HOW TO MAKE A CANDLE POWERED TURBINE

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ABSTRACT

As demonstrated in this research, to make a turbine by a candle under a spiral it starts to rotate above the needle that is attached to the tip of the rod so, we can say the spiral above the candle rotates by the air flow that comes from the heat that is given to it by the candle. But to investigate this phenomenon , different experiments have been done and the most important parameters related to the characteristic of spiral,candle and heat transfer are studied.

Keywords : *Candle, Turbine, heat Transfer, Spiral*

1. Introduction

The problem states that a paper spiral suspended above a candle starts to rotate optimize the setup for maximum torque (Fig.1).

Fig.1: Paper spiral suspended above a candle

The candle under the spiral lit up, spiral starts to rotate above the needle that is attached to the tip of the rod so, we can say the spiral above the candle rotates by the air flow that comes from the heat that is given to it by the candle. The candle heats the surrounding air heated air causes the air particles to go farther apart. Thereby, making the air less dense and less dense air always rise above the dense air.

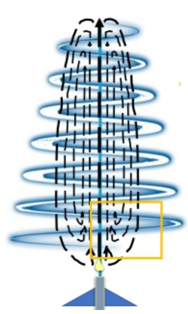

Fig.2: Heat transfer around the spiral

2. Materials and Methods

To analyze this setup in a theoretical way initially we're going to start with the spiral itself that is divided into 3 parts we can name:

1. Number of the spiral cycles
2. Radius of the spiral circle
3. The paper width

As the second part of the theory analyzing, we will discuss about the convection mechanism and the effects on the phenomenon, then the candle that is divided into three parts:

1. candle wax combustion
2. candle flame
3. the causes effect from the distance between candle and spiral

Moving to the division between our theories we can distribute them to two different viewpoints which are the macroscopic view and the microscopic view. First we start with the microscopic view to discuss the partial forces applied to the spiral and the transition between energies.

The heat conduction makes the burning fuel releases CO_2 and Water and the steam as well as the heat radiation causes the air molecules to run parallel to the spiral (Fig. 3).

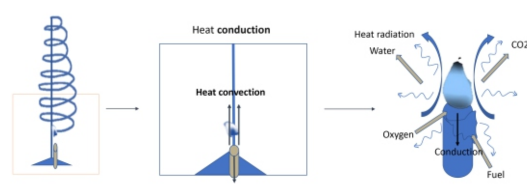

Fig.3: Burning fuel and heat radiation

Wax combustion makes turning thermal energy into kinetic energy of the air particles.

$$C_{25}H_{52} + 38\,O_2 \rightarrow 25\,CO_2 + 26\,H_2O + \text{Heat}$$

So to divide each applied force to the system the definition of the drag force is needed. The applied force by the particle is an action force and a reaction force is from the opposite direction. The air particles begin to rotate in the direction of motion (Fig. 4).

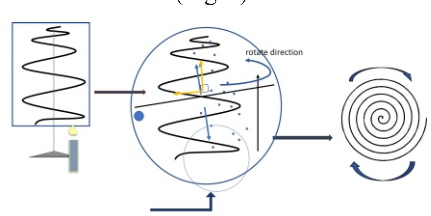

Fig.4: Rotation of spiral

To name each force that is applied to the strip part of the spiral, we can see as the laminar flow runs throw the strip it goes up with a turbulent form, and the force from air flow is divided into one in the direction of motion and one perpendicular to the strip which makes a total force which applies into the torque according to the changes of spiral radius (Eqs. 1-3) .

$$\tau = Fr\sin\theta \qquad (1)$$

$$\Delta\tau = r\Delta F\sin\theta \qquad (2)$$

$$\tau = \sum \Delta\tau = \sum r\Delta F\sin\theta \qquad (3)$$

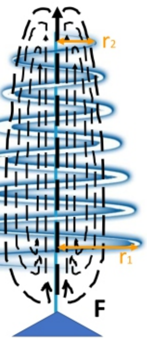

Fig. 5: Applied forces on spiral

Also there is a maximum torque by air transfer and friction which works on the opposite direction of motion (Eqs.4-6).

$$\tau = Fr \longrightarrow \tau = I\alpha \qquad (4)$$

$$F \sim v$$

$$\tau' = Fr \sim r^2\omega \qquad (5)$$

$$\tau' = \tau \qquad (6)$$

The macroscopic view which is the definition of air transfer and starts with convection is the circular motion that happens when warmer part of fluid rises while the cooler part of fluid drops down.

