TEKA Kom. Mot. i Energ. Roln. – OL PAN, 2010, 10B, 49-55

FLAP TYPE LOUVER APPARAT FOR COOLING DEVICE IN MODERN LOCOMOTIVES

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Summary. The experience of using the upper louver of locomotives is analysed in the article. Constructive solutions of the upper louver with improved characteristics are proposed. The effectiveness of the structures of the upper flap-type slouver is substantiated. The results of research is represented.

Key words: diesel engine, cooling device, ventilator setting, jalousie vehicle, efficiency.

INTRODUCTION

World experience of the use of cooling devices with louver apparatus (upper louvers) of different constructions and their analogies (roof shutters, net cover), clearly demonstrates the importance and relevance of the development directions of improving the efficiency of cooling devices using the newest modern diesel development of universal louver units and research in this area.

In the cooling devices of modern locomotives fan works primarily on the absorption with the immediate release of air in the upper atmosphere through the blinds or grid (for some diesel locomotives, mostly destined for export, upper blinds replaced by a grid or lattice of wires) [1]. For diesel engine cooling devices are used exclusively axial fans, which provide higher performance at a relatively small diameter of the fan wheel hub. Usually in the fan inlet guide vanes are installed, usually motionless. At the exit of the fan the diffusers or cut-off devices to reduce the loss of dynamic pressure are instaled often.

STATEMENT AND PROBLEM SOLVING

The power that is expended on the fan motor, depends not only on the aerodynamic drag of cooling machines, but also from losses in the intake and discharge channels, which on average is for domestic locomotives 50-60% of the total aerodynamic drag of the system [2]. Using such a fan almost all dynamic head is lost in

production output. The lower the dynamic pressure, the lower the losses and, consequently, the more economical will be the work of the fan and cooling device.

In the cooling devices of the domestic and many foreign locomotives bihind the fan wheel the louvers with flat parallel or radial valves are instaled. In this case, they have a significant influence on the characteristic of the fan installation by modifying mainly the curves of pressure and efficiency, which leads to diesel operation at high temperature fluids, reduce reliability, limiting the power propulsion unit and, consequently,to a deterioration in fuel economy.

The currently applied at locomotives upper shutters of various designs are material intensive and work from an actuator (hydraulic), reduce the performance of a fan cooling device. Lack of heat-dissipating capacity of the refrigerator and a large variance power for driving the motor-fan due mainly to poor design of the refrigeration chamber. Therefore, the new locomotives should use cold chamber with the upper blinds best design.

As a result of research and review of the existing constructions, it was found out that the upper shutters must meet the following requirements:

- Have minimal aerodynamic resistance;
- Work independently, i.e. without drive;
- Be the least material intensive, inexpensive and yet reliable in operation;
- Should be easily dismantled, interchange.

Concerning the foregoing, it should be noted that the usefulness of a particular design of the upper shutters should be determined on the basis of cost-effectiveness analysis, and other conditions being equal quantities efficiency of the fan and the coefficient of aerodynamic drag. In addition, the hard clear height forces to develop and establish upper blinds most compact design.

Improving the efficiency of cooling devices of locomotives is largely determined by the aerodynamic perfection fan channels with louvre apparatus at the output, which, on the one hand, must have a minimum hydraulic resistance, on the other - meet all the requirements of the unification of separate elements,and design in general. The combination of the above mantioned requirements is provided in the construction of the upper rims [3], which is a petal Lasts a cooling device of the locomotive apparatus (schematically shown on Fig. 1) that was developed by the Department of Railway Transport of V.Dal EUNU. Its advantages over the old construction of the upper shutters are the following: deletion of the pneumatic (hydraulic) drive blinds to reduce the consumption power of the locomotive to work the fridge, getting the full battery life of this designuniform opening louvre shutters, depending on the speed of the fan wheel, use louvre shutters as rectifying apparatusreduction of the material.

