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Underwater Windmill

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Light Sensing Robot

Hills Train Power Generation & Automatic Railway gate control

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Automatic Tool Store
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Programmable Drilling Machine
Computer Based Color Identification System
CNC Pallet Changer for Drilling Machine
Computer Controlled Servo Indexing Table
Computer Controlled PCB Drilling Machine
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Combustion and Ignition

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Machine Design
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Inference and Interpretation with Classification, and Comparison Of Construction Equipments Prevailing to Site Conditions

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A B S T R A C T

In the present days with globalization of Indian economy & introduction of multinationals in India for construction activities, it has become foremost to have speedy construction using new technologies & trends in construction equipments. Construction equipments play a vital role in making the project successful with respect to cost & duration required to complete it. Conventional methods viz. adopting manual handling of materials, excavation, hauling, loading & unloading cannot cope up withdemand of infrastructural facilities with high degree of quality control & assurance thus extending the duration of project. Though conventional method proves to be economical but fails in providing required number of dwellings in time. Thus latest construction equipments with new technologies have eliminated these drawbacks thereby permitting speedy excavation, loading, unloading & hauling with reduction in time & labor cost. Thus it has become an important task to develop the automated services in this sector too whereby it will be covered by studying, classifying & detailing the construction equipments.

Keywords: - Construction Equipments, Equipment selection.

I. INTRODUCTION

Construction of any projects include basic operations such as Excavation, Digging of large quantities of earth, Moving them to fairly long distances, Placement, Compacting, Leveling, Dozing, Grading, Hauling, Construction equipments play an important rolein construction sector. Proper selection and allocation of equipments at site enhance time management activity at site. Construction equipments are important focus centers at site for proper cash flow at project & maintain quality of work at site. The need for Mechanization arises due to the following reasons:\

1) Material handling in large quantities at high rise building & major projects.
2) Optimum use of Material, Manpower and Finance.
3) High grade materials increasing complexity of Projects

Construction equipment is an important part of any construction process. It is not always desirable or possible for the Contractor to own each and every type of Construction Equipment required for the Project. Considering the various aspects of the utility of particular Equipment, the Contractor has to economically justify whether to purchase the Equipment or to hire it.

II. BRIEF DESCRIPTION OF FACTORS TO BE CONSIDERED WHILE SELECTING EQUIPMENTS

Typically, construction equipment is used to perform essentially repetitive operations, and can be

broadly classified according to two basic functions:

1. Operators such as cranes, graders, etc. which stay within the confines of the construction site.
2. Haulers such as dump trucks, ready mixed concrete truck, etc. which transport materials to and from the site. In both cases, the cycle of a piece of equipment is a sequence of tasks which is repeated to produce a unit of output.

III. CLASSIFICATION OF EQUIPMENTS

The basic operations involved in the construction of any Project are Excavation, Digging of large quantities of earth, Moving them to fairly long distances, Placement, Compacting, Leveling, Dozing, Grading, Hauling, etc. Construction Equipment can be classified as under:

1. Excavating Equipment a. Power Shovel b.Dragline c.Hoe 2. Earthmoving Equipment 3. Hauling Equipment 4. Hoisting Equipment a. Tower Cranes b. Mobile Cranes c. Crawler Mounted Cranes d. Builders Hoist e. Passenger Hoist	5. Conveying Equipment 6. Dredging Equipment 7. Pumping Equipment 8. Compacting Equipment 9. Pile Driving Equipment 10. Drilling Equipment 11. Equipment used for the Production of Aggregate 12. Equipments used in Hot Mix Batch Plant 13. Equipments used for Concrete Works 14. Material Testing Equipments

IV. NEED TO FOCUS ON CONSTRUCTION EQUIPMENT ISSUES ON SITE

Construction equipments though an important part of construction projects are ever ignored by owner & engineers thus leading to following problems as below

i) Expenditure of more amount of finance by contractors.
ii) Increased duration of project as a result of unavailability of skilled labors for equipment operation.
iii) Risk in construction projects as a result of unavailability of equipments spare parts & maintenance.
iv) Unnecessary inculcated cost in improper equipment selection leading to extra labor & equipment cost.

Thus it has become a foremost need to avoid these risks in project & extra cost by detail studying & making available all required specifications to common people.

V. METHOD OF ANALYSIS

1) Classification& study of construction equipments according to their work & family classes.

The construction equipments focus centre of work is primary stage classified & studied in detail so as provide a datum to project.

Various equipments have been considered for detail view of all classes of equipments use in construction from primary stage of planning of project till concreting phase.

2) Select sites & consultancies to gather construction equipment details.
3) Collection of data from site& office.

After the selection of sites & consultancies further the approach towards these locations is carried out for collection of details such as Cost of equipments, Duration of work & the working efficiency.