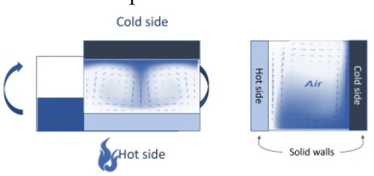

Fig. 6: Microscopic view of convection

As the warm air rises upward the paper begins to spin, the process keeps working because the cooler surrounding air keeps coming towards the candle and warms up. But of course, there is a difference between two parts of the spiral from down to upside part and that is where the area of air flow starts to increase and the velocity of the movements decreases (Eq. 7) (Fig.7).

$$A_1V_1 = A_2V_2 \qquad (8)$$

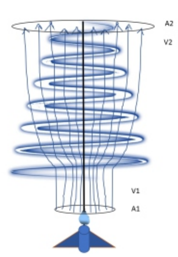

Fig. 7: Modeling of air flow around the spiral

Having an intuitive view of the Continuity equation a simulation of velocity for each air particle is done. If we have an imaginary closed area around the spiral to avoid other effective parameters such as wasted air flow that gets out of the spiral area, as the solution for air particles velocity , we can observe the movements of the particles are not the same in every part of the spiral and the velocity streamline divided these speeds into different colors is possible to see in the model itself (Fig. 8).

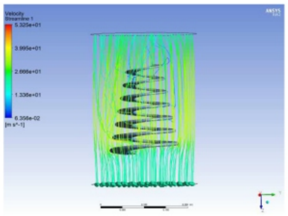
Fig. 8: Simulation of velocity for each air particle

3. Experiments

The microscopic view of the theory in our experiment proves the reason for the spiral to rotate regularly with almost constant speed which helps to find a version of transition between airflow.

The schlieren photography shows there are two different types of air flow, laminar and turbulent . As the experiment shows as the spiral appears the laminar flow transforms into turbulent flow including the air currents or we can say turbulent flow moves around the spiral (Fig. 9).

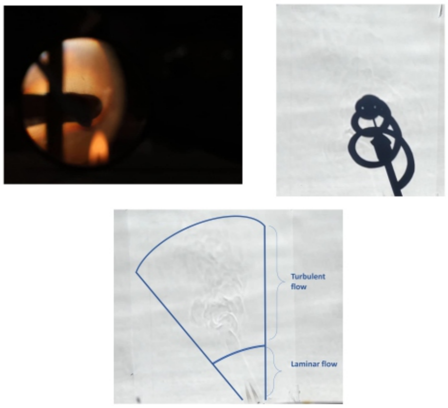

Fig. 9: The schlieren photography

In our Experiment the spiral is divided into a 4 different number of cycles and 4 different densities for each number of cycles with a needle is attached to the rod to keep the friction as less as possible .The candle is in three different distances from the rod to see the result .Further, we used tracker to measure the radiation of the spiral and it is analyzed by the Fourier transformation (Fig. 10) .

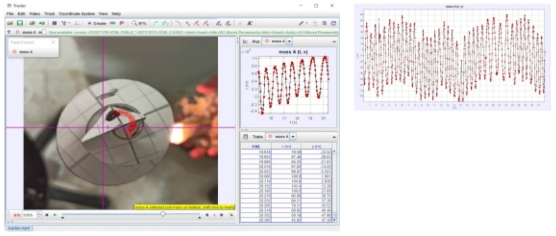
Fig. 10: Tracker to analyze data

For the next part of the experiment, density and angular velocity of the strip from 1 cm to 2.5 cm are investigated. In each experiment by the change of number of rounds, when the density\width of the strip for paper spiral increases, there is a decreasing trend in the graphs which occurs for each number of rounds from 4 to 7 (Fig. 11).

