

Conceptual Analysis to Prove Kinetic Energy in Wind is Generated

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Abstract: Wind and Wind energy are being utilized since ancient times for various purposes. Our ancestors were wise enough to devise different methods to deploy wind for their own good. Examples that can be thought of simply include use of wind to separate the grain from its cover which is still practiced in rural India, use of wind's direction while sailing a ship over sea and many more. With the development of technology, we are now able to forecast the weather with the help of wind directions and generate electricity using the wind flow through windmills. In these developments over the years, the fundamental aspect of wind that is significant is its kinetic energy. In this paper, we have focused on why and how the wind flows, along with whether the kinetic energy present in the wind is conversion of some type of energy or is generated. To draw this conclusion, we have presented a theoretical analysis of various aspects of wind.

1. Introduction

Wind is simply the movement of air across the Earth's surface and it is produced due to the pressure differences in air between two places. Wind strength varies from a light breeze to hurricane force. Air pressure depends upon the motion, size, and number of gas molecules present in the air which is dependent on the temperature and density of the air mass [1]. Within the atmosphere, the speed and direction of winds are dependent on various force. The most important though is the Earth's gravitational force. As gravitational force compresses the Earth's atmosphere, it creates air pressure- the driving force of wind. Without gravitational force, there would be no atmosphere or air pressure and thus, no wind.

This change in air pressure is called the "pressure gradient". Pressure gradient is the pressure difference between high and low pressure areas. The speed of the wind is directly proportional to the pressure gradient meaning that as the change in pressure increases (i.e. pressure gradient increases) the speed of the wind also increases at that location [2]. In the next section we examine the forces responsible for wind flow and energy present in the wind flow.

2. Wind Flow

There are two forces that cause the wind to move as it does [3]. Both the forces work together at the same time. The pressure gradient force is a force that tries to equalize pressure differences. This is the force that causes high pressure to push air toward low pressure. Thus, air would flow from high pressure to low pressure if the pressure gradient force was the only force acting on it.

The difference of pressure is a result of unequal heating of the earth's surface because of the incoming concentrated solar radiation at the equator. Due to this, the air in this region becomes warm compared to air near the poles. Warm air has low barometric pressure than the cold air at high altitudes, as their density is less. The warm air with less density travels to the northern and southern hemisphere during the same time cold air from northern and southern hemisphere travels to the equator. This happens because of

gravitational force as an object or material with higher density always tries to settle at the bottom and the lower density object or material settles at the top.

There is a second force, because of the earth's rotation, the Coriolis force that affects the direction of wind flow [4]. This force is what causes objects in the northern hemisphere to turn to the right and objects in the southern hemisphere to turn to the left.

The flow of wind is nothing but the velocity of the wind. As wind has velocity and mass it has kinetic energy. The kinetic energy in the wind is given by [5],

$$E = 1/2 * A \rho v^3 \quad (1)$$

where, A = Area perpendicular to the direction of wind
t=time
 ρ =density v=volume

From the above equation, it is clear that kinetic energy in the wind is dependent on the velocity i.e the flow of the wind. The wind flow is mainly dependent on the pressure gradient force which is further dependent on the gravitational force as explained above. Therefore, the kinetic energy present in the wind is due to gravitational force and not the conversion of any type of energy. Thus, it can be said that this kinetic energy is generated.

3. Conclusion

From the analysis presented in the paper, we can conclude that the movement of air i.e. the wind is present because of the gravitational force, which does not change even after the continuous flow of wind as it is a conservative force. Therefore, we state that kinetic energy in the wind is generated and if required, can be destroyed as well by making the air static.

References

- [1] Amanda Briney. "Winds and the Pressure Gradient Force". In: (). URL: <https://www.thoughtco.com/winds-and-the-pressure-gradient-force-1434440>.
- [2] David Brunt. "WHAT MAKES THE WEATHER?" In: Journal of the Royal Society of Arts 93.4687 (1945), pp.

- 190–197. ISSN: 00359114. URL: <http://www.jstor.org/stable/41361938>.
- [3] Julie Barnes, Tom Koehler, and Beth Schaubroeck. “Fly with the Wind”. In: Math Horizons 21.4 (2014), pp. 10–13. ISSN: 10724117, 19476213. URL: <http://www.jstor.org/stable/10.4169/mathhorizons.21.4.10>.
- [4] James E. McDonald. “The Coriolis Effect”. In: Scientific American 186.5 (1952), pp. 72–79. ISSN: 00368733, 19467087. URL: <http://www.jstor.org/stable/24950681>.
- [5] Kira Grogg. “Harvesting the wind: the physics of wind turbines”. In: Physics and Astronomy Comps Papers 7 (2005).