Design and Development of Reusable Sand Power Generation

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Abstract

Conserving energy has become the biggest issue in present scenario. This paper proposes a cheap and effective method for design and manufacturing of Reusable sand power generation. Due to the development and modernization the electricity demand is increasing at high extent. To fulfill this demand globally which is without any harmful effect on environment is possible by using Reusable sand power generation. The reason behind generating power by using sand is that it is available all over the earth. The basic concept of Sand power generation mechanism is, Reusable sand Power generator is a simple technology, more economical, can meet from domestic (house hold) to medium power requirements .In this process ordinary beach sand placed in the main funnel is allowed to fall on the blades of a sand wheel, the rotation of turbine which is used to generate power and stored in a DC battery The concept of sand power generation is simple. when a sand moves down from higher altitude to lower one its potential energy is converted into kinetic energy. This motion is converted into circular motion and that circular motion is converted into electricity by using a Mini DC generator. In case the external power source is provided, this sand power generation is not a cost effective mechanism for producing sufficient levels of power. Therefore, there is need for a integrated design system and method for using this concept. This project is implemented as a subsystem in the main system for the already existing industries.

Keywords - *Conveyor (bucket elevator), Sand slider, Funnel, Sand wheel, Generator, Motor, Sand.*

I. INTRODUCTION

Now a days due to the effects of pollution and global warming there is a need for generating power from renewable sources. Due to the availability of beach sand all over the earth, abundant and consistent it is very suitable to generating power by using beach sand. Energy demand is increasing day by day with rapid growth in industrialization as well as modernization. But the energy resources are gradually decreasing at high extent. Within a few years the energy resources will be finished and hence there will be lack of fuel (coal, wood, water, etc.) for power generation. The other renewable sources such as solar, wind, biomass etc are available only for a particular duration of time during the day and night. Therefore the Reusable sand power generation is one of the method to generate power which fulfill energy demands and requirements of present time.

In this process ordinary beach sand placed in the main funnel is allowed to fall on the blades of a sand wheel, the rotation of turbine which is used to generate power and stored in a DC battery .The collided and scattered sand particles are collected by a box which have a small vent, through which the sand collected is and then poured in to the boxes of conveyor. The DC motor, which consume small quantity of power generated by the dynamo. The buckets of the conveyor (bucket elevator) carries the sand to certain height which is 1/3 rd more height than funnel stock point From this the sand will reach to the main funnel which is the storing point .Thus the reusing of sand starts and continues for months till it worms out as minute particles .The process is unique and could be enhanced from small requirements to any extent of power needs. That effect makes it possible to extract energy from the sand power generator, which makes the sand power generation technologically feasible.

Sand powered electric power plant has advantages over the hydro-electric plant, such as not needing of fuel and not polluting the environment. However, the sand Powered electric plant would be much smaller than hydro-electric plants. The location of that plant would not be restricted to suitable water elevations... If the sand power electric generation comes under operation and working then it can replace all existing nuclear and fossil fuel plants and it would essentially solve the problem of global warming to the extent it is caused by fossil fuel used.

A. Scope and Contributions

The utilization of energy is an indication of the growth of a nation. For example, the per capita energy consumption in USA is 9000 KWh (Kilo Watt hour) per year, whereas the consumption in India is 1200 KWh (Kilo Watt hour). One might conclude that to be materially rich and prosperous, a human being needs to consume more and more energy. A recent survey on the energy consumption in India had published a pathetic report that 85,000 villages in India do not still have electricity. Supply of power in most part of the country is poor . Hence more research and development and commercialization of technologies are needed in this field. India, unlike the top developed countries has very advanced technologies are available for power generation.. By just placing a unit like the "Reusable Sand power generator", so much of energy can be tapped. This energy can be used for commercial as well as industrial usages.