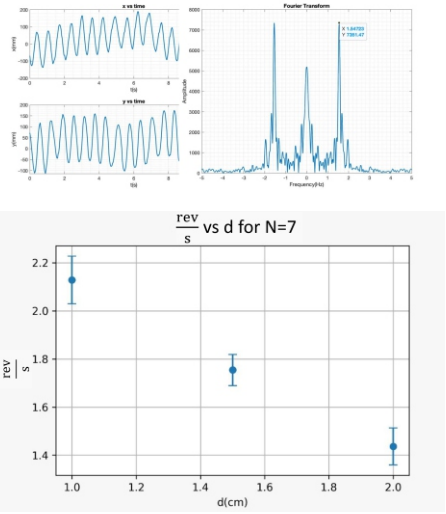

Fig. 11: Changing density and angular velocity

4. Results

It can be reported that by increasing the density of the strip, rotating per second for that specific spiral is decreasing. The same thing happens for the number of rounds, five, and the change of the density in the same way and there is almost an decreasing trend by increasing the density. Best change and almost close to the theory is given in the diagram for number of rounds six with the least error of the experiment which is possible to observe a more logical decrease of angular velocity of the system, the same experiment goes for number of rounds 7 but to mention that density, 2.5 cm couldn't be investigated for this spiral because of the weight of the strip which I couldn't measure. Each experiment for each density of the spirals is done four times to make sure that the variation of angular velocity for the same spiral has a little error.

As the result of the experiment, the color-coded version is used to show 9 different number of rounds by the different density and divergent number of cycles. The velocity will decrease by increasing the number of rounds or density for each number of rounds.

A color-coded approach from the experiment represents the state of the rotational speed for each spiral. The green stands for the best and the fastest ones as it is possible to see in the intuitive view of the experiment, the light green section is consider as the well rotation and between the time range of 1.5 to 1.7 for each rotation in this phenomenon, and the yellow section is representation of the 1.7 to 2.5 seconds for each rotation of the spiral (Fig.12).

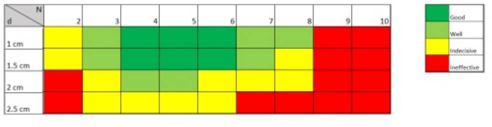

Fig. 12: Color coded approach

An optimization for the best setup in this experiment I reached to two best setups that the speed of the rotation had the best result, and it is possible to observe by the experiment in the video of each spiral for maximum torque. (Fig 13).

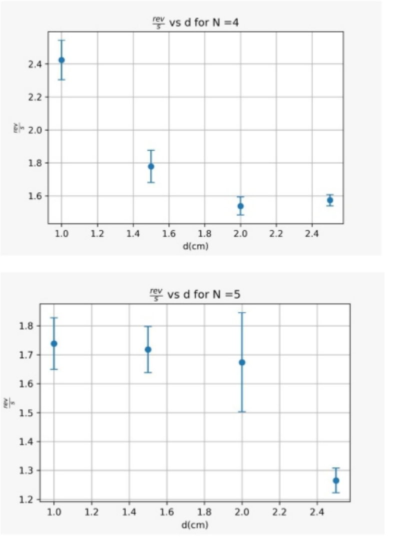

Fig. 13: The best spiral for maximum torque

5. Conclusions

This research by the theory in energy transition and the division between forces applied to the system and obtaining each force. Total torque equation and the factors to have a maximum torque and the study of airflow that causes the force were studied. For the experiment to measure the maximum torque four number of rounds with different densities of the strip for each spiral have been used. The result of the experiment by a color-coded version for the diagrams and optimized the setup for maximum torque between the best experiment and angular velocities have been presented that was gotten from the green code experiments.

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