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Substantiation of parameters and operation modes of device for thermal comfort of a mobile machine operator

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Abstract

The effects of heat and cold on the human body lead to a reduction in its protective power and reserve capacity. The productivity of operators is reduced by 25~55% with ambient temperature increasing up to 28~31°C. It is proved that the temperature and human performance have a strong correlation. The process of forming the thermal state of the human operators in the cabs of mobile machines is still to be understood by automotive engineers. On the basis of theoretical research, we have identified the main factors influencing the thermal state of the human body, justified the blueprint and design parameters of the proposed device for thermal regulation. There is a power dependence of heat flux on the thickness of the operator's clothes, the power, and distance of their body from the local device. When experimenting with the relationships between the human operator's thermal state (thermal sensation) indicator and the parameters of microclimate in the mobile machine cabs, we considered the operating modes of the device. Experimental studies were carried out in a climatic chamber based on a unified cabin. The experiments determined the value of the power density of the heat flow. It amounted to 486 watts; this will be needed in the future to calculate the constructive and regime parameters of the proposed device.

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Keywords: The operator of the mobile machine; thermal comfort; conductance; thermoregulation; thermal sensation; the climate; the heat flux.

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1. Introduction

The level of conditions and safety in the workplace operators of automotive engineering determines its demand and the competitiveness of the market. High power equipment and complexity of control systems in modern mobile machines (MM) requires a search for new solutions to create comfortable conditions for the work of the human operator. The causes and the degree of reduction human performance are defined by the thermal condition of his body and its heat content. Scientists say that high efficiency is maintained for 6 hours at the heat content in the body 128 kJ/kg and decreases over time by 10~20%. But if you increase the value to the level of 129~131 kJ/kg return is reduced at the same time by 30~45%. In a cold climate an increase in the mass of clothes is the cause of poor performance. For example, the energy consumption of the body increases by 18% when performing the same job by increasing the mass of clothing from 4.3 to 6.5 kg. The effects of heat on the human body in conditions of heating microclimate leads to a reduction in its protective power and reserve capacity. The cold also affects the cardiovascular system and blood pressure. Observed dystonia and exacerbated chronic disease. The productivity of the human operator is reduced by 25~55% with increasing ambient temperature until the interval of 28~31°C, and reducing the skills of workers leads to a more intense decrease in performance [1 – 6].

2. Methods

2.1 Theoretical research

The influence of microclimate on the health of operators in the cabs MM devoted a significant amount of research. Human thermal comfort is one of the main factors that characterize the conditions of the production environment, the health and well-being, the degree of job satisfaction. It is proved that there is a high level of correlation between the temperature regime and the level of human activity. It was found that people performing work of moderate severity with the energy consumption of 313 watts (40 minutes work, 20 minutes rest) under conditions of heating microclimate occurs a pronounced decrease of efficiency, especially under thermal impact. Solution of tasks to ensure the comfortable state of the human operator in the cabins MM is a rather complex problem. The device of an artificial microclimate must meet the requirements of simplicity of design, low cost of fabrication, possibility of service personnel of low qualification, they must ensure that the design conditions with constantly changing modes of operation of the machines. Partial reduction of the air temperature in the cabin at the expense of natural ventilation leads to an increase in speed of air movement and dust accumulation in it. Currently numerous experimental studies have established a negative influence of adverse environmental conditions on productivity [7 – 25].

Many papers are devoted to the study of the formation of the thermal state of the human organism in the conditions of industrial premises. However, the process of forming the thermal state of the human operator in spaces of small closed volume, such as the cockpit MM remains poorly understood. This makes it difficult not only to control the thermal state (thermal comfort) of a person in the cockpit MM and evaluation of the effectiveness of normalization of the microclimate in their selection, testing and use, this hampers the development of new ways and means to ensure a comfortable state of the human operator [5, 6].

For the last time on the basis of the principles of control theory created a number of models of temperature regulation of man. In these models, represented the human body in the form of geometric segments, each subdivided into a number of layers and compartments. Passive thermoregulation system can be described using the heat balance equation for each compartment, taking into account the contact surface of the skin with the environment. On the basis of established reference temperature for each compartment in the system are formed by control signals, allowing you to modify physiological responses during exposure to various environmental factors, physical load and thermal resistance. Scientists recognized system *Stolwijk J. A. J.* in the field of thermoregulation, designed to study the thermoregulatory responses of the body in the field of positive temperatures. This model was the most appropriate for the interval of temperatures from 25~48°C and has a complex system of generation of control signals and their distribution, taking into account the deviation of the temperature values of each compartment and the reference level. The researchers obtained important information when using mathematical modeling to describe the thermal regime of the body. So, *Gagge A. R.* and co-authors have developed an index of effective temperature, which has been used in the practice of evaluation of physiological strain of an organism when exposed to a thermal