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ELECTRICAL POWER USES FOR RURAL AREAS WITH ANIMAL POWERED DEVICE HYBRID WITH SOLAR ENERGY IN PLACE OF CONVENTIONAL FUEL

D. L. Soni[1], H.Chandra[2], Dhannjay Kumar Yadav[3]

[1]Department of Mechanical Engineering, [3]Mechanical Engineering,
Parthivi College of Engineering and Management, Bhilai-3,C.G., (India)
[2]Department of Mechanical Engineering, VECL, Sarguja University Ambikapur, C.G., (India)

ABSTRACT

In this paper a hybrid power system combining solar energy and animal energy is experimentally studied to supply continuous power for lightening in home and small uses of electrical power aplications at rural area where wood and carosine has been using and removal of its harmful effect on environment caused by the the of these fuels. Animals have been using for domestic works at rural areas but the electricity generation by Animal power is a new idea. The invented animal powered mechanical device has unique features of using animal power as prime mover for electricity generation. Animal energy in form of high-torque is converted into high-speed through mechanical system to energize the electrical energy generator. The electricity is stored in the battery and using invertor it can be use for lightening of home by converting Direct Current to Alternative Current. This equipment has long life, emission free and it is cost effective. The photovoltaic systems is used as primary source while the animal system is used as secondary source which can be used when needed. This system can work when the sun light is either available or not available in both conditions. This can replace the carosine and other fuel uses for lighting and for small uses of electricity and can decreases the harmful effect on environment.

Keywords: Animal Power, Photovoltic Systems, Kerosene Effect, Hybrid Energy.

I. INTRODUCTION

Lack of suitable home lighting is directly linked to illiteracy, poverty and health problems. Over 1.5 billion people rely on kerosene for light. The current widespread burning of kerosene also results in environmental pollution. It is very difficult and very costly to available grid power everywhere specially at remote isolated communities in developing countries. There are many renewable power sources like solar power, wind power, hydropower, bio-energy, geo-thermal power, tidal energy etc, but all have their limitations. Although from beginning of mankind animals have been using for domestic works at rural and remote areas, but the electricity generation by Animal power is a novel technology[1-4].

There is still widespread dependence on traditional forms of energy, and human and animal power still contribute a significant proportion of the energy used in the rural areas of developing countries. After biomass, they are the most important energy sources for their populations. On a global scale, the energy contributed by human and animal power is estimated to be twice that of wind power and 13% of hydro, the largest single contributor of the renewable energy sources [17].

Some of the opportunities which exists and recommends approaches to develop and promote entrepreneurship in animal traction [19].

Global environmental concerns and the escalating demand for energy, coupled with steady progress inrenewable energy technologies, are opening up new opportunities for utilization of renewable energy resources. Solar energy is the most abundant, inexhaustible and clean of all the renewable energy resources till date. The power from sun intercepted by the earth is about 1.8×1011 MW, which is many times larger than the present rate of all the energy consumption. Hybrid PV generation, various light absorbing materials, performance and reliability of PV system, sizing, distribution and control is presented. The different applications of solar PV system such as building solar home systems [20].

The stand-alone hybrid solar–animal power generation system is recognized as a viable alternative to grid supply or conventional fuel-based remote area power supplies all over the world. It is found that continued research and development effort in this area is still needed for improving the systems performance. based on load demand is essential for reducing the hybrid system‟s initial cost and operation cost[4]. Renewable energy technologies are known to be less competitive than traditional electric energy conversion systems, mainly because of their intermittency and the relatively high maintenance cost. However, renewable energy sources have several advantages, such as the reduction in dependence on fossil fuel resources and the reduction in carbon emissions to the atmosphere. Furthermore, renewable energies avoid the safety problems derived from atomic power [25], which is why, from the social point of view; it has become more desirable to adopt renewable energy power plants [26]. Several authors have evaluated the main renewable energy technologies taking into account sustainability indicators, such as Evans et al [27]. who compared wind power, hydropower, photovoltaic and geothermal energy taking into account the price of generated electricity, greenhouse gas emissions during the full life cycle of the technology, availability of renewable sources, efficiency of energy conversion, land requirements, water consumption and social impacts [4].

