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Utilizing kinetic energy of wind as a source of power in commercial vehicles

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Abstract: This project is about using kinetic energy of wind in a vehicle moving at a high speed for generation of electricity. This can be achieved by installing a housing on top of the vehicle which will contain an air duct of varying cross sectional area, a turbine and generator. This project gives information about where and how these components should be installed to produce maximum power. This article also gives information about limitations of this project and explains its drawbacks. The model is designed using Autodesk INVENTOR Professional.

Keywords: Renewable, Wind Energy, Vehicle, Turbine, Kinetic Energy, Pollution Free

1. Introduction

We are in a world which largely depends on power which is obtained from various sources where contribution of conventional, non-renewable source is much more. Because of this reason consumption of conventional and non renewable sources is very high. Ifthe same rate is maintained, then in the near future these sources will not be available. In this situation we will be left with only one option of using renewable sources. So we should control the use of non-renewable energy sources and at the same time use renewable energy sources so that these resources can be balanced. This project deals with utilizing kinetic energy of wind in a fast moving vehicles and explains the process and methodology to be followed.

When a vehicle is moving at a very high speed, air flows at the same speed on the outer surface of vehicle but in the opposite direction. Kinetic energy of the air is very high. This paper will explain how this energy can be utilized.

2. Description of the Model

2.1. Setup of the Model

This model consist of components like a duct of varying cross sectional area, nozzle, a turbine, generator and housing. These components will be mounted on top of any heavy vehicle like a commercial truck or a bus.

When the bus or truck will move forward, air will move with the same velocity on it's outer surface but in the opposite direction. This design will make use of this moving air. Since the duct will be mounted on the top surface of the vehicle with its one end open, flowing air will pass through it. This duct will perform basically two functions,viz. passing air to the turbine and increasing pressure energy of air. Duct will have reducing cross sectional area so that when air will enter and move through it, pressure energy of the air will increase and at the end of the duct, pressure energy will be converted to kinetic energy with the help of a nozzle. The nozzle will make a jet of air having a very high speed .When this air jet will strike the blade of a turbine, it will rotate the turbine with a very high speed. Since the nozzle will convert all pressure energy of air into kinetic energy and this kinetic energy will be utilized so the turbine used will be an impact turbine. This turbine can be coupled with a generator which will produce electricity.

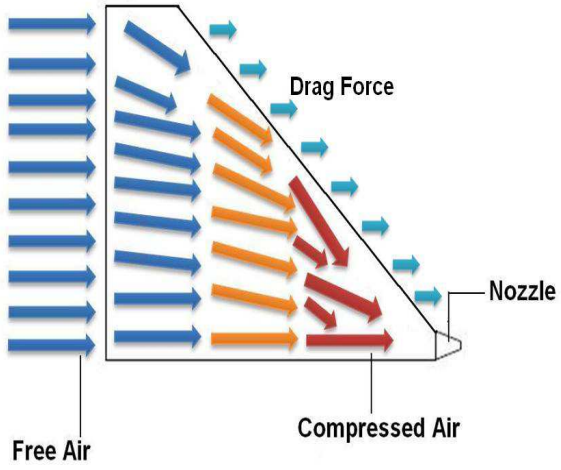

Figure 1: *Flow of Air through duct*

Cross sectional area of the duct at the entrance should be rectangular. There are two advantages of this rectangular area. Firstly it can intake more air compared to a circular section of same height and secondly it will have a lesser height so that the vehicle can pass through smaller tunnels.Cross sectional of duct is shown in figure 1.

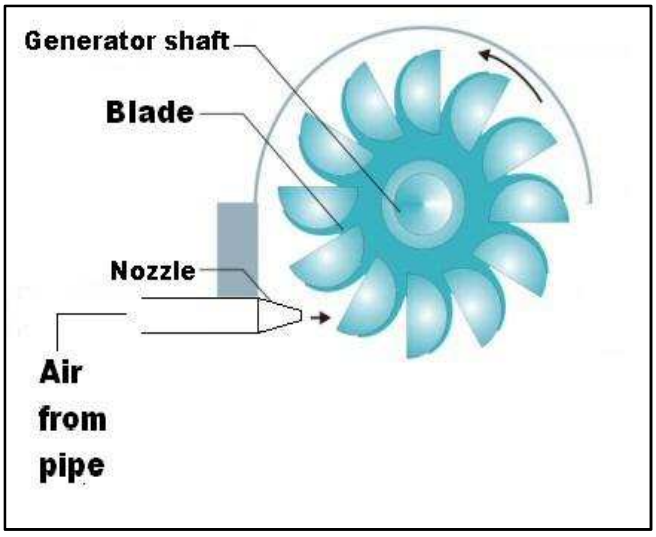

Figure 2: *Turbine setup*

The whole setup which can be installed on a vehicle is shown in figure 3. Since here the working medium for the turbine is air, so there is no question of pollution and another advantage is that air can be exhausted in open environment .There is no need of any special arrangement for exhaust like in a water turbine.

2.2. Position of the Turbine Shaft

Since horizontal turbine (turbine with horizontal shaft) requires more height, it will increase height of whole casing. This is not possible because then it will restrict vehicle from passing through tunnels. To overcome this problem, best solution is keeping shaft of turbine vertical instead of horizontal. Whole setup including turbine and duct for passing of air is shown in figure 4.