The design of the leaf louvre apparatus has a frame 1, which placed the leaf 2, made in the form of petals. Large base of wings connected to the apparatus housing 1 louvre hinges 3. On the radome of the fan 4 intevalvulars trough is installed 5, reinforced rubber seals 6 and housing 1 louvre system, coupled with an output confuser-limiter 7. Alternatively, intevalvulars trough 5 can simultaneously perform the function of rectifying apparatus.

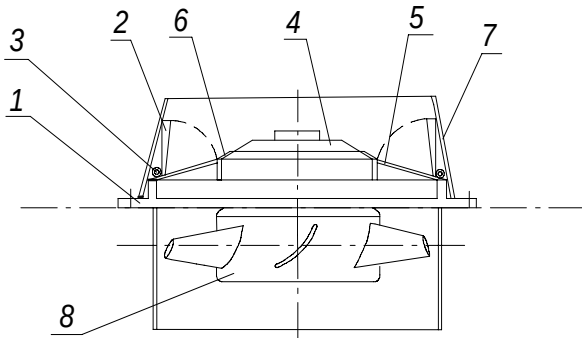

Fig. 1. Scheme of the flap-type louvre apparatus with confuser-limiter of the cooling device of the locomotive

Flap louvre unit operates autonomously on the basis of the valve. The device operates as follows: the content of housing 1 leaf 2 opening when the fan 8, under the action of aerodynamic pressure. Net weight or spring (flat or cylindrical) help to close door. Angle of opening valves 2 is adjusted by changing the number of fan speed 8.

Among all the variety of patented designs of the louvre apparatus for cooling device of the locomotive remains only to determine the most efficient use of a design on a particular locomotive, considering confused or cone shape outlet louvre system.

Flap type apparatus that is used in the cooling device of the locomotive and that is installed directly behind the fan wheel, has opening doors, that are petals shape, which, while opening make confused or cone ring channel [4]. In turn, confused and cone circular channel also depends on the performance of various constructive flap louvre apparatus (cone shape of the fairing of the fan, the output channel of corpus louvre system, effuser-limiter).

With constructive calculating of the regulatory air flow organs, such as petal louvre unit with confuser-limiter [3] and other pipeline narrowing devices as design parameters is widely used flow coefficient μ, magnitude of which depends on the type of construction of the equipment in service and rate of opening of flow passage, as well as the flow regime. It is necessary for determining the area of flow passage in the louvre unit and of narrowing unregulated devices (muzzle, nozzles, diaphragms). That is why the discharge coefficient is the most important integral characteristics of narrowing devices. In this regard, the urgent question is about the extreme maximum rating of the discharge coefficient, and, consequently, a theoretically optimal from the aerodynamic point of view of the channel.

Flap louver apparatus of cone-type apparatus [5] (Fig. 2) is used to convert kinetic energy of flow into the energy of pressure, which in a smooth transition from section to section of smaller area to larger area provide a minimum pressure loss. Diffuser channel of the petal louvre apparatus should have a shape of running part that provide the maximum efficiency, i.e. unseparated flow in a wide range of inlet flow rate, and also have the most uniform field distribution of the flow at the outlet. Maximum efficiency of louvre apparatus (diffuser) depends on the geometric and operational parameters, foremost among which is the degree of expansion $m=(D/d)^2$ and

the opening angle β. Small opening angle increases the length of the channel, i.e. increase material intensity and the weight of the flap louvre system.

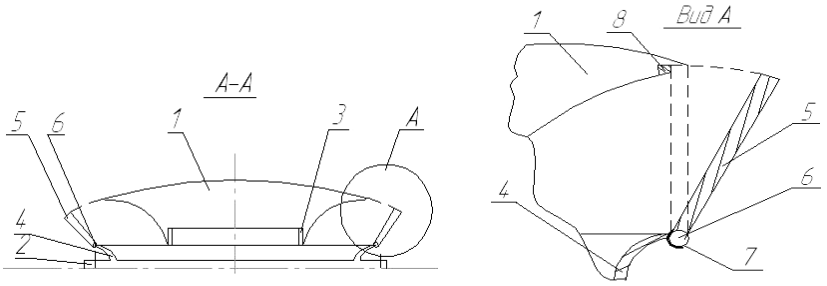

Fig. 2. Scheme of the diffuser type flap louvre apparat of the cooling device of the locomotive: 1 – fan radome; 2 – the body of louvre apparat; 3 – rainforced rubber units; 4 – outlet channel of diffuser shape; 5 – louver shutters; 6 – swing joints; 7 – torsional spring; 8 – rubber joints.