II. EXPERIMENTAL DETAILS

2.1 Experimental Details of Solar System

2.1.1 **Solar Power**: The solar power of size 1000 Watt which has four solar panels of 250 Watt in series was used in experiment which has been using by author for last two years. Solar panel is manufactured by Sova Power Ltd. It has efficiency of more than 85%. solar photovoltaic system has SS 250P Module, 250 W Rated peak power (Pmax), 34.85 V Rated voltage (Vmp), 7.19 A Rated current (Imp), 42.91V Open circuit voltage (Voc), 7.85 A Short circuit current(Isc). **2.1.2 Battery system**: Inverter Tubular Battery of 12V 180 AH is used. The maximum charging current not exceed 25 Amps. The system cut off voltage shall be at 14.4V and discharge cut off voltage10.8V.

Type: 6SB-180XLTT

12V 180AH @ 10Hr. Rate

1.250 SP. GR. @ 27˚C

2.1.3 Inverter: MRO-TEK‟s DSP based Sine wave Solar PCU with state of the art technology is used. The key functionalities are when the solar power is available, battery will be charged by solar panel and the load will be powered by solar energy. If the load requirement is more than the available solar power then the battery will supply the additional load. Also this inverter work on Maximum Power Point Tracking (MPPT) battery charge control system which has Inverter Model NS 1024S+, MPPT Model NS 1024S+, Max solar open circuit volt 85 and 85% Efficiency with 15A Output current (Amps)

2.2 Experimental Details of Animal Powered Device

2.2.1 Draught animal: The authors‟ main object is to use the animal power for generating electricity for domestic and agriculture use. And bullocks are mainly used in Indian agriculture for different purposes. For this experimental study authors use the pair of bullocks. The weights of bullocks are 456 kg and 478 kg. The mechanical link is fitted with a device pulled by pair of bullocks called bellan (Dhauri) which is made of wood and has the weight of 105 kg.

2.2.2 Mechanical link: mechanical link of mild steel material having 52 mm diameter and 230 mm length with extended extra strong GI pipe of 3000 mm length and 4.5 mm wall thickness, capable of transmitting animal power in form of high torque low speed is attached to speed increaser. Mechanical link starts moving in a circular path of 5 meter diameter when bullock drived belan attached to mechanical link with the help of GI wire starts moving. A pair of bullock‟s moves in a circular path of 5 meter diameter With approximate speed of 60 meter/min. Input shaft of the speed increaser coupled to mechanical link rotates at 3.8 rpm when a pair of bullocks completes one round of 5 meter dia. circular path in one minute.

2.2.3 **Speed increaser**: Speed increaser is a four set of spur gears housed in a frame of mild steel angles having 690 mm × 690 mm at the top and 780 mm × 780 mm at bottom. It is having 4 numbers of stages with gear ratio of 1:4.5. Input shaft of the speed increaser having 50 mm diameter and 1500 mm length of mild steel material is in vertical position whereas output shaft having 50 mm diameter and 1000 mm length of mild steel material of the same is also in vertical position. The vertical shafts are supported with taper roller bearings at top and bottom. Bearings are fastened on tie-bars which are welded on frame. Speed increaser is specially designed for transmitting and converting low-speed high torque to high- speed low – torque.

Fig1: Integreted Belan, Mechanical link, Speed Icreaser, belt & pulley, alternator and battery

2.2.4 Gears: Four sets of spur gears transmits the power among parallel shafts. The spur gears are made of cast iron having module 5 mm. the spur gears has 68 teeth while the spur pinions has 15 teeth. The pressure angle is 20 degree and outside diameters are 350mm and 85mm respectively. The speed ratio of 1:4.5 is obtained in single stage. Material properties spur geare made of cast iron which is used is of 320-350Mpa Ultimate Tensile Strength, 1.67e5 N/mm^2 Young‟s Modulus, 7.2e-6 kg/mm^3 Density, 0.25 Poisson‟s Ratio, 1.1 Co-efficient of friction. the geometric for cast iron spur gear is done according to Module (m) 5 mm, Pressure angle (α) = 20 degrees, No of teeth (z) = 68 and 15 and strength calculation Is done using Lewis equation [5]

2.2.4.1 Geometric details of desired spur gear[5]

Module	=	5 mm	
Addendum	=	1 module	
Dedendum	=	1.157 × module	
Pressure angle (α)	=	20 degrees	
Tooth thickness (t)	=	1.571 × module	
	=	1.571 × 5	= 7.855mm
Whole depth	=	2.25 × module	
Face width (b)	=	5.4 × module	
	=	5.4 × 5	= 27mm
Fillet radius	=	3.9 × module	
No of teeth (z)	=	68 and 15	
PCD	=	z × module	
	=	68 × 5	= 340mm
And		15 × 5	= 75mm
Outside diameter	=	(z+2) × module	
	=	350mm	
And		85mm	