II. LITERATURE SURVEY

A. Overview of the Indian Power Sector

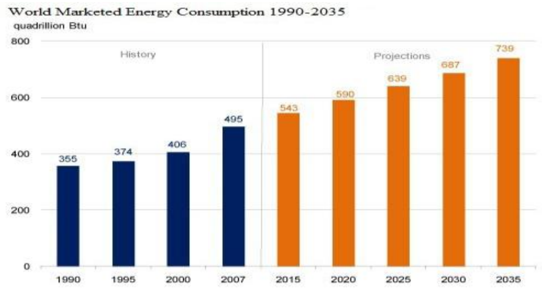
Electricity consumption in India has more than doubled in the last decade, outpacing economic growth.

1) Literature Survey Based on Energy Consumption

In today's modern society, most people just flip a switch or push a button, and everything we depend on is readily available. Cell phones, computers, televisions, heated water, lights, and so much more, are all the backbone of any modern society's functionality. The electricity powering all these systems is something most people rarely think about until the power is no longer available for use. The extensive system that allows for an instant and near constant supply of conditioned power is referred to as the grid. This grid is usually supported by government and or private in developed countries; a government must have enough financial resources to establish and support a significant investment to provide the service of electricity. With this idea in mind, it may be hard to believe that nearly 80% of all people living in third world countries have no access to electricity. That is an estimated 1.5 Billion people with no electricity

This power crisis will not be getting better in the future. The U.S. Energy Information Administration stated in their International Energy Outlook Report for 2010 that the world energy consumption will increase by 49 percent, or 1.4 percent per year, from 495 quadrillion Btu in 2007 to 739 quadrillion Btu by 2035, as shown in Figure 11. The Organization for Economic Co-operation and Development, OECD for short, is an international organization, which includes a majority of the world's most advanced countries. Historically, OECD member countries have accounted for the largest share of current world energy consumption; however, in 2007 for the first time energy use among non-OECD nations exceeded that among OECD nations as depicted in Figure 1.1.

If any growth in the world's energy supply and infrastructure is to occur in the future, it is likely the majority of this energy will go to these developed countries before any 7 developing or third world country. This will only exasperate the needs and deficiency of these developing and third world countries.



(1.1) World Marketed Energy Consumption

2) Literature survey based on Energy Demands in India

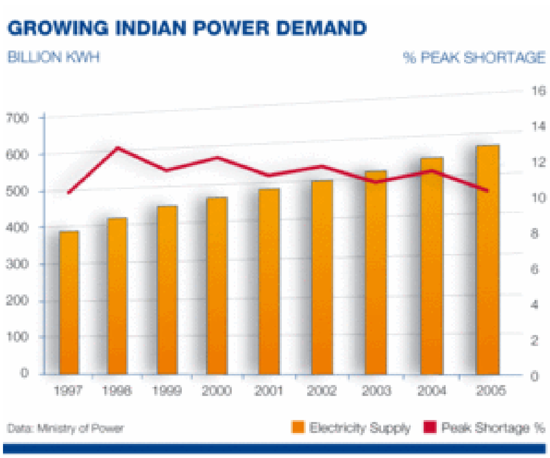
Central Sector or Public Sector Undertakings (PSUs), constitute 29.78% (62826.63MW) of total installed capacity i.e, 210951.72 MW (as on 31/12/2012) in India. Major PSUs involved in the generation of electricity include *NHPC Ltd., NTPC Ltd.,*, and *Nuclear Power Corporation of India (NPCIL).*

Besides PSUs, several state-level corporations are there which accounts for about 41.10% of overall generation , such as Jharkhand State Electricity Board (JSEB), Maharashtra State Electricity Board (MSEB), Kerala State Electricity Board (KSEB), in Gujarat (MGVCL, PGVCL, DGVCL, UGVCL four distribution Companies and one controlling body GUVNL, and one generation company GSEC), are also involved in the generation and intra-state distribution of electricity.

