International Journal of Science, Environment and Technology, Vol. 6, No 4, 2017, 2369 – 2385
ISSN 2278-3687 (O)
2277-663X (P)

Case study

A CASE STUDY ON 'DUAL ENERGY SOURCE RUNNING VEHICLE', IT'S DESIGN AND IMPLEMENTATION IN BANGLADESH

Md. Arman Arefin[1], Avijit Mallik[2] and Imran Rashid Mujawar[3]
[1]Department of Mechanical Engineering, RUET, Rajshahi, Bangladesh
[2]Department of Mechanical Engineering, RUET, Rajshahi, Bangladesh
[3]Department of Mechanical Engineering, Walchand College of Engineering, Maharashtra, India
E-mail: dipto70@yahoo.com, avijitme13@gmail.com

Abstract: Dual energy source running vehicles are not so familiar. But this system is environment friendly and more effective for the developing countries transportation system. This technology is a growing one now. This paper is basically focused on developing a dual energy source running vehicle system which would be more environment friendly and less fuel consuming. The system will basically use thermal energy and solar energy. The new thing introduced here is the number of batteries will be less and those will operate on a rechargeable condition through solar system and also a new type of gear arrangement has been introduced here. Our center of interest is mainly on Bangladeshi common vehicles. How those can be transformed into environment friendly ones? For example- An Auto rickshaw can be transformed into a Dual energy source running vehicle. The system is theoretical and further experimentation is needed to develop it perfectly. Here the paper will explain the basic theory.
Keywords: Environment friendly vehicle, dual source vehicle, Fuel efficient vehicle, Solar running vehicle.

Objectives

1. To introduce a new type of vehicle
2. To introduce a less fuel consuming and more environment friendly vehicle
3. To find out the system's short-comings and advantages

1. Introduction

Bangladesh is a developing country. Bangladesh is developing in all sectors day by day. But the road condition in Bangladesh is not satisfactory. In small cities and villages many roads are broken or not repaired properly or narrow. Sometimes in big cities like Dhaka, Chittagong some broken and narrower roads are seen. This is one of the main reasons of accident. Because of these broken roads travelling requires more time. Many vehicles cannot run on these broken or narrow roads.

*Received June 24, 2017 * Published Aug 2, 2017 * www.ijset.net*

There are mainly 3 types of transport/vehicle in Bangladesh according to travel distance, time and road condition. [1]

1) Road transport
2) Train transport
3) Water transport

Road transport: There are several vehicles out there in Bangladesh running on the road.[2]

1) Bus – Long distance vehicle
2) Truck-Long distance vehicle
3) Auto rickshaw – Medium and Short distance vehicle
4) Rickshaw – Short distance vehicle.
5) Motor cycle e.t.c

Normally, Bus is used to travel from one city to another. It is a long distance travelling transport. Truck is used for carrying different goods from one city to another. Rickshaw is used to got to a very short distance. Whenever it is necessary to travel 1 Km-7 Km (approximately) rickshaw is used. Auto-rickshaw is mostly used to travel at any distance inside a city or area. Auto rickshaw is the most used vehicle in Bangladesh. It is familiar all over in Bangladesh. Mainly inside a rickshaw and auto rickshaw are used. But auto rickshaw is faster, comfortable than rickshaw. IT has more space too than a typical rickshaw.

The word rickshaw's is originated from Japanese language, and it translates to "a human-powered vehicle". The term was first used in 1887.In Bangladesh the rickshaw began as a two or three-wheeled Passenger cart, called a pulled rickshaw, generally pulled by one man with one or two Passenger. The rickshaw is one of the oldest mode of transportation, and it is a source of Employment for male labors in Bangladesh from the 19th century. The auto-rickshaw and the relatively newer iteration of the e-rickshaws (electronic rickshaw).Because of their low cost auto rickshaw is becoming more popular than taxies in 21st century. Auto-rickshaws are a common means of public transportation in many countries in the world. They are Also known as a three-wheeler, samosa, tempo, tuk-tuk, trishaw, autorick, bajaj, tricycle, mototaxi, baby taxi or lapa in popular parlance, an auto rickshaw is a usually three-wheeled cabin cycle for private use and as a vehicle for hire. Battery operated auto-rickshaw is a newly added Para-transit mode in urban transportation system of Bangladesh.[1]

There are many different auto rickshaw types, designs, and variations. The most common type is characterized by a sheet-metal body or open frame resting on three wheels, a canvas roof with drop-down side curtains, a small cabin at the front for the driver (sometimes known

as an auto-wallah) with handlebar controls, and a cargo, passenger, or dual purpose space at the rear. [2]

At present in Bangladesh the fuel price is increasing day by day. Thats why the auto rickshaw drivers are claiming more money from the passengers. Moreover, using petrol, gas etc are not good for the environment. They release different types of deadly gas and chemicals to the atmosphere which is very dangerous and harmful for humans and animals.

