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Automobile Absorption Conditioner

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Abstract. The purpose of this study is to develop a circuit for an automobile air conditioner, which will reduce the consumption of power developed by the engine. This paper proposes the design of an automobile absorption air conditioner. A description of the principle of operation of an automobile absorption air conditioner operating on a cycle of a one-stage absorption refrigeration machine has been given in the paper. It consists of a stripper (generator), a condenser, an absorber, an evaporator. Lithium bromide (LiBr) solution has been used as an absorbent, which has a low boiling point, is non-toxic and safe. 3D-models of the absorber and generator of an automobile absorption air conditioner has been developed in the course of the research. The absorber is designed to form a weak absorbent solution. This solution is supplied to the generator heat exchanger using a liquid pump. There it is heated by the exhaust gases to the boiling point. The solution evaporates and water vapor enters the condenser (evaporator). In the generator, the solution is concentrated from 52 to 60 %. After that, water vapor is supplied to the absorber from the condenser, and a concentrated absorbent solution is supplied from the generator. It should be noted that the generator is a key element of an automobile absorption air conditioning system. Inside it is a strong LiBr solution that feeds the absorber. The design of the air conditioning system does not provide for the use of a compressor and allows to reduce the power loss of the power plant to the drive of the liquid pump. According to calculations, the pump drive power was 0.17 kW. For comparison, the compressor of a modern car air conditioner consumes 7–11 kW. An absorption car air conditioner provides the following advantages: additional engine cooling, environmental friendliness, fuel economy, efficient use of the heat of vehicle exhaust gases. A distinctive feature of this design is that it is proposed to use the heat of the exhaust gases for the process of heating the absorbent. This design can fully compete with the existing modern car air conditioners.

Keywords: automobile conditioner, absorption bromide-lithium refrigerating machine, absorption, absorber, desorber, lithium bromide, exhaust gases

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Автомобильный абсорбционный кондиционер

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Реферат. Целью исследования являлась разработка схемы автомобильного кондиционера, позволяющего снизить потребление развиваемой двигателем мощности. Предложена конструкция и приведено описание принципа действия автомобильного абсорбционного кондиционера, работающего по циклу одноступенчатой абсорбционной холодильной

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машины. Она состоит из десорбера (генератора), конденсатора, абсорбера, испарителя. В качестве абсорбента использовали раствор бромида лития (LiBr), который имеет низкую температуру кипения, не токсичен и безопасен. В процессе исследования разработаны 3D-модели абсорбера и генератора абсорбционного автомобильного кондиционера. Абсорбер предназначен для образования слабого раствора абсорбента, который при помощи жидкостного насоса поступает в теплообменник генератора, где нагревается отработавшими газами до температуры кипения. Раствор испаряется, и пар идет в конденсатор (испаритель). В генераторе раствор концентрируется от 52 до 60 %. После этого в абсорбер из конденсатора поступает водяной пар, а из генератора – концентрированный раствор абсорбента. Следует заметить, что генератор является ключевым элементом системы абсорбционного автомобильного кондиционера. Внутри него находится крепкий раствор LiBr, питающий абсорбер. Конструкция системы кондиционера не предусматривает использование компрессора и позволяет снизить потери мощности силовой установки на привод жидкостного насоса. Согласно расчетам, мощность привода насоса составила 0,17 кВт. Для сравнения, компрессор современного автомобильного кондиционера потребляет 7–11 кВт. Абсорбционный автомобильный кондиционер имеет следующие преимущества: дополнительное охлаждение двигателя, экологичность, экономию топлива, эффективное использование теплоты выхлопных газов автомобиля. Отличительная особенность данной конструкции в том, что для процесса нагрева абсорбента используется теплота отработавших газов. Такая конструкция может составить полноценную конкуренцию имеющимся современным автомобильным кондиционерам.

Ключевые слова: автомобильный кондиционер, абсорбционная бромисто-литиевая холодильная машина, абсорбция, абсорбер, десорбер, бромид лития, отработавшие газы

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The car air conditioning system is actively progress. A lot of research is implement to improve the design. Much attention is pay to improving the evaporator heat exchanger and other details of existing systems [1, 2]. In addition, new air conditioning systems are being developed. For example, using an ejector [3]. Research is being conducted to select a new, more efficient type of refrigerants [4, 5]. The results of these studies, to one degree or another, solve the problem of improving the efficiency of the vehicle air conditioning system.

