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# Research by Air Flow of Metal Shavings Used In a Solar Air Heater as a Heat Receiver

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**ABSTRACT:** In the article, a visualization of the flow of the air flow of metal shavings used as a heat receiver in a solar air heater was made. The scheme of the developed experimental stand is given. The results of visualization of the air flow around the metal shavings at speeds from 0.2 to 0.4 m / s, which corresponds to the numbers Re = 1000 ÷ 7000, are given. The results of the experiments obtained in the form of photographs.

**KEYWORDS**: renewable energy sources, solar air heater, efficiency, heat exchanger, metal shavings, visualization, laminar flow, turbulent flow.

## I.INTRODUCTION

At present, the rapid development of technology, technology and production in a place with this increase in population has led to an increase in energy demand, a decrease in mineral resources and a deterioration of the ecological situation throughout the world [1]. In view of this finding of new ecologically clean types of energy, it acquires an important role in human life [2].

Many countries are facing a way out of the current situation to consider the widespread use and introduction of installations operating on the basis of renewable energy sources [3]. One of the easy-to-use installations that do not require additional costs due to the simplicity of the design is solar air heaters (SAH) [4]. A study aimed in this area is aimed at improving the efficiency of these installations due to the intensification of the thermal process [5-10]. Due to this, an important role is played by the selection of the heat transfer heat sink of the main element of the SAH. At this time, in order to intensify the thermal process, protruding flows in the SAH use protrusions of various shapes that require additional installations to create efficient heat sinks [11]. In the present work, we proposed a heat sink of metal shavings which is considered a production waste that lost its initial consumer properties. To assess the effectiveness of metal shavings as a turbulizer of the air flow, we carried out a visualization of the flow of metal shavings over the air flows. Below is a detailed description of the experiment and the results obtained.

## II. EXPERIMENTAL STAND FOR THE VISUALIZATION OF THE AIR FLOW AROUND METAL SHAVINGS

A schematic diagram of the stand is shown in Fig. 1. The stand's layout is made with a forced smoke supply system 4 to the working section 11. The vessel 3 with a water capacity of 1.5 liters consists of two parts, a water tank 1 and a cover 13. The vessel lid has an outlet where the flexible hose 5 is connected which serves to connect to the fan 6. The fan 6 is connected to the glass smoke box 8 through the valve 7. The working section 11 is connected to the drive 8, through the valve 9 and the fan 10.

Fans 6-10 have the same power of 3 W with a voltage of 12 V, controlled by a power supply that regulates the voltage 0-18 V. The air velocity range is generated by the fan up to 1 m / s. Valves 7-9 are controlled manually.

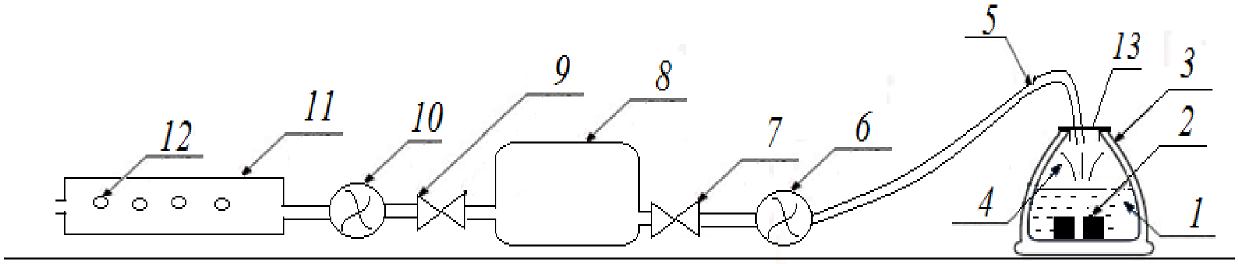



Fig 1. Experimental stand for visualization of the flow of metal shavings

The rubber connecting flexible tube 5 has a diameter of 15 mm, a length of 400 mm. Glass storage vessel 8, cylindrical, with a volume of 0.01 m3. The working section 11 is a box with axial holes, the upper and single-lined part, which has a glass coating, for fixing the passage of smoke 4, obtained by changing dry ice 2 from solid to gaseous by reaction with water 1.

The stand works as follows: when the valve 9 is closed and 7 is open, the smoke is attracted by the fan 6, passing through the connecting hose 5 enters the glass tank 8. After the accumulation of smoke of the desired concentration and the required amount of it in the glass tank 8, the valve 7 is closed and the fan stops 6. Next, the fan 10 is turned on and the valve 9 is opened and the smoke enters the working space 11, and flowing around the metal shavings 12 leaves the working space.

## III. THE TECHNIQUE OF CONDUCTING AN EXPERIMENTAL STUDY ON THE VISUALIZATION OF THE FLOW OF AIR SHAVINGS OF METAL SHAVINGS.

Before starting the experiment on visualization of the flow of metal shavings by the air flow, the water level in the flask is checked. Next, the working status of the valves and fans is checked, after checking the valves they must remain open. Next, dry ice is placed in the water, the fan 6 is turned on and the valve 9 is closed. After the desired density of smoke has been reached in the accumulator, the valve 7 is closed, the valve 9 is opened and the fan 10 is turned on.

Smoke flows into the work area. After the camera fixes the flow of smoke from the metal shavings, a new portion of smoke is fed into the channel. After research, all sites are turned off in the reverse order.