One of the defining conditions for effective work of the flap louvre apparatus (diffuser) is unseparated nature of the movement of the working environment in his flowing part. There is no area of stabilized motion, and therefore smooth of the flap louvre apparatus with inlet section, even with a small radius significantly reduces the loss. The loss of energy determines the degree of perfection of the cone flap louvre system, i.e. the smaller it is the more perfect louvre unit is. Energy loss in the flap louvre apparatus consists of friction losses and flow on the wing and diffuser to increase the flow.

The problem of the flow in the diffuser, and, consequently, in one of the proposed design performances of the flap louvre aparatus - one of the most difficult problems in aerodynamics.The main purpose of the diffuer - a gradual decrease in flow velocity and hence pressure recovery with the greatest possible efficiency, i.e. with the least losses that leads to greater efficiency of heat transfer in the cooling device. The structure of flow in the diffuser elements and processes that accompany the over flow are quite complex, that significantly complicates their analytical calculation. In this regard, the experiment plays a significant role in obtaining reliable design characteristics of the diffusers.

The aim of the pilot study is to determine the aerodynamic characteristics of the louvre apparatus cooling device of the locomotive, which will be needed to confirm the correctness of theoretical calculations when creating a mathematical model of airflow. Object of the tests, i.e. petal louvre apparatus is part of the air cooling systemof the locomotive and serves as a rectifying device, the refrigerator device and air exhaust channel, and also prevents the ingress of precipitation in the fan.

While testing the models of louvre apparatus the method of Integral Studies in the wind tunnel was implemented. Application of this method for research of the louvre apparatus cooling device may be due to axisymmetric arrangement of wings of the louvre system and their absolute identity to each other, as well as a comprehensive and reliable measurement of the basic aerodynamic parameters of the model [6]. Wind tunnel allows to determine the aerodynamic parameters of air flow pneumometric

devices, both in the individual model elements, the cooling device, and taking into account their interaction [7,8].

Investigation of aerodynamic characteristics of the cooling device of the locomotive with the flap type louvre apparatus at the output is made with the mathematical modeling of the air flow in the fan channel of the cooling device. The results of researches have shown that the air flow in the flap type louvre apparatus of the cooling device of the locomotive is turbulent flow of a liquid [9].

In the louvre mechanism under the study, depending on the angle blinds, flows occur with gradual expansion of the flow (positive angles) and a gradual compression (negative angles). Flow with a gradual increase (diffuser) is accompanied by an increase in pressure and, consequently, by the conversion of kinetic energy of the gas into the energy of pressure. Particles of the moving gas overcome the growing pressure due to kinetic energy, which decreases along the gradual expansion. The layers of gas adjacent to the walls have such a low kinetic energy that sometimes are not able to overcome the increased pressure, they stop and begin to move back. The reverse movement causes separation of the main flow from the wall and vortex. The intensity of these processes increases with the angle of expansion, together with the growing losses on the vortex formation. Thus, with different corners of the opening blinds occur different resistance and, consequently, the coefficient of local resistance. With a gradual narrowing of the stream (at small angles of opening shutters) gas flowing is accompanied by increase of the speed and decrease of the pressure at the beginning of a gradual narrowing of greater than at the end, there are reasons for the occurrence of vortex formation and disruption of the flow (as in a gradual expansion, or at large angles of opening blinds). Vortex formation and flow separation from the wall with simultaneous compression of the flow occurs at the output of confused flow part. Thus, the smaller the angle of opening shutters is, the more stream is compressed, that leads to great losses of energy and, consequently, the coefficient of local resistance increases. As a result of mathematical modeling [10] the approximating the second-order polynomial is obtained, describing the change in the coefficient of aerodynamic outlet drag with with leaf lasts mechanism from regime and geometric parameters:

$$\zeta = 1.871 - 0.015 \cdot \mathrm{Re} + 0.039 \cdot \alpha + 0.283 \cdot \mathrm{Re} \cdot \alpha - 0.81 \cdot \mathrm{Re}^2 - 1.315 \cdot \alpha^2.$$

