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Electric Vehicle Using Drag Force to Increase its Range

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Abstract— From a long time, In Automobile sector, Vehicle are widely used in travelling and transportation of goods or material as per need from one place to another. And with the time needs are changing same way Automobile are also advancing for better Fuel efficiency and economic benefits. But major problem that automobile sector is facing now days is regarding shifting of vehicle from conventional to Electrical mode. Here, these Electrical vehicle runs on electric current that is stored in a battery pack by charging it. But the problem is that this battery pack doesn't provide a sufficient range in a single charge. So, to enhance its range, we tried to come with such a system to utilize the energy loss during mobility of an Automobile in the form of 'Air Friction' or 'Air Drag'. Here, we developed a system to convert the Air resistance that is experienced by automobile while moving into electrical energy that will be transferred to battery pack for Charging. And hence we will get the same battery pack with extended range

Index Terms—Air drag, turbine, Magnetic Levitation, battery, blades etc.

I. INTRODUCTION

On analysis of the problem, we came up with the solution to the problem by a model that is 'Wind Powered Electric Vehicle' (Support Charging of battery pack by Magnetic levitating Induction turbine rotates by Air drag or Air Friction Force). Generally, we find that the efficiency of battery is the main problem in electric vehicle, so for that we have found the source to increase its efficiency, and after using this technique(equipment) we got good result and we have increased the efficiency of TATA Electric truck. We mounted a vertical wind turbine horizontally on the TATA Electric Truck and we suppose the average speed of vehicle is 60 Km/hr, for this experiment we created a virtual model also for testing with the different number of teeth in bible gear, and we found it more effective in some combinations, also if we increase the speed of vehicle, in that situation we found it more effective. In this research experiment we took care of drag force coming on the wind turbine, for that we've maintain all the drag forces and other forces coming on equipment with the help of calculation which is also mentioned in this thesis. This model comprises of Induction motor, magnetic levitating mover, a blade, electric circuit, Air flow controller and some miscellaneous parts. These all are assembled in a systematic manner so that Air drag is utilized by converting it in the form of electrical energy and then it will be supplied to battery pack for charging.

II. LITERATURE REVIEW

A. About Vertical Wind Turbine
[1] As per the suggestion of Computer modelling, the wind farm constructed using VAWT can be up to 15% more efficient than the system using HAWT, as VAWT generate less turbulence. This is because the design of VAWT does allow the wind to pass through the rotor with more smoothness, increasing the efficiency of adjacent turbines and reducing turbulence.

B. About Magnetic Levitation Motor
[1] [2] This technology has potential applications in various fields, including transportation and energy generation. Axial flux disc permanent and magnet synchronous generators are a type of electric generator used in wind turbines that have several advantages over traditional generations. One such advantage is the use of magnetic levitation, which increases 23.61% efficiency of the wind turbine. Magnetic levitation in wind turbine involves the use of strong magnets to create a magnetic field that levitates the rotor of the generator, reducing friction and increasing efficiency.

C. The Battery Generally Uses Electric Car & Truck
Battery is one of the most important components in an electric vehicle, it also called as "life" of electric

vehicle. Because battery is the only source which stores energy to run the vehicle.

The five most common type of batteries are listed below:

Lead Acid (SLA) battery, Lithium-Ion (Li-on) battery, Nickel-metal Hybrid battery, Ultra Capacitor battery, ZEBRA (Zero Emissions Batteries Research Activity)

D. Vertical Wind Turbine Generate Electricity by Using the DC Motor [5]

In this experiment, we used a 12V DC gear motor an apparatus that transforms electrical energy to mechanical energy was utilized in the experiment. The motor was installed vertically on a shaft. Subsequently, various wind speeds were generated using a blower during the laboratory experiment. The speed of the wind was measured using an anemometer.

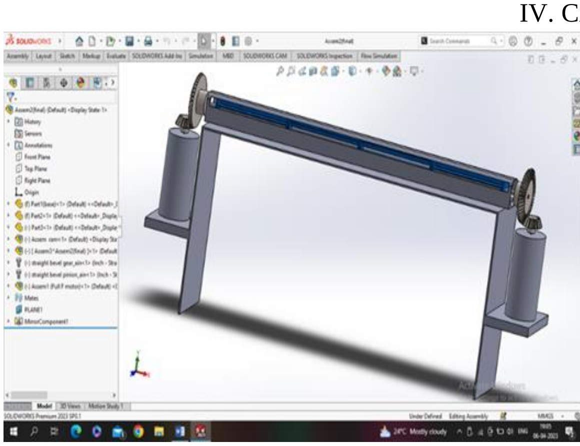
This is the practical values in the one of the research paper by using the DC motor.