In this paper a mechanism of using two power sources to run an auto rickshaw is shown and described. Here solar energy and thermal energy is used to run the rickshaw separately. There are several reasons behind this work. These are stated below

1) Bangladesh gets huge amount of energy from the sun. In Bangladeshthe highest sunlight hours received is in Khulna with readings ranging from 2.86 to 9.04 hours and in Barisal with readings ranging from 2.65 to 8.75 hours[3]

2) Fuel price is increasing day by day.

3) Combining with solar energy will reduce environmental pollution.

2. Theory:[10], [11], [12], [13], [14], [15], [16], [17]

Here two power sources are combined. One is solar power and other is thermal power. The solar power will be utilized by motor and the thermal power is utilized by the engine. in this duel energy source vehicle two power source is not being used at a time, only one power source is used at a time. When one is running the engine then the other is off and when the other source is running the engine then the first one remains off.

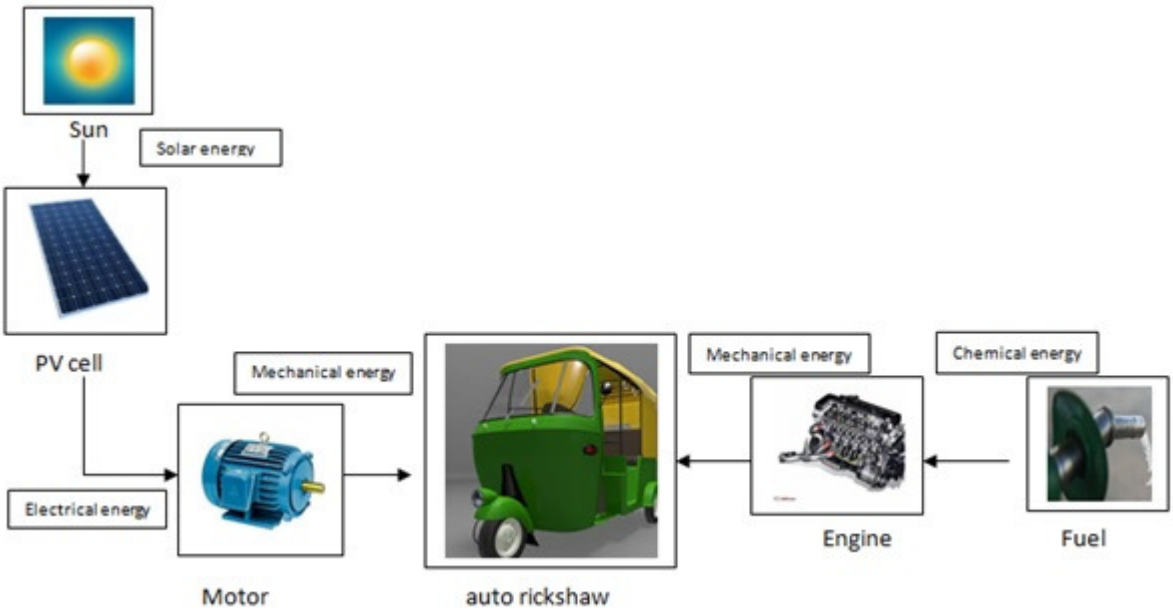

Fig: 1- Schematic Diagram of the proposed system

The sun is the main source of energy. The outer atmosphere of the sun gets enormous amount of energy.PV cell is used to produce electrical energy from solar energy. PV cell uses solar light energy and converts it to electrical energy. Electrical energy is then stored to the battery (energy storage device). Battery runs the motor. The motor rotates the axle and the wheel of the rickshaw rotates.

The other source is thermal energy source. Fuel (petrol) has chemical energy which when used in an engine converts to Thermal energy and this thermal energy is converted to mechanical energy, which is supplied to the vehicle keeping the wheel running.

These two sources of energy are separately used in the vehicle and separately keep the vehicle running at different times.

3. Mathematical Modeling:

This paper is mainly based on a duel energy source vehicle. Here, two sources will be operated separately. The sources used in this vehicle are solar energy source and thermal energy source (2 stroke IC engine).

By using energy created by sunlight the PV module will run and using necessary fuel (petrol) 2 stroke petrol engine (Tata ace engine -1993) will run.

The mathematical modeling is shown below:

3.1. Engine calculation:

According to Physics, Power is the rate of doing work. It is the amount of energy consumed per unit time.

Engine power also known as Horse Power is the power that an engine can impose upon. The power output depends on the design and the size of the engine along with load or torque and the running speed.[10], [12]

Indicated power also known as Indicated Horsepower developed inside the engine cylinder by burning fuel. It is the theoretical power of a reciprocating engine converting the expanding gas energy in the cylinder if it is considered as completely frictionless. But in physical process, two types of friction are observed in the running vehicle .these are

1) Internal friction (piston sliding inside cylinder, bearing friction, gear box friction etc.)

2) External friction (friction in running wheel, environmental friction etc.)