2.2.4.2 Strength calculation for spur gear [5]

Using Lewis equation

Tangential load (F) = $\sigma b \times y \times P_c \times b$

y = 0.1034

P_c = $\pi \times$ module

F = 2×500 = 1000N

putting in Lewis equation

1000 = $\sigma b \times 0.1034 \times (\pi \times 5) \times 27$

σb = 22.81N/mm2

σ_{all} of Cast iron (high grade) = $\sigma_{ut}/3$

= 320/3 = 106.67 N/mm2 > 22.8 N/m

According to [5, 6] an animal (bullock) can applied the tangential force of 500N.

Therefore total force can be applied is 1000N for two side animal working.

2.2.5 Belt and Pulley transmission unit: The final increase in speed is done by using belt and pulley system. First pulley of 228.6mm (9 inch) was mounted on the output shaft of the speed riser and counter pulley was mounted on car alternator having 76.2mm(3 inch) thereby stepping up the speed with 1: 3 when connected to the toothed belt. According to Indian Standard Code (IS: 2494-1974), the A type of belt is selected which has power ranges 0.7kW – 3.5 Kw.

2.2.6 Generator: In this experimental study the car alternator is selected to generate electricity which is Lucas-TVS car alternator of 12V and 95 Amp. Car alternator works at high rpm efficiently. It produces constant voltage but current is dependent on rpm and produce more current at high rpm. The alternators rotor can be rotated either clockwise or counter clockwise to get the same output energy values. The pulley belt is connected between the output gear shaft and alternator head and the alternator is wired to output DC storage or load. The alternator and battery circuit is shown in figure.

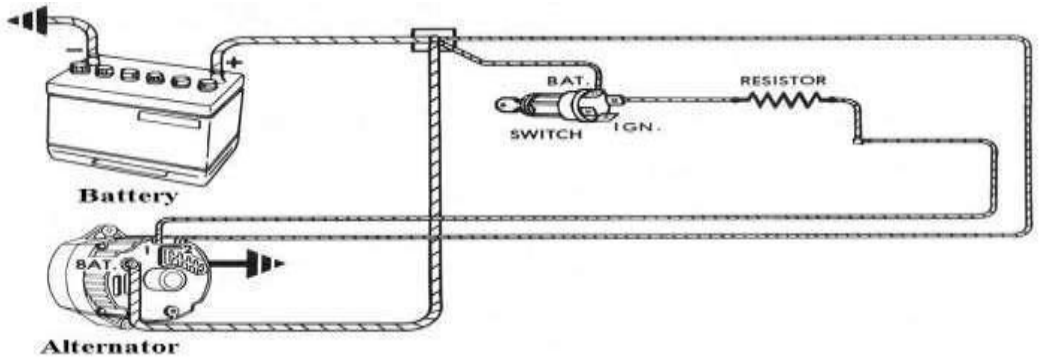


Fig 2: Standard alternator and battery charging circuit[13].

2.2.7 Storage system: A typical 12 V and 150 Ah Lead-acid battery as used in automobile is selected. It is a type of battery which is rechargeable and supplies electric energy to an automobile electric circuits. It shows 12.6 volt at full charge and 11.8V at fully discharged. Charging time depends on the capacity of that battery and the resting voltage of that battery when starts charging it. If battery is 50% or more charged, it takes less time to charge more.

This inventions main object is to produce power for home lighting at rural and isolated remote areas where population rely on kerosene for lighting. This system consist the six CFL bulbs of 25 watt which means total 150 watt for AC use and six DC bulbs of 60 watt with total consumption of 360 watt. The inverter(Microtek) of 750VA, 230 Volt at 50 Hz is used for converting DC to AC power.

