brake fluid and fuel it is one of the main functional fluids of the car. The cooling system malfunctions during severe frosts usually occur if there has been a need to add water into an expansion tank during the year. This leads to the change in water proportion in ethylene glycol mixture and to the increase of the freezing point, respectively. Although, antifreeze diluted with water does not freeze, like water, however, if turned into a gel or a dense mixture with ice particles, it may cause problems with cooling system circulation and accelerated wear of a water pump.

Today the market of antifreezes (tosol cooling fluids) is rather diverse. Fakes, having nothing to do with original cooling fluid, flooded shop shelves and markets.

The question arises how to distinguish the true tosol from its fake, or how to check the quality of used antifreeze. The use of thermoelectric cooling in the development of special equipment for antifreeze quality control will promote to answer this question in full.

Literature analysis. Unlike water, antifreeze, being a water-ethylene glycol solution is freezing in several stages. Water freezes «instantaneously» and antifreeze freezes gradually; the liquid crystals begin to form at a certain negative temperature during cooling. Then, upon further cooling of the fluid, the amount of crystals increases therein - something similar to slurry is formed, and finally at some lower final temperature this slurry solidifies. The initial temperature of the first crystal formation is called «crystallization point». The final temperature of transition from liquid to solid state is called the «pour point».

There are different methods for determining antifreeze freezing point. Usually, «crystallization point» is used. In the CIS countries, this index is described in the regulations, developed on the basis of GOST 28084-89. However, in Europe, the term «freeze-proofing temperature» is oftener used. It is defined as an arithmetic average of the «crystallization point» and the «pour point». It is described in ASTM D1177.

There are many laboratory-household appliances for measuring crystallization point under «field» conditions. When using such devices, antifreeze does not freeze until the crystals appear, and other characteristics – density or refraction index, are measured, which are related to ethylene glycol concentration in the solution, and to the freezing point, respectively. The first type of such «laboratory-household» appliances includes a submerged density hydrometer («float»). It is immerged into the liquid, and base on its depth of submersion value one can estimate the density, and hence, the freezing point of the fluid. Sometimes, the measuring scale of such aerometers/ density hydrometers (also referred to as «aerometer - hydrometer») is not normally calibrated in grams per cubic centimetre, but in degrees Celsius, or in the percentage of ethylene glycol content in the solution. A typical representative of this class of devices is «hydrometer АЕГ / tosol cooling fluid, antifreeze /» Fig. 1.

Fig.1. Hydrometer АЕГ / tosol cooling fluid, antifreeze.

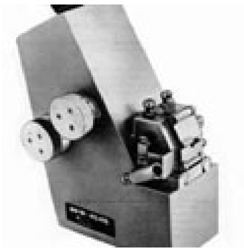
It should be noted that each hydrometer of this kind is calibrated for a certain liquid, such as "Tosol cooling fluid AM" or water-ethylene glycol solution, and when measuring other antifreeze it will cause an error of up to five degrees. When using an aerometer - hydrometer, the following three factors should be taken into account.

Firstly, this device measures the actual liquid density, rather than the freezing point. Therefore, the measurement made with hydrometer, can serve only as the indicator, the estimate of the freezing point, but not the qualification test.

Secondly, all antifreezes (and Tosol cooling liquids) include additive packages in their composition along with water and ethylene glycol, which differ in quantity and density. Therefore, various antifreezes have different densities when diluted with water depending on the freezing point, although they are similar to each other.

Thirdly, when conducting measurements with hydrometer, one should strictly observe the set temperature of the liquid measured. It is known that all bodies expand when heated, including antifreeze. Therefore, the same antifreeze will have different density outside and in a warm room. Accordingly, the hydrometer readings will be different: outside antifreeze would be «good», and the same antifreeze would turn «bad» inside. For the large majority of such devices measurements are expected to be conducted at the exact temperature of liquid + 20 °C.

The second type of «laboratory-household» devices is refractometers. In fact, this device measures the optical characteristics of antifreeze – the refraction index, which is also associated with the degree of dilution of antifreeze concentrate with water and the crystallization point. The accuracy of determining antifreeze crystallization point using it makes up ± 1 °C. Typical representatives of refractometers are laboratory «Refractometer ИРФ 454Б2 М» or pocket «Refraktometer VBC4T», fig. 2.



a) *b)*

Fig. 2. Refractometers: a) laboratory IRF 454Б2 M b) pocket VBC4T.