So two types of excess power have to be calculated. These are 1) Break power 2) frictional power.[10], [11], [12], [13]

Necessary formulas for calculating these two powers are: Power equation for IC engine-

Indicated Power,IP $= \frac{P_m.10^5.L.A.n}{60} \times k$(Watts)[10]

Here, P_m = Actual mean effective pressure in Bar

L = Length of strokes in meters

A = Area of the piston in sq. meters

n = Number of working strokes

k= Number of cylinders

n = N/2 ; N= Speed of the engine in rpm

In case of pony Break,

Break Power, BP $= \frac{T.2\text{Ⅲ}.N}{60}$(Watts)[10]

Here,

T = Torque in N-m

N = Speed of the engine in rpm

T = W .l ; W= Break Load in Newton, l = Length of arm in meters

In case of rope brake,

BP $= \frac{(W-S).\pi.(D+d).N}{60}$ (Watts)[10]

Here,

S = Spring balance readings in Newton

D = Diameter of brake drum

d = Diameter of rope

Frictional Power, FP, = Indicated Power – Break Power[10]

The selected engine is TATA ace-1993 model. The specification of the engine is given below-

Dimensions	**Value with unit**
Engine type	Naturally aspirated petrol(SI)
Manufacturer	Ford
Cylinder	V2
Capacity	4.9 litre
Bore * Stroke	101.6*76.2 mm
Bore stroke ratio	1.33
Valve gear	OHV(2 valves per cylinder)

Maximum power output(DIN)	194 kW at 5250 rpm
Maximum torque (DIN)	434 Nm at 3200 rpm
Specific output power(DIN)	52.6 bhp/litre
Specific torque (DIN)	87.82 Nm/litre
Brake mean effective power	1013.6 kPa
Crankshaft bearings	5
Coolant	Water
Unitary capacity	617.75 cc
Catalytic converter	Y
Fuel tank capacity	40 litre
Aspiration	Normal

Table: 1- Specifications of Tata Ace -1993 model engine [4], [8]

3.2. PV module calculation: [15, 16, 17]

The proposed vehicle will run depending upon time, environmental factors, road condition mainly. Considering all these factors the vehicle engine power or the solar power will be used separately to keep the vehicle running.

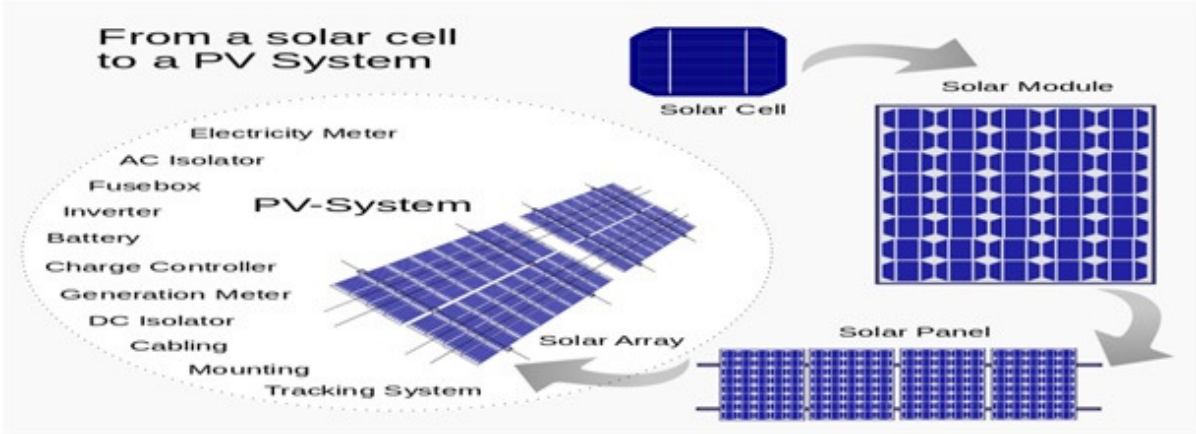

Fig: 2- Solar cell to PV system diagram [18]

Total power= total weight*g*speed*gradient

= 500* 9.81*20kmph *.03 = 817.5 watt

So require 12 volt 1 kwatt motor

Battery: 24 volt battery

Load current = 1000/24= 41.67 amp

Estimating 4 hours of tricycle running

Load current= 4*41.67*1.2=200.016 = 201 Ah/day

Assuming 25% overall losses

Size of battery = 201*1.2=241.2 Ah/day

Energy required for 1500 w motor=241.2 Ah*24= 5789 Wh/day

So 5789 Ah/day, 24 volt power required for the system

This can be achieved with the help of two 24 volt batteries of 5789 Ah/day

Charging time: let, solar panel being used is -

Parameters	Model with units
Solar Panels	Bosch Solar Module c-Si M60
Rated output	245 W each
Dimensions	1660*990*50 mm
No. of cells per panel	60*mono-crystalline solar cells
Efficiency	17.6-18%

Table: 2- PV module parameters [19]

Solar capacity - 245 watt.Taking 12 volt solar.