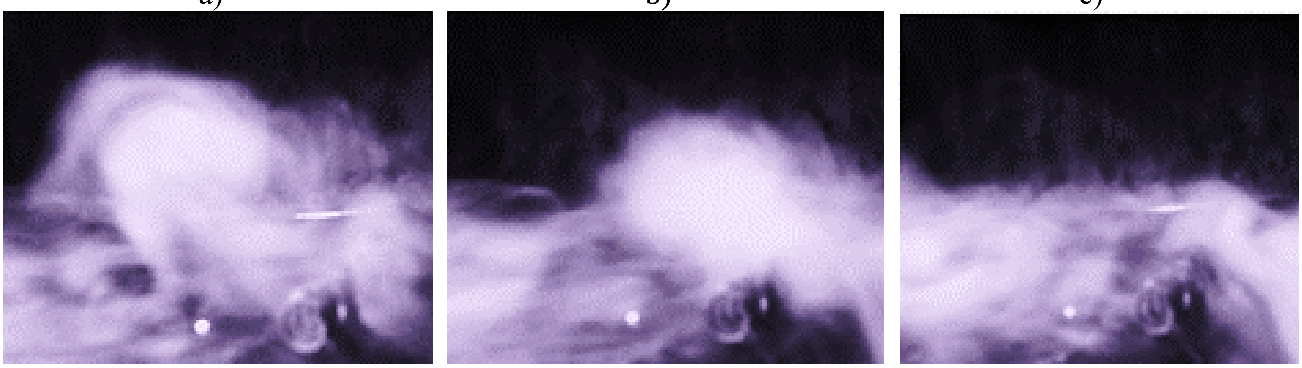
The Nikon D-90 high-speed video camera equipped with a Nikon 18 - 105 mm F / 5.6 G AF-S Nikon D ED VR optical system was used to study and fix the physical mechanism of airborne metal shavings.

The experimental area was illuminated by a 5W LED lamp.

## IV. ANALYSIS OF THE FLOW PATTERN OF METAL SHAVINGS

Coolant flow in the photographs presented (Fig. 2)

a) b) c)



d) e)

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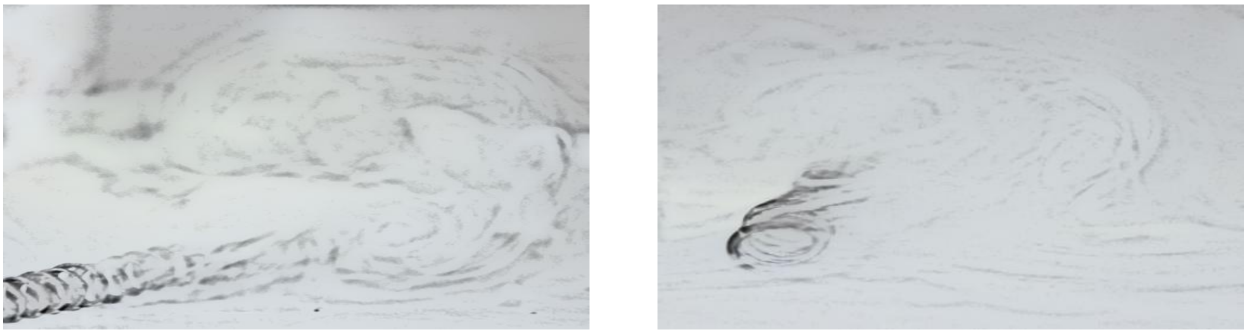

Right to left withc,b,a, and the pictures were taken in sequence with an interval of a fraction of seconds
d - enlarged photographs of airflow death
e - turbulization of air flow
Figure 2. Photographs of the flow of air flow drain metal shavings

## V. ANALYSIS OF THE RESULTS

When calculating the Reynolds number, ReD was taken as the average flow rate. The equivalent diameter of the channel is chosen as the determining size. $D_Э$=4F/P=0,084 м, where F is the cross-sectional area of the channel $F = 0{,}073 \cdot 0{,}1 = 0{,}0073$ м$^2$, a P-perimetr 0,346 м. The experiment was carried out at speeds of air flow from 0.2 to 1.6 m / s, which corresponds to the Reynolds numbers 1120 ÷ 9000 table 1.

| № | *v*, *м/с* | *Re* | Photographs of the flow of air flow of metal shavings |
|---|---|---|---|
| 1 | 0.2 | 1120 |  |
| 2 | 0.4 | 2224 |  |

| | | | |
|---|---|---|---|
| 3 | 0.6 | 3336 |  |
| 4 | 0.8 | 4480 |  |
| 5 | 1.0 | 5600 |  |
| 6 | 1.2 | 6720 |  |

In experiments with increasing speed, the amounts of steam supply to the working area were increased. Air flow with Reynolds numbers Re = 2224 a transition from laminar to turbulent flow is observed. With an increase in the Reynolds number, eddies begin to form on the downstream protrusions of the shavings, which, together with the main flow, flow around the ledge. The attachment of the flow to the protrusion occurs above the recirculation zone formed on the forward stream edge of the protrusion. In experiments with airflow speeds of $v$ = 1.0 m / s, which corresponds to the Reynolds number of 5600 and higher, large airflow tilts were observed in places where metal shavings are close to the protrusions of the V-shaped corrugated surface. In front of the protrusions of metal shavings, a small thickness of the boundary layer is observed (Table 1), which leads to a maximum heat transfer coefficient. A low heat transfer coefficient is observed on the rear protrusion of the metal shavings, where a stagnant zone is formed downstream, which causes air to move upward along the main stream. The results of visualization of the air flow in the air channel with single metal shavings (Fig. 2) are consistent with the results when metal shavings arranged in a row of single layers flow around the air flow in the channel (Table 1).

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From the analysis of the visualization of the flow of metal drain shavings (Table 1 and Figure 2), it follows that large-scale eddies are generated behind the metal drain shavings. The vortices formed behind the shavings have a two-dimensional directionality and contribute to a strong flow turbulization.

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