Other than PSUs and state level corporations, private sector enterprises also play a major role in generation, transmission and distribution, about 29.11%(61409.24MW) of total installed capacity is generated by private sector.
The Power Grid Corporation of India is responsible for the inter-state transmission of electricity and the development of national grid.

India is the sixth largest in terms of power generation. About 65% of the electricity consumed in India is generated by thermal power plants, 22% by hydroelectric power plants, 3% by nuclear power plants and rest by 10% from other alternate sources like solar, wind, biomass etc. 53.7% of India's commercial energy demand is met through the country's vast coal reserves. The country has also invested heavily in recent years on renewable sources of energy such as wind energy. As of March 2011, India's installed wind power generation capacity stood at about *12000 MW*. Additionally, India has committed massive amount of funds for the construction of various nuclear reactors which would generate at least 30,000 MW. In July 2009, India unveiled a $19 billion plan to produce 20,000 MW of solar power by 2020 under National Solar Mission.

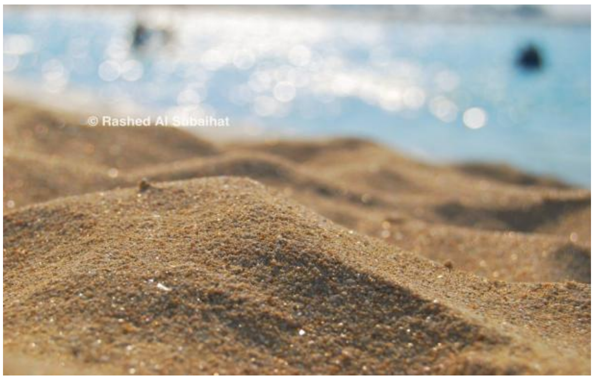
The per capita power consumption in India is 733.54KWh/yr, which is very minimal as compared to global average of 2340KWh/yr.
Electricity losses in India during transmission and distribution are extremely high, about 28.44%(2008-09). India needs to tide over a peak power shortfall of 13% between 5pm and 11pm by reducing losses due to theft and pilferage.. Due to shortage of electricity, power cuts are common throughout India and this has adversely effected the country's economic growth. Theft of electricity, common in most parts of urban India, amounts to 1.5% of India's GDP. The condition of utilities are not good either, cumulative loss of 110 power utilities are estimated as Rs 86,136 crore which is expected to to rise to Rs 1,16,089 crore by 2014-15. Despite an ambitious rural electrification program, some 400 million Indians lose electricity access during blackouts. While 84.9% of Indian villages have at least an electricity line, just 46 percent of rural households have access to electricity.



(1.2) Energy Demands in India

B. Sand Properties and its Composition

Sand is a naturally occurring granular material composed of finely divided rock and mineral particles. It is defined by size, being finer than gravel and coarser than silt. Beach Sand is a fine sand. It can be mixture of White, brown, beige, tan and grey in color. Beach sand is used for patios, volley ball courts, sand boxes, playgrounds and creating faux beaches. But in our method the sand is used as a source for rotating the sand wheel to generate electricity. The composition of sand varies, depending on the local rock sources and conditions, but the most common constituent of sand in inland continental settings and non-tropical coastal settings is silica (silicon dioxide, or SiO_2), usually in the form of quartz. The second most common type of sand is calcium carbonate, for example aragonite, which has mostly been created, over the past half billion years, by various forms of life, like coral and shellfish. It is, for example, the primary form of sand apparent in areas where reefs have dominated the ecosystem for millions of years like the Caribbean.



(1.3) Ordinary Beach Sand

C. Bucket Elevator and its Types

A bucket elevator, also called a grain leg, is a mechanism for hauling flowable bulk materials (most often grain or fertilizer) vertically.

It consists of:

1. Buckets to contain the material;
2. A belt to carry the buckets and transmit the pull;
3. Means to drive the belt;
4. Accessories for loading the buckets or picking up the material, for receiving the discharged material, for maintaining the belt tension and for enclosing and protecting the elevator.