Speed of Wind(m/s)	Voltage(V)	Current (amps)	Power(W) $P = VI$
7.20	2.091	0.1251	0.261
10.89	2.89	0.1901	0.550
24.9	3.22	0.1990	0.641

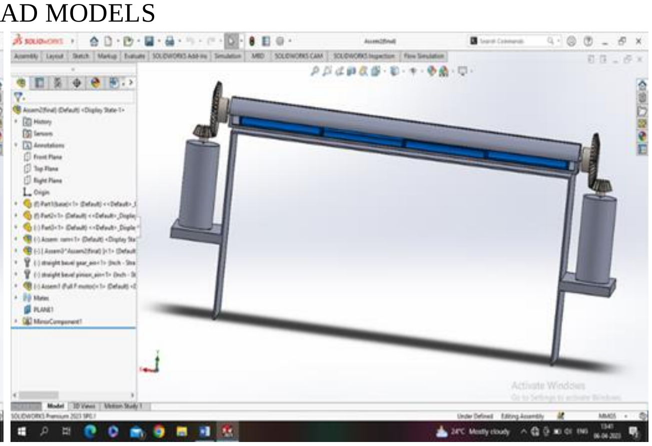
III. PROPOSED METHODOLOGY

When the Truck/car is traveling on the Highway. It faces numerous amounts of drag force. With the help of that drag force, the turbine will rotate and generate the electricity and charging the Battery pack at the same time (Like our laptops) we use that at the time of plug in or plug out also. We know that our solution does not generate the electricity in that amount, which is required to run a whole vehicle. But if, we charging the battery pack at the same time of running (Discharging). We will increase the efficiency of battery and the range of that vehicle according to the electric power which we are generating from the drag force. In our model, we have the entry gate for the air and the exit gate for the air. So that, the effect on the speed of vehicle reduced by that drag force will be negligible. We will also modify the design and position of the model on the roof of the truck/car according to requirement in different type of vehicles, so that the aerodynamics of the cars/trucks will be efficient. Since, the efficiency due to the magnetic levitation is increased by 23.6% & The Efficiency of Permanent magnet synchronous is 92% - 97%. Where, the Efficiency of the DC motor is only from 70% - 85%. So, we can generate the much more amount of electricity as compare to the literature survey practical experiment. We also analysis the drag forces, strengths, torque at different-different parameters on the open turbine blades. If we analysis the turbine blades inside shell (given in the CAD Model) the opposing drag force on the turbine blades which oppose the rotation of the turbine blades will reduce. So that, the turbine will rotate faster than our Analysis and calculations.

IV. CAD MODELS



A. Front View



B. Back View

V. MATERIAL WHICH WE USE IN BLADES [6]

We are using E-Glass fiber /Plastic composites material for blades of our equipment model. The most commonly used material for wind turbine rotor blades is E-glass fiber due to its affordability. However, carbon fiber is often preferred for aerospace applications because it has a higher specific modulus and specific strength, even though it is more expensive than E-glass fiber.

Properties of E-Glass fibers:

Property of blades	Minimized Value(S.I.)	Maximized Value(S.I.)	S.I. Units
Volume of Atoms (average)	0.00801	0.00901	m3/k mol
Density	2.550	2.60	Mg/m3
Compressive Strength	4000	5000	MPa
Ductility	0.026	0.028	
Elastic Limit	2750	2875	MPa
Endurance Limit	2970	3110	MPa
Fracture Toughness	0.50	1	$MPa.m^{1/2}$
Hardness	3000	6000	MPa
Tensile Strength	1950	2050	MPa

VI. POWER GENERATED BY TURBINE BLADES

We do power calculation for TATA ULTRA T-7 Electric Truck (CBC):

Given Data--- Battery Capacity = 62.5 kwh, Length = 5720 mm, Height = 2150 mm, Width = 1905 mm

For CBC (TATA ULTRA T-7 Electric Truck)