So, Current = 4.7 amp

Charging time = 241.2/4.7 = 51.32hours…means 51.32 hours needed to charge battery fully.

[2 solar panels will be used, so the charging time will become 51.32/2= 25.66 hrs]

Bangladesh has typically 8 hours sun light per day in dry season.

So in 8 hours the battery will be charged (100*8)/25.66= 31.2%

The rest of it is being charged by national grid.

3.3. Fuel economy calculation:[12], [13], [14]

Assuming the auto rickshaw runs 10 hours a day. 6 hour by petrol and 4 hour by battery energy.

Now,

Typical speed of an auto rickshaw is approximately 50 km/hour.[20]

In 10 hours it runs = 50*10=500 km

In 6 hours it runs = 6* 50 =300 km

Fuel consumption of an auto rickshaw is approximately 20km/liter. [21]

So, To run 10 hours needs = (500/20) = 25 liter petrol.

And to run 6 hours needs = (300/20) = 15 liter petrol.

So, this auto rickshaw will consume less fuel than typical one. This prototype will be more environment friendly.

4. Design (prototype):

Firstly the engine model was designed in solid works. The engine used here is TATA Ace-1993 modelaccording to Table-1 specifications.

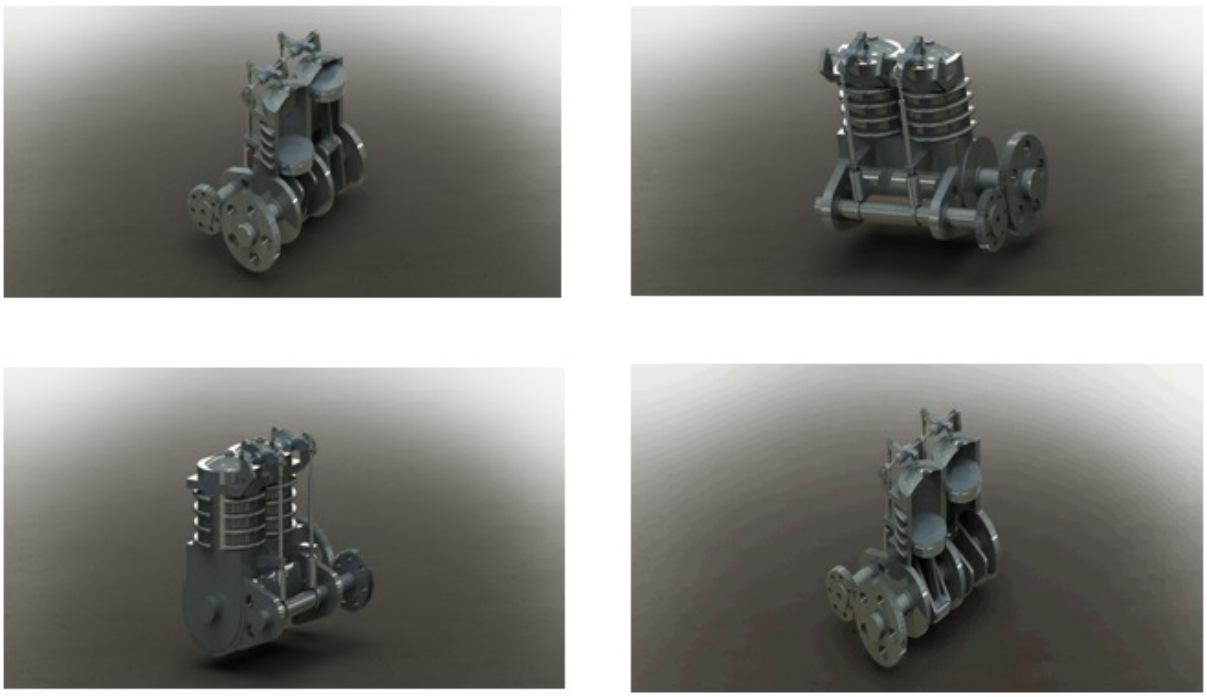

Fig: 3 - Design of the 2 stroke auto-rickshaw engine

Fig: 4 – Actual TATA ace – 1993 engine [4]

The PV cell module was designed in solid works then it was practically designed according to thefollowing specifications-

Parameters	Model with units
Solar Panels	Bosch Solar Module c-Si M60
Rated output	245 W each
Dimensions	1660*990*50 mm
No. of cells per panel	60*mono-crystalline solar cells
Efficiency	17.6-18%

Table: 3 – PV module specifications [19]