When using the refractometer one should follow the rules and safety measures for operating aerometers. The measurements were carried out at the exact temperature of liquid + 20 °C. The conversion table of the refraction index to the crystallization point for certain antifreeze brand should be used. If the pocket refractometer measuring scale has been set in degrees Celsius, it should be taken into consideration that the scale is adapted to a particular antifreeze type, most probable to ethylene glycol and water mixture. Such a device may be used only for indication (determination) of the crystallization point.

In addition to the devices, indirectly determining the antifreeze freezing point, there are devices for direct measurement of the freezing point, operating on the principle of actual antifreeze cooling with simultaneous monitoring the fluid state. For example, a series of automated devices for determining the crystallization point of oil products АРТЕ АТКт-01, АТК-02, АТЗ-01.

Fig. 3. ATK-02 device.

Fig. 4. "CRYSTAL" measuring device for low-temperature indicators of oil products.

The technological block of such devices has a form of a cryostat with an integrated test cell. The cryostat consists of an aluminium cup, wherein the product test tube is placed in the process of analysis. The cooling units consisting of semiconductor micro-refrigerators and radiators are placed on two opposite sides of the cup. Refrigerant continuously flows through the radiators in the course of analysis. Due to high efficiency of the semiconductor refrigerators, the temperature in the cup can be several tens of degrees lower than the temperature of the refrigerant, which, in most cases, allows the ordinary tap water with a temperature of above 20 °C to be used as the refrigerant.

Another example is "CRYSTAL" measuring device for low-temperature indicators of oil products.

The device has many functions, using it the crystallization point is automatically determined by analyzing the nature of the temperature change.

However, along with high precision of measurements, the mentioned devices are rather complicated in operation, have large dimensions and weight, and as a consequence, are rather expensive (approximately 5 – 7 thous. USD). Therefore, only large enterprises can purchase them [1-4].

Description of the development results

The device, which is easy to operate and is designed for experimental determination of antifreeze freezing point (or other non-corrosive liquids), has been developed and manufactured at ITE. The device lacks drawbacks that are inherent to aerometers and refractometers (can determine the freezing point practically of any non-corrosive fluid, falling within the operating range – from the ambient temperature to – 50 °C), has a high accuracy and low cost.

The principle of the device operation consists in a gradual cooling of an antifreeze drop placed in a cavity of an operating platform with simultaneous measurement of the temperature of this platform and visual monitoring of the aggregate state of the drop. The Peltier thermoelectric module is used as a cooling actuating element of the device. Heat dissipation from the thermoelectric module is achieved by a finned heat sink with a fan blow-off. Heat exchange system – operating platform with antifreeze drop – the Peltier module – heat sink with a fan – has been optimized by means of computer simulation. A two-stage low-power thermoelectric module was used in the device, which together with a highly efficient DC/DC voltage converter provided a possibility to manufacture sufficiently compact and fast-operating device.

The device for determining antifreeze freezing point is shown in Fig. 5 and its electrical circuit diagram – in Figure 6.

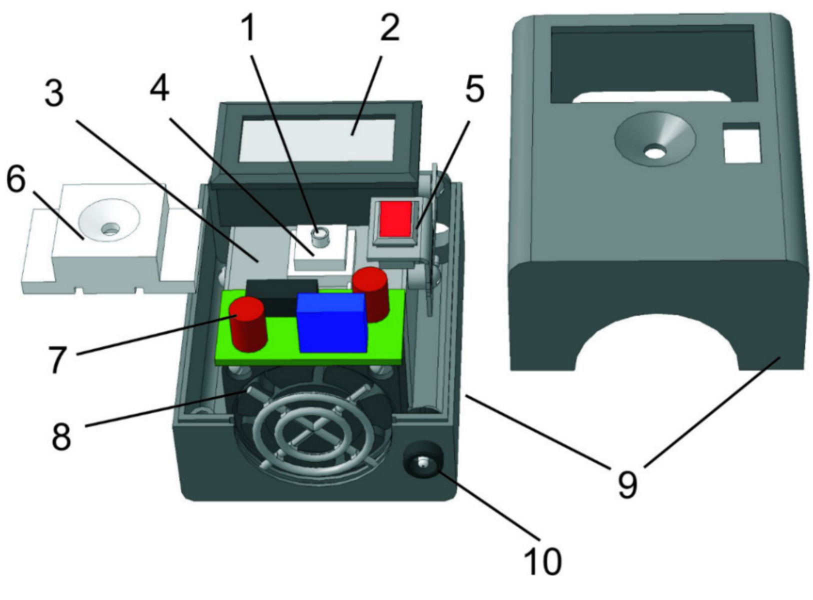


Fig. 5. Device arrangement. 1 – operating platform, 2 – digital thermometer, 3 – heat sink, 4 – thermoelectric module, 5 – switch, 6 – foam insulation, 7 – DC/DC converter, 8 – fan, 9 – housing, 10 – power input connector.