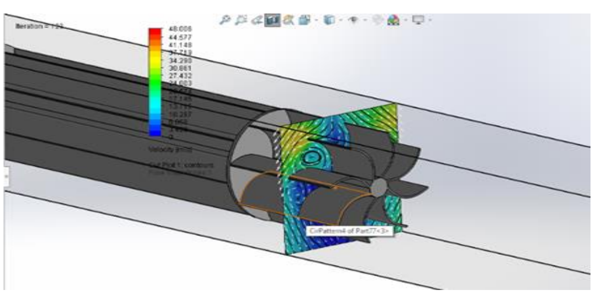
The Diameter of blades D= 14cm, The length of blades (L) = 198.4cm

Since, we are assuming the speed of the wind drag are:

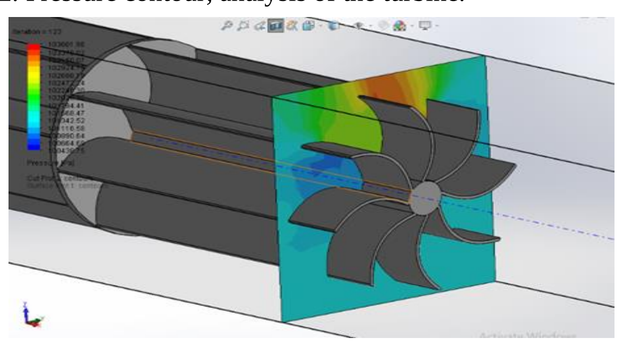
(A) 64.8km/h = 18m/s (B) 80km/h = 22.222m/s (C) 120km/h = 33.333m/s

1. According to the flow simulation of the turbine under the wind drag Speed = 64.8km/h

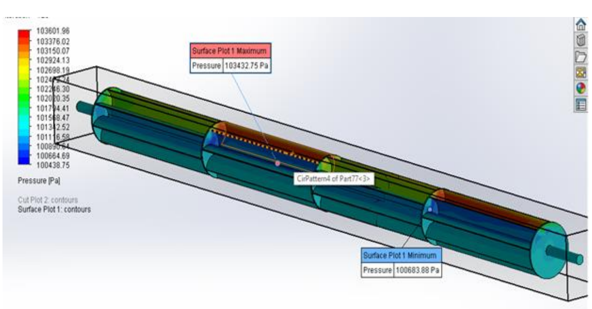
1.1. Velocity contour, vector and stream line, analysis of the turbine.



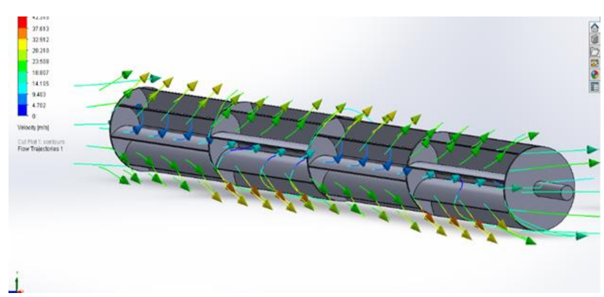
1.2. Pressure contour, analysis of the turbine.



1.3. Pressure contour on the surface of the turbine.



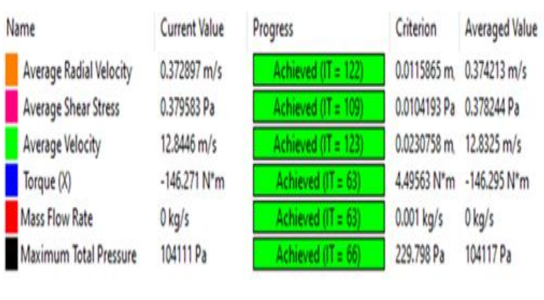
1.4. Flow trajectories of wind drag on the turbine.



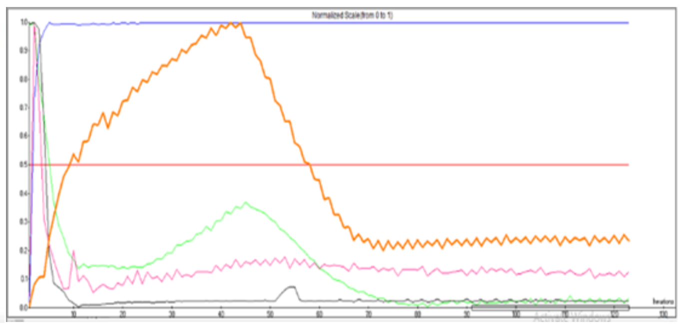
1.5. **Result of different parameters** of the Analysis:

Name of Goal	Units	Observed Value	Average Value	Minimum Possible Value	Maximum Possible Value	Progress [%]	Use In Convergence	Delta	Criteria
Total Pressure	[Pa]	104110.9467	104116.8365	104075.4018	104168.5628	100	Yes	4.828479751	229.7984648
Mass Flow Rate	[kg/s]	0	0	0	0	100	Yes	0	0.001
Velocity	[m/s]	12.84457156	12.83249598	12.81765013	12.8532378	100	Yes	0.022504201	0.023075819
Radial Velocity	[m/s]	0.372896509	0.374213431	0.364841465	0.381965186	100	Yes	0.008038737	0.01158652
Force	[N]	286.0058844	285.9698152	285.7038577	286.1812986	100	Yes	0.222456611	7.524239345
Shear Stress	[Pa]	0.379582764	0.378244347	0.367078389	0.388847531	100	Yes	0.00484407	0.010419274
Torque (X)	[N*m]	-146.2709736	-146.2951437	-146.5212004	-146.1199131	100	Yes	0.202061873	4.495632446

1.6. **Graph and the values** of the Analysis result:



Name	Current Value	Progress	Criterion	Averaged Value
Average Radial Velocity	0.372897 m/s	Achieved (IT = 122)	0.0115865 m	0.374213 m/s
Average Shear Stress	0.379583 Pa	Achieved (IT = 109)	0.0104193 Pa	0.378244 Pa
Average Velocity	12.8446 m/s	Achieved (IT = 123)	0.0230758 m	12.8325 m/s
Torque (X)	-146.271 N*m	Achieved (IT = 63)	4.49563 N*m	-146.295 N*m
Mass Flow Rate	0 kg/s	Achieved (IT = 63)	0.001 kg/s	0 kg/s
Maximum Total Pressure	104111 Pa	Achieved (IT = 66)	229.798 Pa	104117 Pa



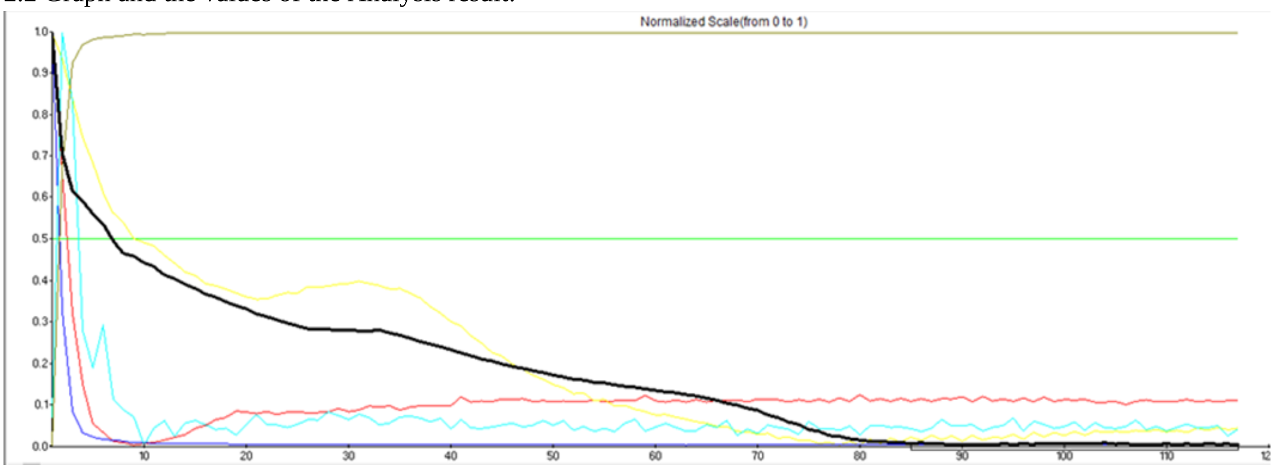
Since, the force is applied in the turbine is same in the gear also.
Therefore the force on the gear (F_g) = 285.9698152N = 285.970 N (approx.)
Since, the average radial velocity of turbine (v_g) = 0.374213431 m/s
Therefore, the angular velocity of the turbine (ω_g) = 0.374213431 / 0.07 = 5.34590614 = 5.346(approx.) rad/sec