Air conditioning systems based on new principles are of great interest. These include systems based on an absorption refrigeration cycle. Ammonia or lithium bromide solution is considered as a refrigerant [6, 7].

A modern automobile conditioner averagely consumes from 3 up to 6 kW of power produced by the engine. The significant decrease of the mechanical losses on the conditioner drive can be achieved removing the compressor, which drives the cold carrier in the cooling system, from the system.

The conditioner adapted for the cycle of absorption bromide-lithium refrigerating machine (ABRM) can be used to produce cold, apart from the compression-type conditioner. In contrast to the compression method, where the single-phase cold carrier (freon) circulates in the refrigerating loop, in the absorption one the mixture of water and absorbent is used. Lithium bromide with low

boiling temperature (90 °C) is used as an absorbent. When moving along the refrigerating loop, this mixture splits into the components and then mixes again [8]. There is no compressor in ABRM design, the engine power is only consumed for the liquid pump drive providing the transport of strong and concentrated solution. ABRM functional scheme is given in Fig. 1.

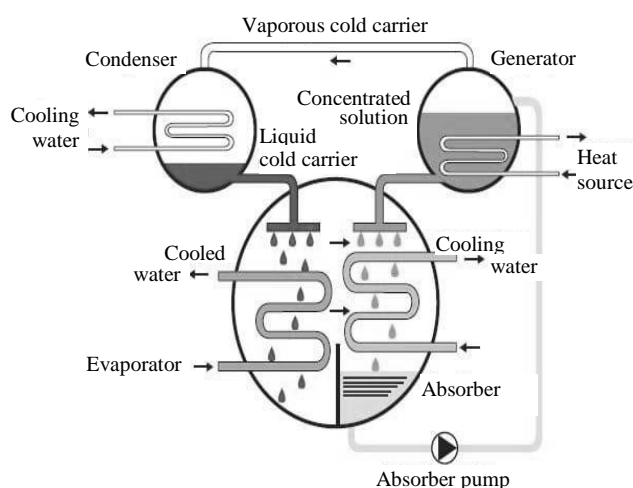


Fig. 1. Absorption bromide-lithium refrigerating machine functional scheme

The main elements of this device are: desorber (generator), condenser, absorber and evaporator. There are also auxiliary elements providing the reliability and safety of the refrigerating machine operation. These are different shutoff, throttle, solenoid valves and automation system.

The water vapor, formed under the action of cooled medium, comes from the evaporator to the absorber with the strong lithium bromide solution. As a result of water vapor and solution absorption, the concentration of the latter decreases [9, 10]. With the help of the liquid pump the weak solution is fed through the heat exchanger fixed on the exhaust pipe of the outlet header. Going through the heat exchanger, the solution is heated up and gets into the generator where it boils. The water vapor formed is fed into the condenser where it is condensed. The solution obtains low concentration again in the generator and gets into the absorber with the help of the bypass valve. Along the system pipes the condensate is fed into the evaporator. Thus the process cyclicity is provided.

The absorber (Fig. 2) is of closed type placed in one body with the evaporator. The desorber (generator) (Fig. 3) is the key element of the absorption automobile conditioner system. Strong LiBr solution, feeding the absorber, is inside the body.

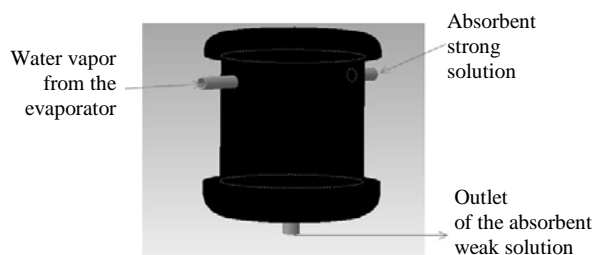


Fig. 2. Absorber 3D-model

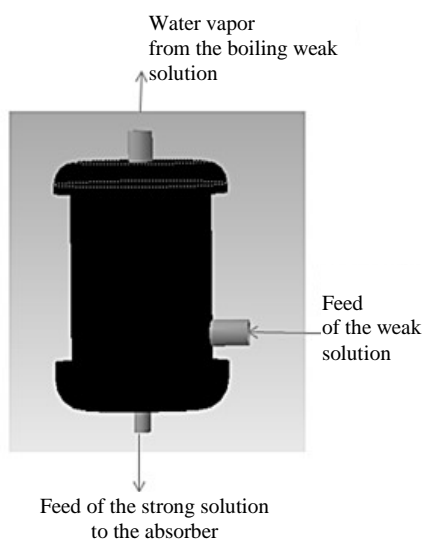


Fig. 3. Desorber 3D-model

The condenser (Fig. 4) consists of copper U-pipes, aluminum plates and brackets of galvanized steel. U-pipes are interconnected by the method of copper U-bends soldering. The couples in the heat exchanger pipes are permanently and uniformly blown by the outer air, which is fed by the fan.