The device operating platform-1 is glued in the centre of the cooling side of the Peltier module - 4. Passive (hot) side of the module is fixed on the finned heat sink - 3. The air fan – 8 is fixed to heat sink on one side, along its fins. These elements constitute the heat exchange unit. The unit is secured with a bracket in the housing – 9, which walls additionally divide the hot and cold side of the unit. The housing incorporates a digital thermometer – 2, a switch – 5 and thermometer and module batteries. On the fan side, there is an opening in the housing for air intake, and on the opposite side – an opening for its outlet. These openings are closed with a decorative and protecting screen.

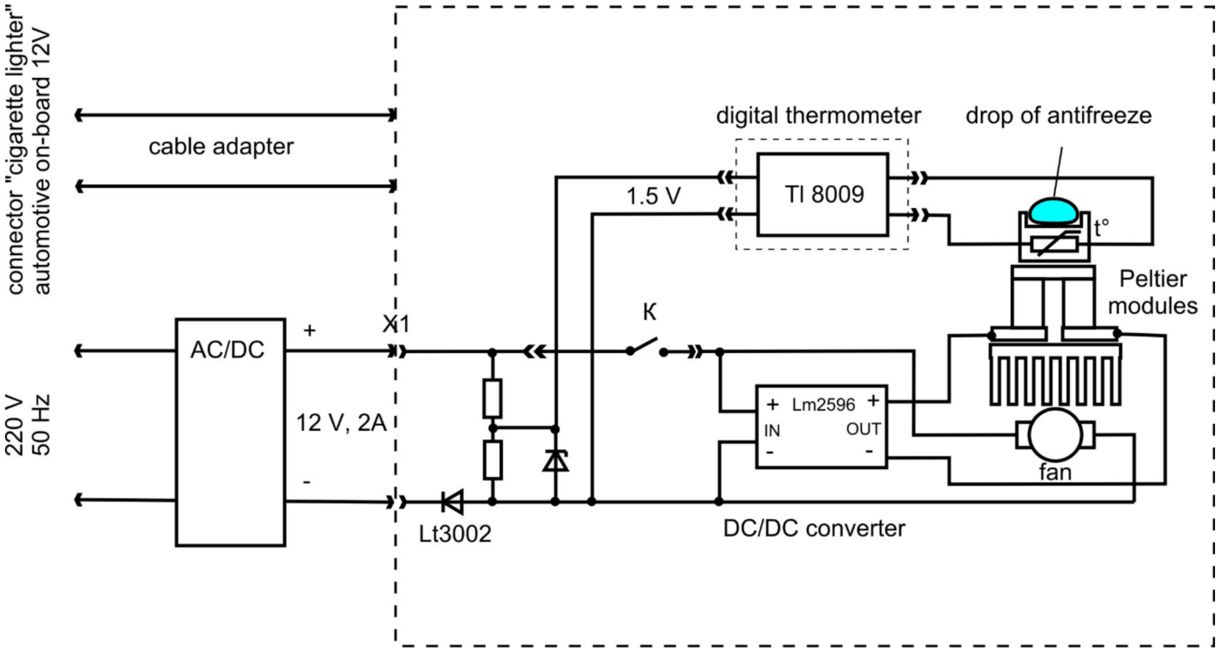


Fig. 6. Device electrical circuit.

Input voltage of X1 connector through the protective diode is supplied to the voltage divider, supplying the digital thermometer. The voltage is supplied from the same connector through the switch to the fan and DC/DC converter, which generates the stabilized voltage to supply the Peltier module.

The device uses a standard digital thermometer, temperature sensor which is located in a special hole designed for it in the operating platform.

The device is equipped with power supply unit. The adapter, with an input voltage of 110 – 240 V with a frequency of 50 – 60 Hz has an output voltage of 12 V DC at 2A. The device package is also completed with the cable adapter for the automotive on-board system voltage, 12V.

The device appearance is shown in Fig. 7.