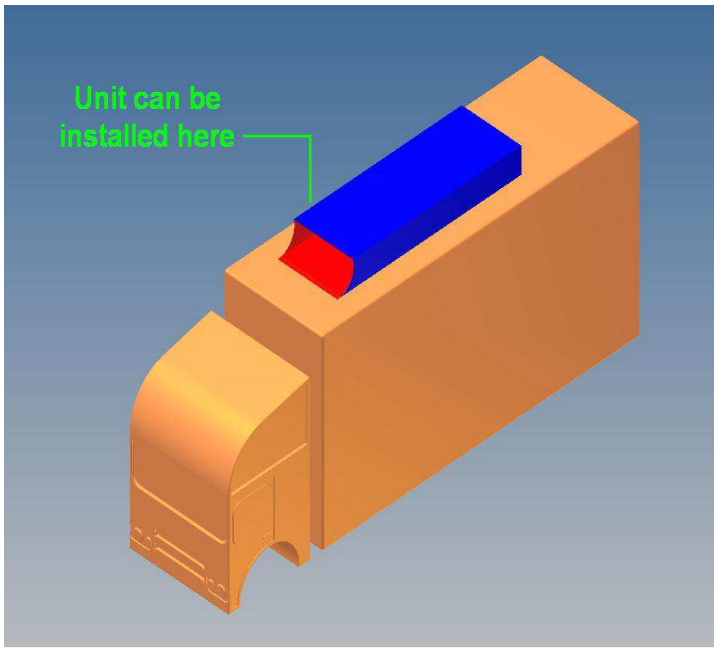

Figure 3: *position of unit on vehicle*

2.3. Approximate Power Generation

Assume that the height of the rectangular cross sectional area is 'h' and width is 'b',then mass of air entering will be

$$M=d\times b\times h\times V$$

Where d =density
V=velocity
Kinetic energy is $\frac{1}{2}\times M\times V^2$
If overall efficiency is 0.6 then power generated will be

$$0.6\times\frac{1}{2}\times d\times b\times h\times V^3$$

Take b=1.5 m, h=0.3 m, v=50km/h=13.88 m/s
Density of air is 1.165 m^3
Then power generated is 421.37 W.
This is the power for that instant when vehicle is moving with that particular velocity.
If the vehicle is operated at an average speed of 50 km/h for 10 hours a day, then power developed will be 15.17 MW.

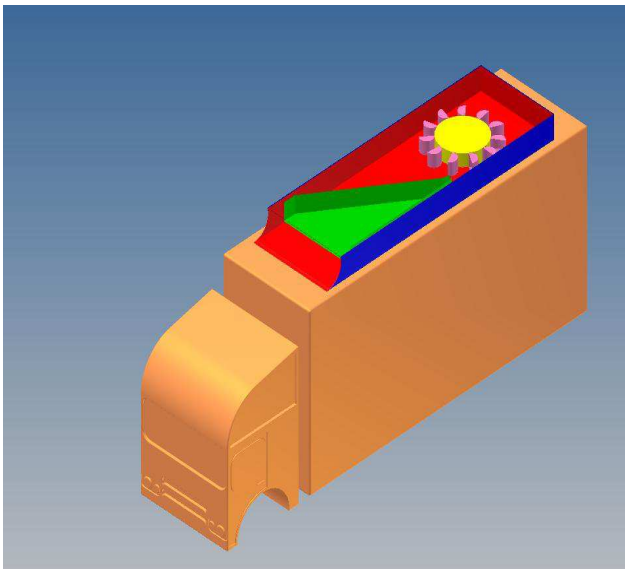

***Figure 4**: Assembly of housing with detail of inner parts*

2.4. Requirements of the Turbine

Since working fluid in the turbine is air so first requirement of turbine is it needs to be light weight. In a water turbine ,water is the working medium which has a higher density compared to air. That turbine cannot be used here because of air density. Turbine material should be selected such that it has high strength and light weight. High weight of the turbine will result in major loss of power during operation.

Second requirement of the turbine is that it should be perfectly balanced. Since this turbine will be used on the roof of a vehicle moving at an average speed of 50 Km/Hr. So small amount of vibration can cause serious damage. This can affect not only the housing but the whole vehicle movement can be disturbed. To avoid this type of issue, perfect balancing of the turbine is a must.

2.5. Design of the Duct

The duct plays a very important role in this model. Since the main function of converting kinetic energy of air into pressure energy is performed by the duct, designing of the duct is very important. As shown in figure 1, cross sectional area of the duct is varying and it is decreasing. Because of this reducing area, air is compressed but along with this it is also changing the direction of air from the middle to the side of thehousing. This is required because the turbine used is an impulse turbine and in an impulse turbine, jet of working fluid should strike tangentially to the turbine. During compression of air, air will induce drag force on the duct. This drag force will act in the opposite direction to that of thevehicle. If the speed of the vehicle is more, amplitude of drag force will increase. This can result in serious losses. To avoid this, the duct should be designed in such a way that drag force is minimum and efficiency of the duct is maximum i.e. compression ratio should meet requirement of the model with minimum pressure losses.

3. Benefits

1. Since this power developed is without any additional input energy, this method is very efficient.
2. In this project, the working medium is air, so there is no corrosion of blades of turbine.
3. Air utilized by the turbine can be exhausted directly into the open environment.
4. Since air is a renewable source of energy, there is no limitation on using this apparatus.

4. Limitations

1. Since this arrangement requires many components ,cost is more.
2. Vehicle will not move with the same speed all the time so there will be variation in speed of the turbine.
3. Since power generated is not uniform, it cannot be used directly. It must be stored in a battery which increases cost.
4. It will work only when vehicle is moving with a high velocity. At low velocities, the air jet will not be able to rotate turbine at a high enough speed.
5. It will cause some amount of drag on the vehicle.

5. Conclusion

Initial cost of this project is high, but as it uses wind energy which is a renewable source of energy, it is a good alternative for generating power. It can be implemented at present so that the fossil fuel consumed by the vehicle can be utilized in a more efficient way. This project can also be used in cars so that they can generate electricity not in large amounts but sufficient for smaller mechanisms.

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