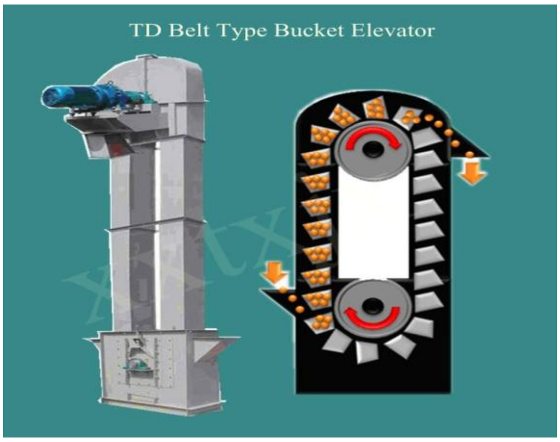
A bucket elevator can elevate a variety of bulk materials from light to heavy and from fine to large lumps.

1) Belt Type Bucket Elevator

The belt bucket elevator type BW-G are equipped with specially developed steel-rope belts permitting a long lifespan and heat resistance up to 130° Celsius. In the bucket elevator boot a bar drum ensures guided return of the belt. An exact parallel guidance is achieved with a parallel tensioning device.

Functions & Features

1. Safe belt-joining by clamping in a cast compound box
2. Friction linings of the drive drums exchangeable without opening of the belt



(1.4) Belt Type Bucket Elevator

2) *Chain type Bucket Elevator*

The Chain bucket elevator casings are self supporting, but they require horizontal guides at least every 15 meters and below the elevator head. The bucket elevator head comprises a lower section with doors to access the adjustable discharge plate, and braced bearing mountings, for the pedestal bearings which support the drive shaft, the shaft exit points use grease filled radial shaft seals. The upper sections comprise a multipart removable hood with an inspection flap. A drive platform is mounted on the side of the lower part of the head for supporting a wide variety of commercially available drives. If required a maintenance platform and or an overhead support/ service beam can be fitted if required. An elevator drive normally consists of a geared motor unit, which is normally connected to a frequency controller for maintenance purposes.

(1.5) Chain type Bucket Elevator

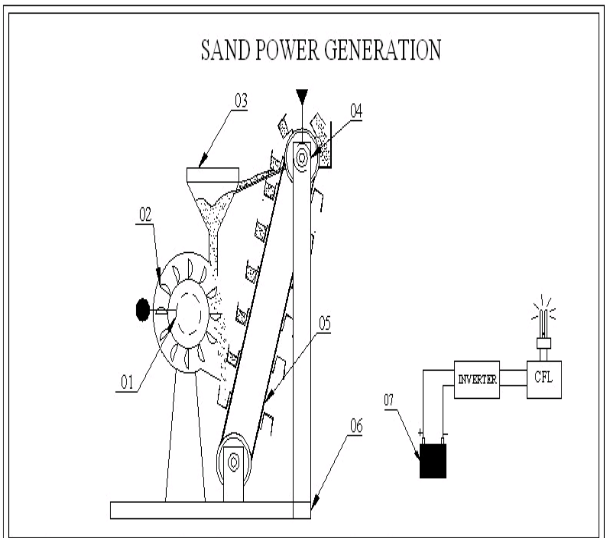
III. DESIGN METHODOLOGY

The Properly designed Reusable Sand Power generator for any Particular application should satisfy the often- Conflicting demands of at least five criteria simultaneously

1. The acoustic criterion, which specifies the minimum noise reduction, required from the Reusable sand power generator as a function of frequency. The Operating conditions must be known because large steady-flow velocities or large alternating velocities may alter its acoustic performance.
2. The geometrical criterion which specifies the maximum allowable volume and restrictions on shape.
3. The mechanical criterion, which may specify materials from which it is durable and requires little maintains.
4. The Environmental Criterion, which specifies the zero or minimal the pollution rate.
5. The Economical criterion is vital in the marketplace.