Fig. 7. The appearance of the device for determining the antifreeze freezing point.

The device operation. When connected to the power supply, the temperature of the operating platform is shown on the thermometer display (in fact – the ambient temperature). Using a drop pipette, or other available means, a small antifreeze drop (2 – 3 mm in diameter) is placed in the operating platform cavity.

Upon switching on the power supply button, the operating platform together with the drop begins to cool. While observing the aggregate state of the drop and the thermometer readings at the same time, the freezing point of the liquid is determined by the drop turbidity. Upon further cooling of the antifreeze drop, some stationary process is observed when the module power is spent on the formation of antifreeze crystals, and at their saturation the temperature of the frozen drop begins to decrease again. The dynamics of antifreeze drop cooling is shown in Fig. 8.

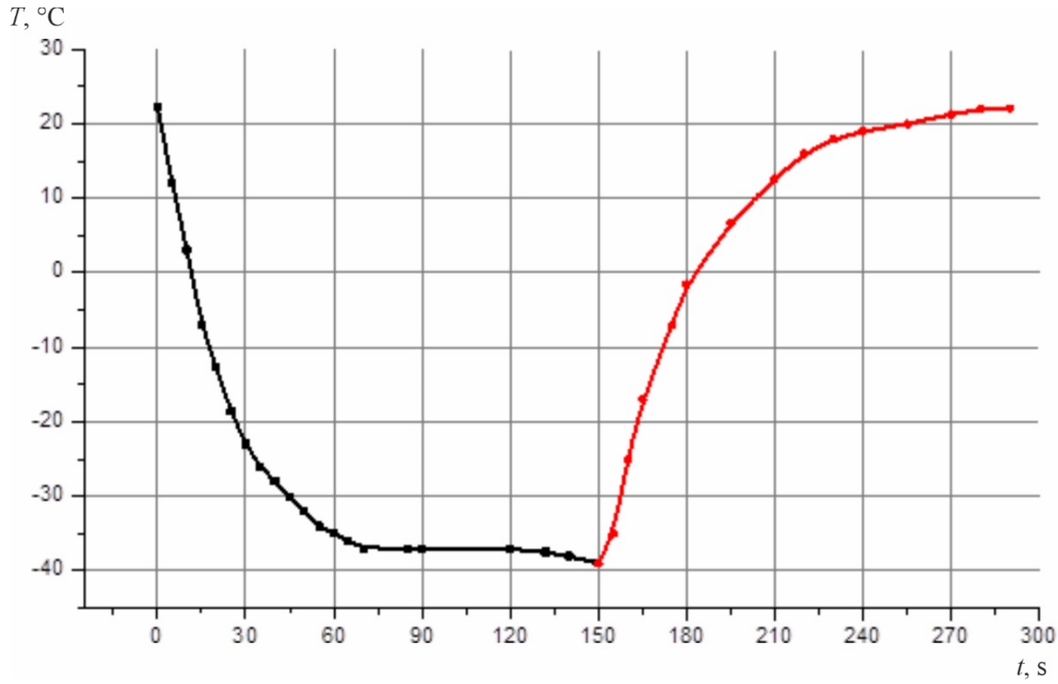


Fig. 8. Dynamics of antifreeze drop freezing-unfreezing on the device operating platform.

If the power supply to The Peltier module is switched off, the process goes in reverse direction, but an additional inflow of heat from the overheated (relative to the ambient air) heat sink, is observed.

After measurement completion, the antifreeze drop should be removed from the operating platform with a cloth or other absorbent material.

Conclusions

The considered device for determining the antifreeze freezing point due to its compact size, ease of operation and low cost will certainly gain interest among ordinary car enthusiasts and entrepreneurs selling automotive fluids and dealing with car maintenance services.

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ТЕСТЕР ДЛЯ ВИМІРЮВАННЯ ТЕМПЕРАТУРИ ЗАМЕРЗАННЯ АНТИФРИЗУ

Наведено результати розробки тестера для експериментального вимірювання температури замерзання антифризу. У тестері використовується пряме вимірювання температури антифризу при його охолоджені до температури замерзання з допомогою термоелектричного модуля. У конструкції тестера застосована оптимізована теплообмінна система, що дозволила створити компактний недорогий пристрій, доступний як рядовим автолюбителям так і підприємцям, які займаються автосервісом.
Ключові слова: антифриз, тосол, тестер, температура замерзання.

Література

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