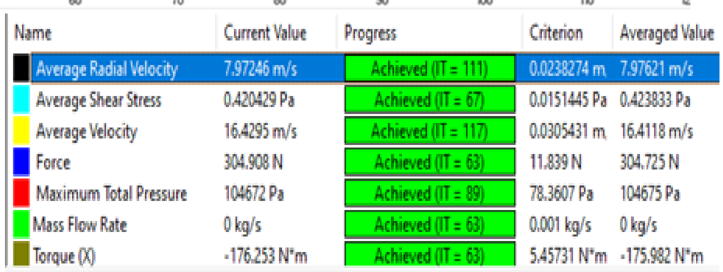
Gear Ratio: $\omega_g/\omega_p = R_p/R_g$= 5.346/ ω_p = 0.03/0.075
ω_p = 13.36 rad/sec (127.626 rpm)
(Since 1 rpm = 2*π / 60 rad/sec)
Since, the force tangential is same in the gear mesh. i.e. 285.970N
Therefore, the torque on the pinion (τ_p) = 285.970 * 0.03 = 8.5791N
Power at pinion side (P_p) = τ_p * ω_p = 8.5791 * 13.36= 114.6167N
Let's, generator efficiency= n_g & transmission efficiency= n_t & electric power= P_e
(Since, generally n_g = 0.8, n_t = 1)
According to the research paper 5,
$P_e = n_g$ x n_t x P_p = 0.8 x 1 x 114.6167 = 91.6933N
With the help of normal DC Motor, we can produce
Pe = 91.6933N electric Power, RPM on pinion=127.626 rpm at 64.8Kmph speed.

2. According to the flow simulation of the turbine under the wind drag Speed = 80km/h
2.1. Result of different parameters of the Analysis:

Name of Goal	Units	Observed Value	Average Value	Minimum Possible Value	Maximum Possible Value	The Progress [%]	Use for Convergence	Delta	Criteria
Total Pressure	[Pa]	104671.7377	104674.9443	104589.9006	104753.112	100	Yes	13.77199	78.3607
Mass Flow Rate	[kg/s]	0	0	0	0	100	Yes	0	0.001
Velocity	[m/s]	16.4295023	16.41175329	16.38843967	16.43123726	100	Yes	0.028577	0.03054
Radial Velocity	[m/s]	7.972458581	7.976208218	7.971975111	7.98116437	100	Yes	0.009189	0.02383
Force	[N]	304.907579	304.7245477	304.4372286	304.907579	100	Yes	0.47035	11.839
Shear Stress	[Pa]	0.420428535	0.423832515	0.410478846	0.43660093	100	Yes	0.002525	0.01514
Torque (X)	[N*m]	-176.253088	-175.981725	-176.2530875	-175.6761595	100	Yes	0.576928	5.45731

2.2 Graph and the values of the Analysis result:





Name	Current Value	Progress	Criterion	Averaged Value
Average Radial Velocity	7.97246 m/s	Achieved (IT = 111)	0.0238274 m	7.97621 m/s
Average Shear Stress	0.420429 Pa	Achieved (IT = 67)	0.0151445 Pa	0.423833 Pa
Average Velocity	16.4295 m/s	Achieved (IT = 117)	0.0305431 m	16.4118 m/s
Force	304.908 N	Achieved (IT = 63)	11.839 N	304.725 N
Maximum Total Pressure	104672 Pa	Achieved (IT = 89)	78.3607 Pa	104675 Pa
Mass Flow Rate	0 kg/s	Achieved (IT = 63)	0.001 kg/s	0 kg/s
Torque (X)	-176.253 N*m	Achieved (IT = 63)	5.45731 N*m	-175.982 N*m

As per the previous calculation:

P_e = 2083.32552711N

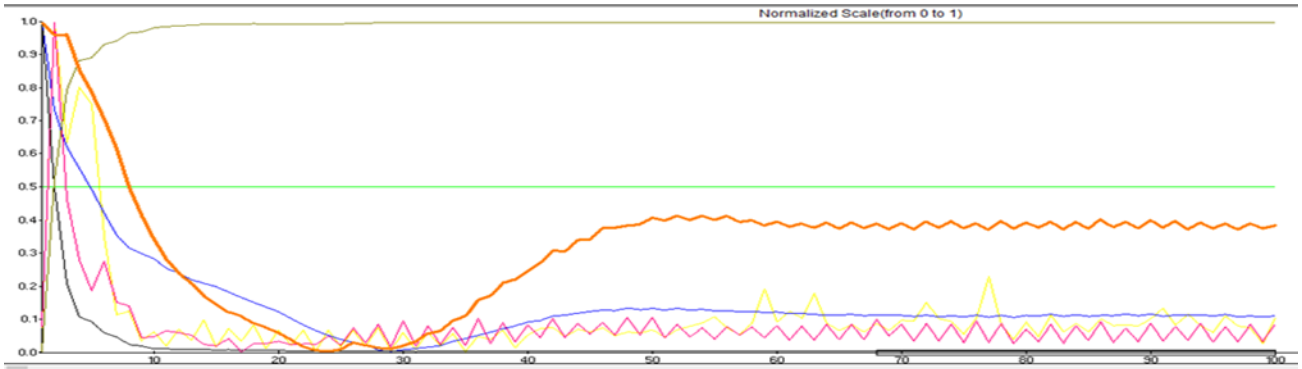
Therefore, P_e=2.083325KN electric power, RPM of the pinion= 2720.2563rpm at 80Kmph speed.