A. *Concept Design Drawing*

The 2-Dimensional Assembly drawing of Reusable Sand Power Generator is drawn by using AutoCAD software



S.NO	PART NAME	S.NO	PART NAME	S.NO	PART NAME
01	DYNAMO	04	MOTOR	07	BATTERY
02	TURBINE	05	CONVEYOR	▶—	TO CONTROL UNIT
03	HOPPER	06	BASE FRAME	●—	TO BATTERY

(1.6) Actual Layout of Reusable Sand Power Generator

B. *Virtual Simulation*

Based on the above mentioned approach, the finalized concepts will be verified virtually using CAE simulation software's towards the achievement of sand power generation.

C. *Theoretical Design Calculation*

Need to Calculate the target frequencies to give more concentration of lifting and transmission losses. For Calculating the target frequencies the sand wheel output (maximum power RPM) produced is calculated.

1) *Design of Bucket Elevator*

NECESSARY INFORMATION

Required product parameters.

Service use = For power generation
Material chemical name = Dry beach Sand
Bulk density - (1780kg/m^3)
Maximum duty - (1800kg/hr)
Height of sand is to be raised (meters) and angle of incline if any. Provide enough height at the outlet of the discharge chute so the product is always falling following discharge.

<u>DETERMINE THE DRIVE ARRANGEMENT</u>

With the head pulley size determined and the linear belt speed known, the RPM of the head pulley can be calculated.

$$\textbf{RPM}= \frac{V(\frac{m}{s})}{2.\pi.r(m)}.\textbf{60}$$

Usually a 4-pole motor at 1450 RPM with a reduction gearbox of suitable ratio is selected to drive the head pulley. The gearbox can be a direct drive or shaft-mounted unit depending on the available space and access.

$$\textbf{RPM}= \frac{1.1(\frac{m}{s})}{2.\pi.0.28(m)}.\textbf{60 = 33rpm}$$

It will be necessary to select sprocket sizes for the motor and head pulley to produce the required rotational speed.
A gearbox can be selected to reduce from 1450 RPM input shaft speed to 33 RPM output shaft speed. Alternatively the sprocket sizes can be used to produce some of the reduction and the gearbox the remainder. Limit reduction the sprockets to around a 3:1 ratio to not over-stress the chain

2) *Velocity of the Sand*

1. Height of the bucket elevator from the base of elevator = 2.1m
2. Time taken by the bucket to reach the top from its bottom = 10sec

Velocity of the bucket = $Distance/Time$

= $2.1/10$

= 0.2 m/sec

3) *Weight of the Sand Lifted Per Bucket*

Total number of bucket attached in the chain = 50

Required amount of sand used to

rotate the turbine = 7kg

Wight of sand lifted per bucket $= \frac{weight\ of\ the\ sand}{Total\ Number\ of\ Buckets}$

$= 7/50$

= **0.15kg/bucket.**

4) *Calculation of Mass flow rate of sand from the Hopper*

Force created by the sand which fallen from each

bucket = Mass of sand x Acceleration

Angle of inclination by the glass slider from it's

vertical axis = 60^o

= 0.25 x 9.81x sin60^o

Force created by the sand F = 4.50 N

Diameter of the Hopper outlet to the Sand wheel(turbine) = 3x10^{-2}m

Area of the hopper outlet to the turbine $A = \pi/4d^2$

= $\pi/4$ (3x10-^{2})^2

Area = 7.068x10^{-4}m^2

Length of the hopper outset, L= 10x10^{-2}m

Volume of the hopper = Area x Length

= 7.068x10^{-4}x10x10^{-2}

V = 7.068x10^{-5}m^3

Density of the sand = $\frac{Mass\ of\ the\ sand}{Volume}$

Dry sand =1780 kg / m^3
Wet sand = 1920kg/m^3
Compact sand = 2080Kg/m^3
} **Properties**