On Fig. 3 the dependence of change of relative factor of local resistance ζ is shown on size of a corner of opening of the jalousie, defined by calculations of mathematical model. The coefficient of local resistance are carried to coefficient of local resistance at $\alpha = 0$. At calculation of coefficient losses on a friction on length of a flowing part are considered. As fig. 3 shows, the least resistance at $\alpha = 0$, also it is possible to consider as optimum angles corners from 80 to 104^0.

The analysis of the received results shows satisfactory conformity of mathematical model of movement of an air stream in the cooling device with petal jalousie device on an exit, to experimental data.

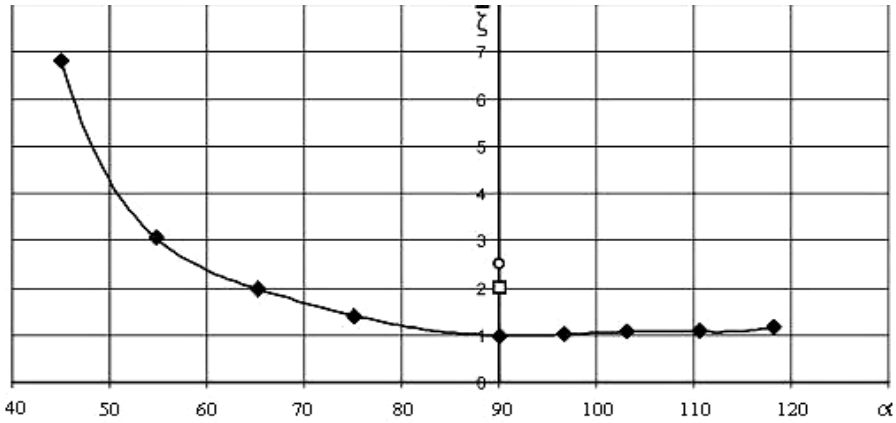

Fig. 3. The characteristic of change of resistance coefficient from a angle of disclosing of louvers:
♦ – petal louver device (each point corresponds to a certain design,
a point on an axis - the cylindrical channel); □ – the top louver of plane folding type;
○ – radial louver.

CONCLUSIONS

Conducted investigations of the designed flap type louvre devices have proven their efficiency and the possibility of real use at the modernized and re-created diesel locomotives.

Conducted investigations have shown that in the locomotive engineering, where the axial dimensions and weight should be as small as possible, preferably to except the opening angle of louvre apparatus (diffuser) maximum permissible, selecting the optimum design of the diffuser on the basis of technical and economic compromise between the length and pressure loss. If we approach the problem from the standpoint of the designer, the best would be a diffuser, which provides the required reduction in the rate of minimal length with a minimum loss of total pressure, uniform fields of the parameters and steady flow at the outlet of the flap louvre system.

In addition, the results of this investigation establish practical recommendations for the creation of new original designs of louvre apparatus to optimize the process of cooling power units of the locomotive.

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ЖАЛЮЗИЙНЫЙ АППАРАТ ЛЕПЕСТКОВОГО ТИПА ДЛЯ ОХЛАЖДАЮЩЕГО УСТРОЙСТВА СОВРЕМЕННОГО ТЕПЛОВОЗА

Могила В.И, Светличный К.А.

Аннотация. В статье анализируется опыт использования верхних жалюзи локомотивов. Предложены конструктивные решения верхних жалюзи с улучшенными характеристиками. Обосновывается эффективность применения конструкций верхних жалюзи лепесткового типа. Представлены результаты проведенных исследований.

Ключевые слова: тепловоз, охлаждающее устройство, вентиляторная установка, жалюзийный аппарат, эффективность.