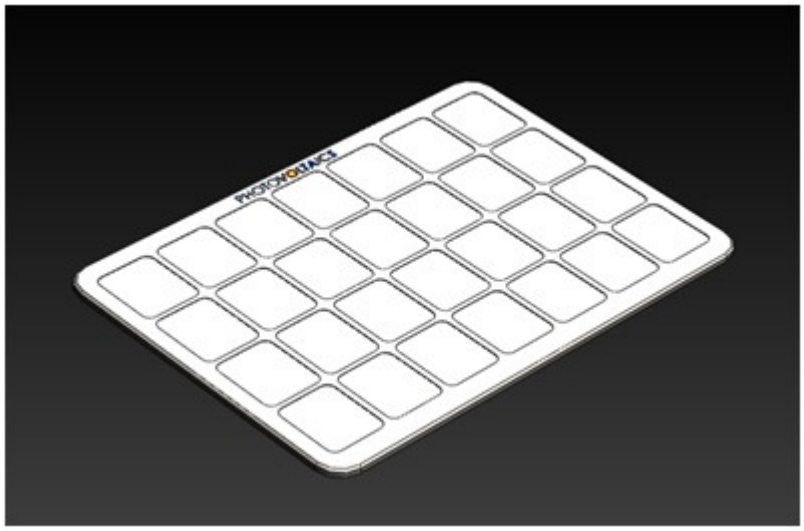

Fig: 5 - Design of the solar PV converter

Fig: 6 – Original figure of selected panel [22]

The engine and PV module designed in solid works was then assembled with an auto-rickshaw body.

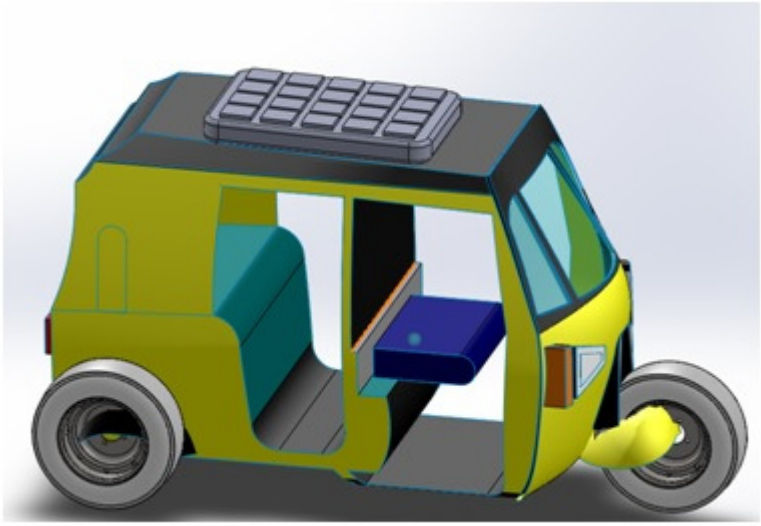

Fig: 7 - Design of auto-rickshaw body

Fig: 8- Real figure of the auto-rickshaw [5]

The specifications of the auto-rickshaw body is given below-

Parameters	Values with Units
Height	1.8288 m
Length	2.1336 m
Weight	95 kg
Width	1.7 m
Couch Space(Back)	1.5 m
Couch Space(Front)	1m

Table: 4 - Auto Body Specifications[5, 9]