Mass Flow rate of sand = 1780 x 7.068x10^{-5}

= 0.125kg

Striking force created by the sand which comes from the hopper to turbine

F = Mass x Acceleration

= 0.125 x 9.81

Fs = 1.556N

5) ***Calculation of Power Produced by Sand Wheel(Turbine)***

Torque available at the turbine

T = Force x Radius

D – Diameter of the Turbine = 20 x 10^{-2}m

=1.556 x 10x10^{-2}

T = 1.2226 N-m

Power produced by the sand wheel(turbine),P $= 2\pi NT/60$

$P = 2\pi * 30 * 1.2226/60$

Power, P =1.527W

6) ***Calculation of Power Produced by the Generator***

Generated voltage at the generator by rotation of the sand wheel = 9 Volts

Power, P = Voltage x Current

= 9 x 3

Power, p = 27 watts

IV. PROTOTYPE MANUFACTURING

Based on the design and theoretical performance calculations, the prototype of reusable sand power generator; can be taken up for manufacturing. Following are some of the important manufacturing considerations summarized based on experience

A. *Materials Used*

1. Base Frame - Mild steel
2. Base plate - sheet metal
3. Connecting links - mild steel
4. Motor - cast iron
5. Bucket Elevator - Plastic
6. Glass slider - Sheet metal
7. Hopper - Sheet Metal

B. *Fabrication Details*

1. The frame is made of mild steel .
2. The length of required length steel pipe is cut out from the steel pipe and it is placed horizontally.
3. By using arc welding or gas welding the pipes are welded mutually perpendicular to each other.
4. The vertical side of the frame is welded by means of another connecting links.
5. Finally the surface finish of the frame is obtained and it's painted.
6. The two sides of the supporting links are machined by means of drilling operation.
7. By using bolts and nuts the belt type bucket elevator is placed in the frame by the appropriate position.
8. The bottom side of the link is placed in the frame and the top side is fixed by the another suitable connecting links.
9. The sand slider is also fitted in the suitable inclination. By using this Sand slider the flowing sand from bucket elevator will strike the hopper and again it will strike the sand wheel (turbine).
10. The Generator is coupled with the sand wheel(turbine) therefore the power will be generated.
11. The developed power is stored in the DC battery and it will be used for household and other requirements.
12. Finally the finishing is carried out by surface grinding operation.
13. Bearing all above in mind, a physical prototype is made in such a way the model is working properly.

(1.7 a) Side view of Fabricated Reusable Sand power Generator

(1.7 b) Front view of Fabricated Reusable Sand power Generator

1) ***Experimental Testing and Design Finalization***

Experimental Testing and Design Finalization is the last critical challenge. We must design a strategy that enables us to increase the flow volumes within the constraints of the physical-plant without violating the safety margins

V. INDUSTRIAL APPLICATIONS

At first we stated the project can be used as a subsystem in many of the already existing industries like(Cement industries, Mineral Extraction, Fertilizer Industries,etc..,). The industrial photographs for practical implementation is attached below

(1.8) Secondary Stage of Stone Crushing

VI. CONCLUSION

This is the unique form of electricity generation which could be very well harnessed if proper action plan is laid out to use this source of energy. At present this is unutilized as nobody has seen the positives of this form of energy generation and started to work on this avenue. Once this process starts to generate electricity it may leave behind all the conventional sources of generating energy available in the market & that too without any hazardous effects on the environment. By the use of sand again & again there is no problem of procuring the raw material continuously.

Prospects of this project are very bright as such because no project is running at present. Also this project involves low maintenance cost to produce electricity & could be made available at cheaper rates as compared to conventional sources of energy. Also as this project is green project therefore carbon credit could be traded in London Stock exchange or like at higher costs as the carbon emission is prevented from the use of this energy.

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