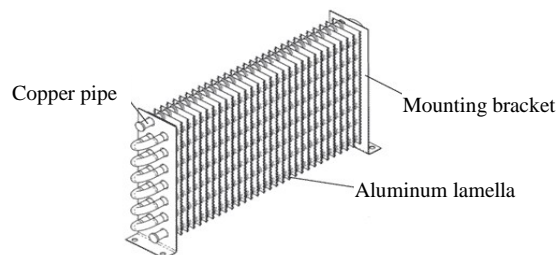


Fig. 4. Air-cooled condenser

The evaporator (Fig. 5) in absorption automobile conditioner is a starting point of the whole process. In the hot season, the warm outer air flows through the evaporator pipes with the help of the fan. As a result, the water circulating along the pipes starts evaporating producing water vapor, which is fed to the absorber via the special nozzle where it gets absorbed with LiBr solution.

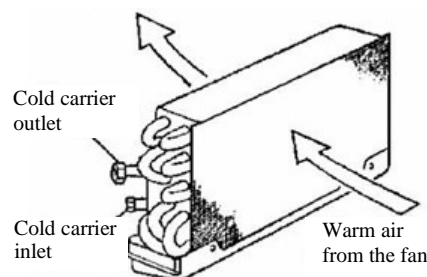


Fig. 5. Evaporator

Exhaust Gas Recirculation (EGR) is used in modern vehicles. This system is designed to improve engine efficiency and reduce fuel consumption [11]. One of the elements in the EGR-system is a shell-and-tube heat exchanger (Fig. 6), through the tubes of which the exhaust gases pass from the exhaust manifold of the engine.



Fig. 6. Exhaust Gas Recirculation heat exchanger

In this paper, it is proposed to introduce the EGR-system heat exchanger into the absorption cycle of the vehicle air conditioning system.

The liquid pump provides the forced cold carrier circulation in the absorption conditioner system. With its help, a weak LiBr solution is fed to the generator from the absorber. The automobile absorption conditioner design is given in Fig. 7.

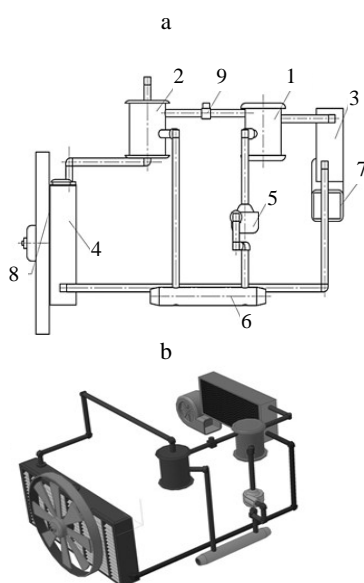


Fig. 7. Automobile absorption conditioner design:
a – schematic diagram; b – 3D-model of the conditioning system; 1 – absorber; 2 – desorber; 3 – evaporator; 4 – condenser; 5 – liquid pump; 6 – heat exchanger; 7 – evaporator fan; 8 – condenser fan; 9 – bypass valve

CONCLUSION

Thus, the design of an automobile absorption air conditioner has been developed. The main elements of this device are: desorber (generator), condenser, absorber and evaporator. Lithium bromide is proposed to be used as an absorbent. It has a low boiling point. Lithium bromide is non-toxic and safe. The resulting design of the air conditioner reduces the power loss of the power plant to drive the liquid pump. According to calculations, the pump drive power was 0.17 kW. For comparison, the compressor of a modern car air conditioner consumes 7–11 kW. An absorption car air conditioner provides the following advantages: additional engine cooling, environmental friendliness, fuel economy, efficient use of heat from vehicle

exhaust gases. This design can compete well with existing modern car air conditioners.

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