2.3 Fabriction and Procedure

The fabrication of speed increaser was done very carefully because there are five vertical shafts which are supported by taper roller bearing. The bearing covers were fitted with the help of nut and bolt on the mild steel ties, which are welded on the frame at top and bottom. Collars are provided at bottoms of shaft to support the load on bearings. Gears are fitted by means of nuts by driling two holes on the shafts and on gear houges. There are four step gear transmission system. The first gear of 68 teeth was mounted on first shaft at 20mm from the color which meshes with the second gear having 15 teeth mounted on second shaft at 20mm above from the collar. The third having 68 teeth was mounted on second shaft 50mm above the second gear and meshes with the fourth gear having 15 teeth which was mounted on third shaft at the same height. The fifth gear having 68 teeth was monthed on third shaft 50mm above the fourth gear and meshes with the sixth gear having 15 teeth which was mounted on the fourth shaft at the same height. The seventh gear having 68 teeth was mounted on fourth shaft 50mm above the sixth gear and meshes with the eighth gear having 15 teeth which was mounted on fifth shaft at same height. The pulley of 228.6mm (9 inch) was mounted on fifth shaft at 200mm from the bottom which drive the another pulley of 76.2mm(3 inch) mounted on alternator and alternator was fabricated on the frame with the help of mechanical linkage.

Authors select the car alternator for generating electricity which has the ideal speed of 2000rpm – 6000rpm but effetely work at 3500 rpm. And animal has very low speed (v = 1m/s). If bullock rotates at radial distance (r) of 2.5 m from the main shaft (first gear) then the distance at one revolution is 15.7 m ($2\times \pi \times 2.5$). And the distance cover in one minute by bullock is $1 \times 60 = 60$ m. Hence the initial rpm is 3.82(60/15.7). Due to compactibility and resources available author select the gears used in sugarcane juice machine of speed ratio 4.5. Four stage gear system is used. Output rpm is increased by using pulley and belt which has speed ratio 3. So that the output rpm of alternator if speed of animal is 1m/s.

$(N_f)_{alt} = 3.82 \times 4.5$ v $4.5 \times 4.5 \times 4.5 \times 4.5 \times 3 \approx 4700$ rpm.

And the speed of output gear according to SS Ratan [14]

$$\frac{8}{1} = \frac{1}{2} \times \frac{3}{4} \times \frac{5}{6} \times \frac{7}{8}$$

$(N_f)_g = 3.82 \times 4.5 \times 4.5 \times 4.5 \times 4.5 \approx 1567$ rpm.

III. HOME LIGHTING FUELS – KEROSENE

A lighting fuel, kerosene (synonyms: kerosine, paraffin, paraffin oil, lamp oil) has become a major household, commercial, and industrial fuel. "Kerosene" started as a brand name but was later adopted (with a small "k") as a general descriptor. In the first half of the 20th century, the prevalence of household kerosene lighting greatly reduced as electrification and availability of gas fuels spread, particularly in developed countries. However, in the developing countries of Africa, Asia, and Latin America, kerosene use for lighting and cooking remains widespread. Kerosene is often used for lighting where electricity is not available. Some countries, such as India and Nepal, subsidize its retail price to stabilize in-country prices and make it affordable to the poor.

The analysis of rural and urban consumer‟s primary source for home lighting represent there is a divergence in consumption patterns between rural and urban consumers. Rural consumers rely almost equally on electricity (55%) and kerosene (44%). On the contrary, the majority of urban households, approximately (92%), rely on electricity as their primary energy source for home lighting, with only 7% relying on kerosene. This cost 0.4 and 1.7 USD Bn for urban and rural consumers respectively.

In India, the 63% of total rural households in India use only kerosene for lighting. In some states like Bihar and Assam, about 72–90% rural households use only kerosene for lighting. Thus nearly 90–100 million rural households do not have electricity and with frequent blackouts even larger number probably use kerosene for lighting.

In the NSSO survey, kerosene is disaggregated intotwo categories: „Kerosene PDS‟ and „Kerosene Other‟. The Kerosene PDS is assigned a mandatory codeof purchase.

In the „Kerosene Other‟ category, over 99% of respondents report paying for it. As the percentage of households that manage to acquire kerosene without purchase is negligible (less than1%).

IV. IMPACT OF KEROSENE ON ENVIRONMENT AND HUMAN HEALTH

The quality of light obtained from flame type devices (hurricane lanterns, candles, etc.) is very poor (< 100 lm). It is based upon incomplete combustion principle. Hence the yellow flame produces soot, CO and CO_2. In the confined space of rural households, use of such lanterns can be injurious to health. Such as Toxicity occurs if kerosene is inhaled while being ingested, Irritating to eyes and skin, Aspiration may cause serious lung injury, etc.

It increases the CO_2 gas in the environment and inform environment agency of substantial release incidents.

Fig.3 Animal powered mechanical device for home lighting system.