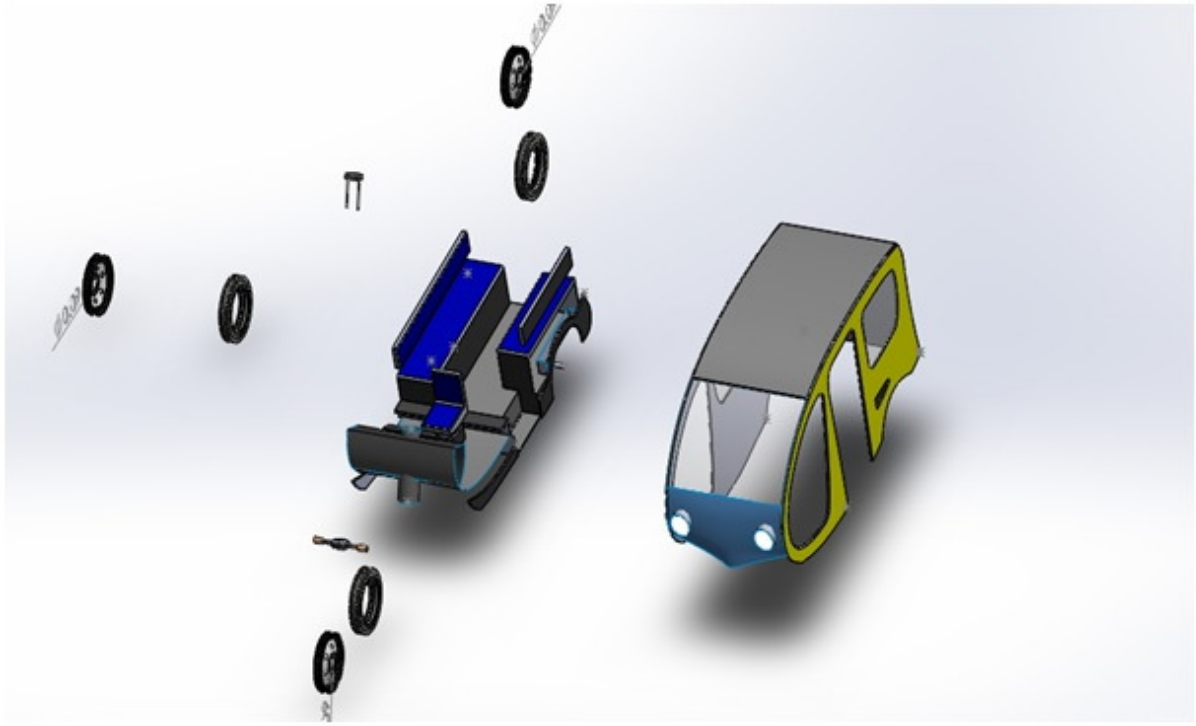

Fig: 9 – Total disassembled body

Fig: 10 - Real figure of the prototype.

5. Linkage:

In the engine we are using chain and sprocket system for transmitting power from crankshaft to axle.

In the auto rickshaw there had to make such mechanism that when the engine runs the vehicle the motor will remain off and linkage of the motor with the axle will break and when the motor will run the vehicle the engine will remain off and the linkage of the engine with the

axle will break. Then again when the engine will run the vehicle the motor will go off and linkage of the engine with the axle will make. Similarly, when again the motor will run the vehicle then the engine will go off and the linkage of the engine with the axle will break and linkage with the motor with the axle will be made. This is how the linkage system works in the vehicle.