3. According to the flow simulation of the turbine under the wind drag Speed = 120km/h.

3.1. Result of different parameters of the Analysis:

Name of Goal	Units	Observed Value	Average Value	Minimum Possible Value	Maximum Possible Value	The Progress [%]	Use for Convergence	Delta	Criteria
Pressure (Total)	[Pa]	114326.2374	114221.7869	113769.0862	115223.5037	100	Yes	129.6008225	171.8511425
Mass Flow Rate	[kg/s]	0	0	0	0	100	Yes	0	0.001
Velocity (Average)	[m/s]	25.17273913	25.17334794	25.15119557	25.20452722	100	Yes	0.044956782	0.048460651
Radial Velocity	[m/s]	12.1627761	12.16421246	12.15356174	12.17497392	100	Yes	0.019197274	0.038888321
Force	[N]	851.9891692	852.8830533	851.9891692	853.4016929	100	Yes	0.706774204	28.87242028
Shear Stress	[Pa]	0.977740593	0.94291998	0.900264796	0.991628676	100	Yes	0.010352025	0.018531055
Torque (X)	[N*m]	-439.42632	-439.6165266	-440.054095	-439.0903911	100	Yes	0.748453835	14.08759583

3.2. Graph and the values of the Analysis result:



As per the previous calculation:
Pe = 829.9720531784N
Therefore, Pe= 829.97205317N electric power, RPM of the pinion= 3871.98907rpm at 120Kmph speed.

Name	Current Value	Progress	Criterion	Averaged Value
Average Radial Velocity	12.1628 m/s	Achieved (IT = 88)	0.0388883 m	12.1642 m/s
Average Velocity	25.1727 m/s	Achieved (IT = 100)	0.0484607 m	25.1733 m/s
Mass Flow Rate	0 kg/s	Achieved (IT = 64)	0.001 kg/s	0 kg/s
Torque (X)	-439.426 N*m	Achieved (IT = 64)	14.0876 N*m	-439.617 N*m
Average Shear Stress	0.977741 Pa	Achieved (IT = 80)	0.0185311 Pa	0.94292 Pa
Force	851.989 N	Achieved (IT = 64)	28.8724 N	852.883 N
Maximum Total Pressure	114326 Pa	Achieved (IT = 96)	171.851 Pa	114222 Pa

VII. EXPECTED RESULT

When a truck or car is in motion on the highway, it encounters a significant amount of drag force, which can have a negative impact on the vehicle's range and efficiency. However, this drag force can be utilized to increase the range of an electric vehicle's by charging the battery pack at the same time. The findings of this research paper suggest that by incorporating a wind turbine to harness the available drag force, it is possible to improve the battery's range and efficiency, thereby enhancing the overall performance of the electric vehicle.

We are expecting the electricity power which produced by the turbine blades when it will rotate inside the shell will be more that our calculation on the open turbine blades. Because the opposing rotational drag force of turbine blades will reduce.

VIII. CONCLUSION

If we use our model, the range of the truck/car is increased on the highway.

With our solution, we will increase the range of the vehicle with no extra battery pack and no use large size Battery pack which in used in transportation, on the Highway.

In Electric vehicle, the main problem is range. With our solution we just try to reduce that problem with one time investment.

If we will successful in our expected result. We are sure that this will increase the adaptation of the electric vehicle in the society.

And this will produce the drastic change in the electric vehicle research.

IX. ACKNOWLEDGMENT

We would like to thank Dr. Ashish Manoria, our Professor-in-charge. We would like to express our Gratitude for their support and guidance in completing our project on the topic (Electric Vehicle Using Drag Force to Increase its Range). It was a great learning experience.

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