V. RESULTS AND DISCUSSION

Experimental result shows that animals speed of 0.8 m/s to 1 m/s and they take very little time to get its average. Alternator generates constant voltage of 12V after reaching ideal speed as specified. The time taken by solar system is depend on atmosphere temperature to charge the battery. Since MPPT technology is used for charge control, battery get the constant valtage. Since temperatue is vary from morning to evening normaly 12V, 180Amps tubular battery is charged in 7–10 hours. But when tubular battery was charged using animal powered alternator of TVS-Lucas 12V, 40AH which generate 21 Amps(average) it took 4 hr 35 minute to fully charge. because of high charging current but Tubular battery can not be charged using alternator of 12V, 95Amps 12V, 150Amps automotive battery took 2 hours to charge. The animals effort and speed depend on the load subjected and force applied by shepherd. Animal speed can change very quickly and abruptly. It may be very difficult to taking speed reading continuously because animals got puzzled.

The present work provides a system and method for producing electricity for home lighting using the biological energy of the muscles of animals like bullock by means of a mechanical device with hybride PV solar energy. The project goal was to supply of energy to 1.5 billion people who rely on kerosene for light. This goal of complete avoidation of kerosene,wood and other fuel for lighting for home can be met within the constraints of a low production cost and high safety. This directly shows that the posibility of the removal of harmful effect on environment and humans because of uses of this fuels. Authors believe this system can accomplished this goal.

The readings are taken after every four minutes within one hour. Speed vs. Current in fig. 4 shows that at low rpm at starting of animal motion it is not generating current by both alternator, but as well as rpm is increasing and reaches to ideal working rang alternators producing high value of currents. But alternator not generating current as expected and specified by company due to very abrupt and quick changes in animal woking speed.

Voltage at different RPM comparision proves completely unchanged voltage generation as expected and alternator generates constant voltage of 12V as specified for alternator after reaching ideal speed. State of Charge vs. Charging Time in fig.5 shows that battery taken more time to charge as less as state of charging was

low for charging same amount. Fully charged battery shows 12.6V. Fully charged battery takes approximately 2 hours and 7 minute to discharge 50% when load is of 6 bulb of 60Watt DC. Since alternator takes initial current to energise coils, so the battery must not be discharged completely.

Lighting Time of 6 CFL bulb of 25W AC for different state of discharge is shown in fig.6. Results shown that inverter and battery have more than 80% expected efficiency. Finally result was found that at least 4 hours (6pm – 10pm) the home will be lighted using this system.

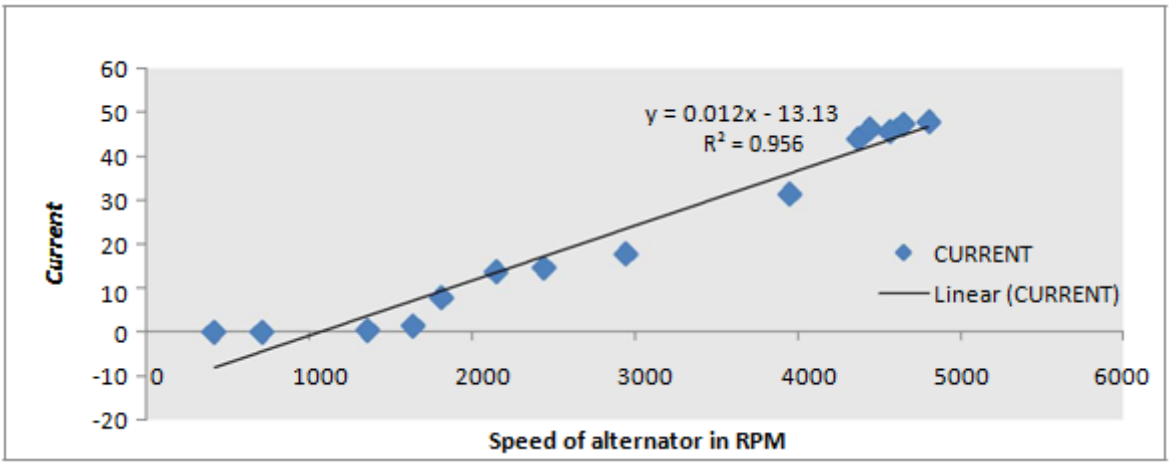
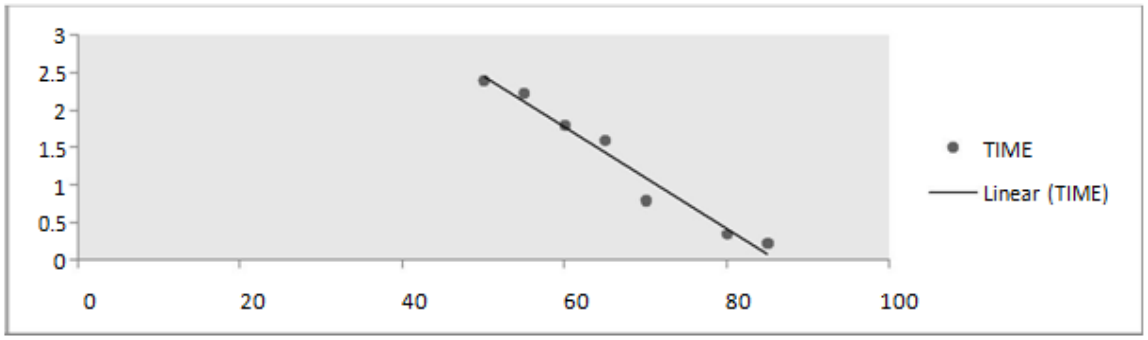