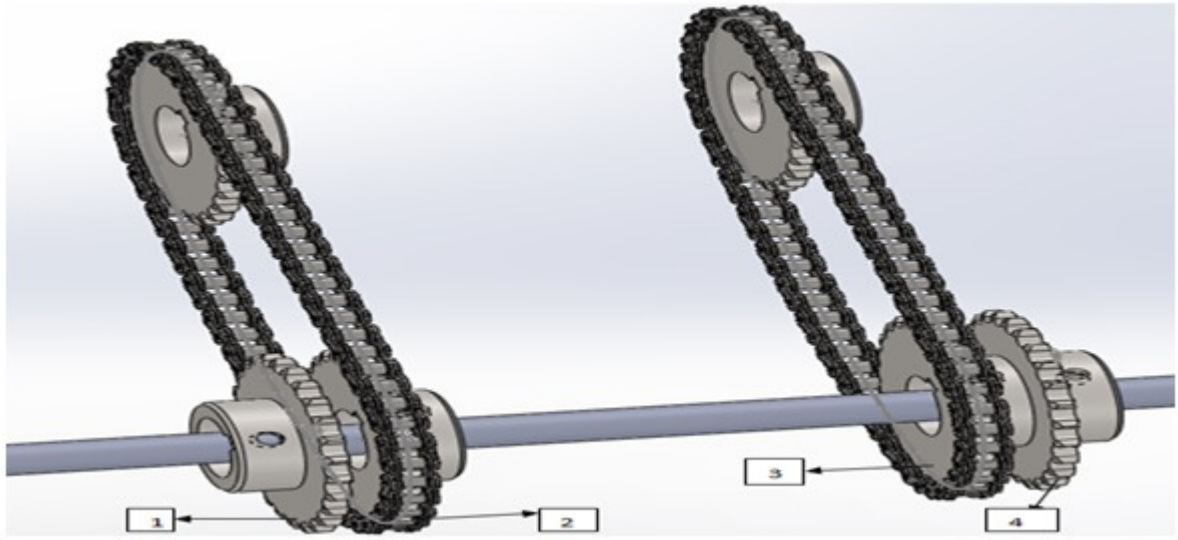

Fig: 11- Gear drive mechanism

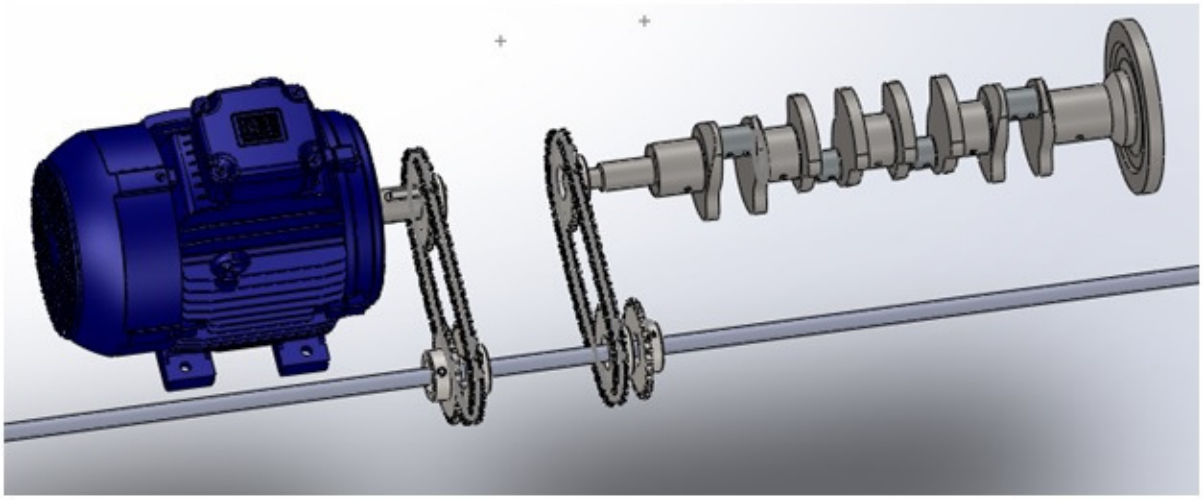

Fig: 12- Design of motor and engine wheel drive mechanism (without wheels)

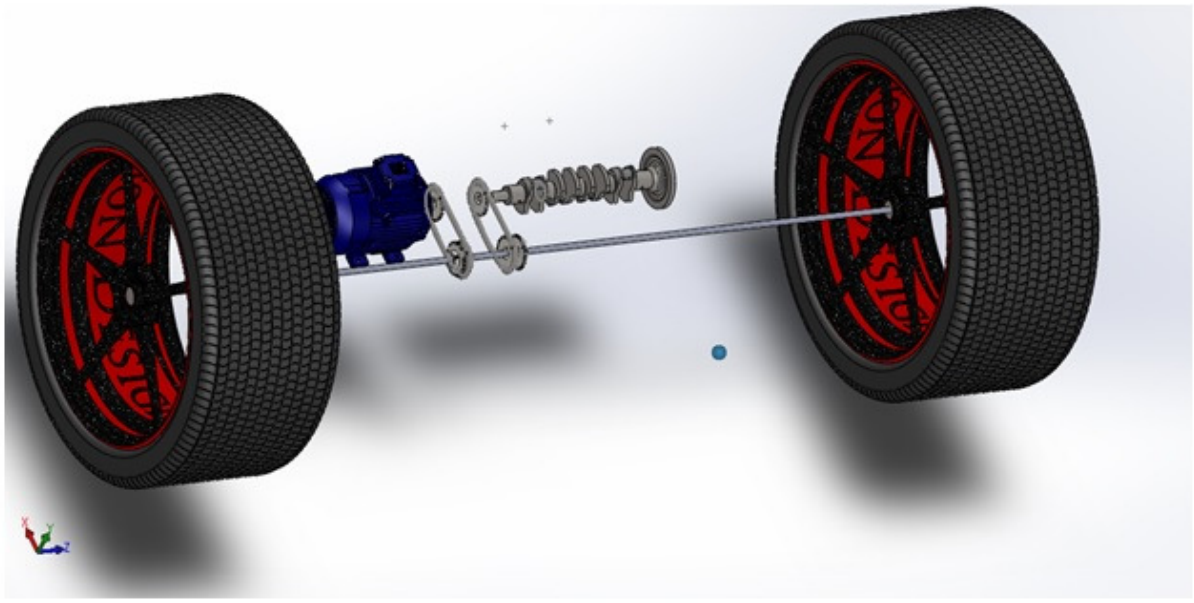

Fig: 13 - Design of motor and engine wheel drive mechanism (with wheels)

Now the question is here how the engine and the motor would get attached and detached with the axle -

For attaching and detaching the motor and engine gear shifting mechanism of bi-cycle is used here. In Fig: 6.1, there are total 6 spur gears. No.2 is attached with engine and motor and No. 4 are with the axle. the gears with whom(gear attached with axle) the chain is attached is fixed with the axle, but the other two gears which attached to the axle are journal bearing supported. So when the axle rotates only the journal parts of the bearing rotates not the gears.

When it is needed to disengage gear the chain would be shifted to the No. 4 gear and it would be disengaged from the axle since it would not rotate any more with the rotation of the axle, again when it is needed to engage the engine with the axle the chain of the engine would be connected with No. 3 gear. Similarly, to disengage the motor with the axle the chain would be shifted to the No.1 gear and to engage again it would be shifted to No.2 gears.

The gear shifting mechanism here used is which is used to shift gear in bi-cycle. Here 2 derailleur with the axle and 2 shifter besides the steering is attached. When the driver presses the shifter 1 of the derailleur attach the chain from 1 to 2 or 2 to 1.when the driver presses the shifter 2 the derailleur attach the chain from 3 to 4 or 4 to 3.

Fig: 14- Back derailleur of gear bi-cycle.

Fig: 15- Gear Shifter

6. Working procedure:

As stated before it is a duel energy source vehicle (Solar energy and thermal energy).The solar energy is converted to electrical energy and stored in battery and the thermal energy is converted to mechanical energy and supplied by the engine. This vehicle can run with one power source at a time. First at the time of starting the vehicle decision must be taken with which power source the vehicle would run. If it is solar power then it is necessary to keep the engine off. If the first power source is engine, then it is necessary to keep the motor off. Then the vehicle can run smoothly. The process can be vice versa (have to keep the motor off and engine running). If after sometime it is necessary to change the power source then have to go through the same procedure stated above.