Fig. 4 Alternator RPM vs. Current in Amp.(DC)[4]



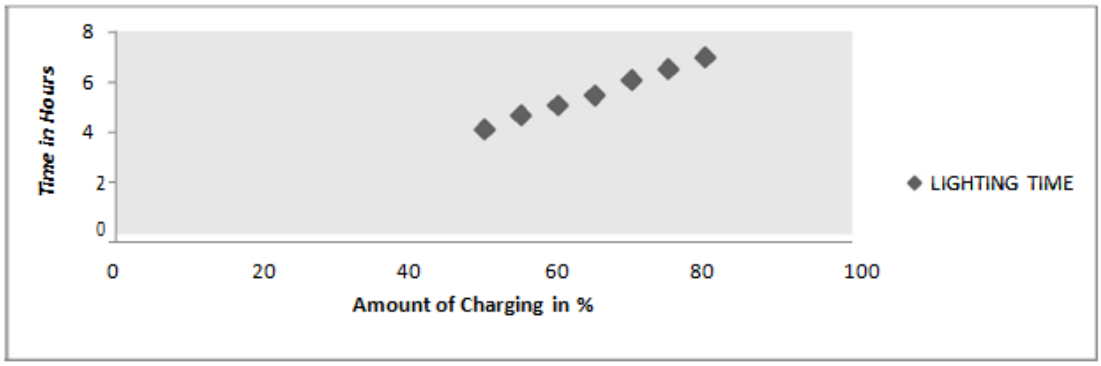


Fig. 6 State of Charge vs. Lighting time in hours.[4]

VI. CONCLUSIONS

In rural area peoples needs energy for lighting homes and other uses that is the time when fuels are used for energy production This is also concluded that Animals are the great energy source for generating power even running at low speed at least for 6pm – 10pm at night for rural and isolated areas. By this hybride system not only for lighting but many of the uses specially cooking energy can be provided and then it is possible to avoide uses of kerosene, wood and other fuel burning which causes a measurable effect on environment.

The present work provides a system and method for producing electricity for small using the biological energy of the muscles of animals like bullock by means of a mechanical device and a hybride combination with solar energy system. The project goal was to combining the solar power and animal power which will work when even sun is not available.The project has to offer a durable product with relatively good efficiency and specially a emission free system.

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Nomenclature

A	Ampere
AH	Ampere Hour
b	Face Width of the gears
d	Pitch Circle Diameter of the gear
MPa	Mega Pascal
MW	Mega Watt
mm	Milli Meter
$(N_f)_{alt}$	Final Speed of Alternator
$(N_f)_{alt}$	Final Speed of Generation
PCD	Pitch Cirle Diameter
PV	Photovoltic system
P_c	Circular pitch
P_{max}	Rated peak power
r	Radius
SP. GR.	Specific Gravity
V_{oc}	Open circuit voltage
V	Voltage
V_{mp}	Rated voltage
y	Lewis form factor
z	No of teeth

Greek letters

σ	Allowable Stress
π	Angle in Radian
σ_{ut}	Ultimate Strength
α	Pressure Angle
σ_{all}	Total Strength
˚C	Degree Centegrate for Temperature

Subscript

ALL	Total
C	Critical
Alt	Alternator
f	Final
max	Maximum value used
min	Minimum value used