7. Properties of The Proposed Vehicle:[2, 3, 4, 5, 14, 15, 16]

7.1. Advantage:

There are several advantages of using this duel power source.

I. Low fuel consumption- If the auto rickshaw runs 10 hour per day. Then it will run 4 four using battery power and 6 hour using petrol. So it will reduce the use of non-renewable energy source

II. Energy Efficient- It utilizes the solar energy. Bangladesh gets huge amount of solar energy getting most of it wasted. This auto rickshaw runs on solar energy and hence utilizes it.

III. Pollution Reducer- Reduces environmental pollution. Since the auto rickshaw can run on solar energy. So there is no harmful gas emission during running on solar energy. It is very much environmental friendly.

IV. More Efficiency- This mechanism Increases the run time of the vehicle. Now it can run 4 hour more in a day by using the battery power.

V. More Durability- This mechanism makes the vehicle safer and noise free than before. If for any reason the engine breaks down then it can use battery power to run and when it runs on battery power it does not make any annoying noise what engine does.

7.2. Shortcomings:

I. The first installation cost is higher than typical auto rickshaw. Approximately 30-40 thousand extra taka (around 372-496 USD) needed for the first installation

II. The driver has to be very careful about turning off and on the power source. When the driver is using the solar power he have to turn off the engine and shift the chain to the next gear in axle and when using engine power then have to turn the battery connection off and have to shift the battery connector chain to the next axle gear. If the driver fails to do any one of this the system will break down.

III. Another shortcoming is the vehicle is little bit heavier than typical auto rickshaw. That's why it requires a little more power to run.

7.3. Personal recommendations:

I. The engine used here is a 1993 model. If a new (modern and developed) engine can be introduced the system would give better efficiency.

II. This type of auto rickshaw requires skilled driver, because it's different from other fuel operating vehicles. So, driver must be a skilled one.

III. Since it is a duel power source vehicle so it requires more space to install the whole system.so, vehicle dimension should be slightly bigger than typical one.

8. Conclusion

In this paper there is just an idea of a new type of energy saver vehicle run by two energy sources. The basic mathematical rule is stated in it. But it's a big challenge to make that possible in practical life. If this vehicle can be introduced then a new era will be made on the "Renewable Energy" field. Especially for the developing countries it will be the best public vehicle for going medium distance.

Acknowledgement

1. Rahimafrooz Batteries Ltd., Dhaka Bangladesh
2. Rahimafrooz Solar Company Ltd., Dhaka, Bangladesh
3. Bosch Solar Energy, Stuttgart, Germany
4. Tata Motors Ltd., India
5. Bajaj Auto Ltd., India
6. Uttora Motors Ltd.

References

[1] Rabeya Basri, Tahmina Khatun, Md. Selim Reza, Dr. Md Moazzem Hossain Khan, '*Changing Modes of Transportation: A Case Study of Rajshahi City Corporation*'

[2] https://en.wikipedia.org/wiki/Auto_rickshaw

[3] SHAKIR-ulhaque Khan, TOWFIQ-ur-Rahman, SHAHADAT Hossain (2012)'*A BRIEF STUDY OF THE PROSPECT OF SOLAR ENERGY IN GENERATION OF ELECTRICITY IN BANGLADESH'*

[4] www.tatamotors.com

[5] www.bajajauto.com

[6] www.uttaramotorsltd.com

[7] http://www.harleyc.com/prelude/articles/allaboutmeaneffectivepressure

[8] http://www.carfolio.com/specifications/models/car/?car=16214

[9] http://www.bharattraders.com/three-wheelers.html

[10] '*Textbook of Thermal Engineering*' book by J.K. Gupta and R.S. Khurmi

[11] '*Internal Combustion Engine Fundamentals*' by John B. Heywod (1998)

[12] '*I.C. Engines*' by V. Ganesan (1994)

[13] '*Vehicle and Engine Technology*' by Heinz Heisler (1985)

[14] '*Thermodynamics : An Engineering Approach*' by Michael A. Boles &Yunus A. Cengel

[15] *'The Physics of Solar Cells'* by Jerry Nelson (2003)

[16] '*Solar Photovoltaic Cells : Photons to Electricity*' by Alexander P. Kirk (2014)

[17] *'The Complete Battery Book'* by Richard A. Perez

[18] https://en.wikipedia.org/wiki/Solar_cell#/media/File:From_a_solar_cell_to_a_PV_system.svg

[19] www.bosch-home.com

[20] http://theforeignchallenge.com/indian_challenge/auto_rickshaw_challenge

[21] http://timesofindia.indiatimes.com/city/pune/Autos-give-20-25-km-mileage-per-litre/kg/articleshow/13087815.cms

[22] http://docplayer.org/5846594-Bosch-solar-energy-corporate-presentation-solar-energy.html