4) Preparing excel sheet giving all details of cost, duration & efficiency of equipments.

After the overall data collection, the collected data is plotted in MS Excel sheet.

VI. DATA COLLECTION

1. Material Handling Equipments :

The details of material handling equipments are collected from various sites & consultancies.

The data with respect to rates, work duration & load carriying capacity is collected.

Further various cost & working capacity range will be considered as input.

Table No.1 (Details of Material Handling Equipments)

SR NO	CLASS	TYPE OF EQUIPMENT	COMPONENT	EQUIPMENTS	BASIC PURCHASE COST EXCLUDING ED AND S.ST/VAT	WORK DURATION IN (HRS)	LOAD CARRYING CAPACITY
1	MATERIAL HANDLING EQUIP	PASSENGER CUM MATERIAL LIFT	PASSENGER CUM MATERIAL LIFT CABIN	Speedo 101-delux (SHP*x2Nos) (Suitable for maximum 60 mtr)	8,35,000	8 hrs	800 Kg
2				Speedo 101 (12.5HPx2Nos)	10,10,000		1000 Kg
3				Speedo 101.2 (12.5HPx2Nos)	10,50,000		1200 Kg
4				Speedo 101.5 (12.5HPx2Nos)	11,25,000		1500 Kg
5				Speedo 102 Tss (12.5HPx3Nos)	15,25,000		2000 Kg
6				Speedo 201.5 (12.5HPx2Nos+2)	22,10,000		3000 Kg
7				Speedo 202(12.5HPx3Nos+2)	25,90,000		4000 Kg
8				Speedo Up(7.5 HPx2Nos)	13,50,000		600 Kg
9				Speedo MPMH 101	9,15,000		1000 Kg
10				Speedo MPMH 102	12,40,000		2000 Kg
11			COLUMN	Colmax SMH 0.5T-Dolax	15,500		88 Kg
12				Colmax SMH 1T	18,500		99 Kg
13				Colmax SMH 1.5 T	21,000		120 Kg
14				Colmax SMH 1.5 T	21,500		130 Kg
15				Colmax SMH 2 T	23,000		140 Kg
16				Colmax SMH 1.5 T twin cage	25,000		148 Kg
17				Colmax SMH 2 T twin cage	26,000		155 Kg
18				H Frame	12,000		------

2. Concreting Equipments :

The collected details of materials are classified into two types depending on the working condition & features as follows.

a) Concrete mixers
b) Batching plant
c) Concrete pump
d) Boom placer

Concreting solution

Table No.2 (Concreting Equipments)

SR NO	CLASS	TYPE OF EQUIPMENT	COMPONENT	EQUIPMENTS	LOAD CARRYING CAPACITY
1	CONCRETING SOLUTIONS	CONCRETE MIXER	100 LTR MIXER	5/3 Concrete Mixer (Hand/Electrical)	5 Cu. Ft. / 3 Cu. Ft.
2			200 LTR MIXER	10/7 GEN X Model	10 Cu. Ft. / 7 Cu. Ft.
3				10/7 Concrete mixer self #Skit	10 Cu. Ft. / 7 Cu. Ft.
4				10/7 concrete mixer hydraulic hopper	10 Cu. Ft. / 7 Cu. Ft.
5				10/7 concrete mixer mechanical hopper	10 Cu. Ft. / 7 Cu. Ft.
6				10/7 Super 09 VH without hopper	10 Cu. Ft. / 7 Cu. Ft.
7				10/7 Concrete mixer cum hoist	10 Cu. Ft. / 7 Cu. Ft.
8		BATCHING PLANT	MOBILE BATCHING PLANT	Pan type plant	2240 Cu. Mtr/Hr.
9				Reversible type plant	1920 Cu. Mtr/Hr.
10			STATIONARY BATCHING PLANT	Boom Scraper	20-30/30 Cu.Mtr/Hr.
11				Bin Feeding System	1215/20 Cu.Mtr/Hr.
12		CONCRETE PUMP	CONCRETE PUMP	Concrete Pump	4820 and 7545 Cu. Mtr/Hr.
13		BOOM PLACER	BOOM PLACER	Boom Placer	120/70 and 100 Cu.Mtr/Hr.

3. Mechanization Equipments

The details of material handling equipments are collected from various sites & consultancies.

Table No.3 (Mechanization Equipments)

SR NO	CLASS	TYPE OF EQUIPMENT	COMPONENT	EQUIPMENTS	WORK DURATION (HRS)	LOAD CARRYING CAPACITY
1	MECHANIZATION SOLUTIONS	COMPACTING SOLUTIONS	CONCRETE COMPACTION	Concrete Compactor Floater	8 hrs	600 ltr batch capacity
2			SOIL COMPACTION	Earth Compactor		30cm/20 cm compaction
3				Tamping Rammer		8.5 cm jumping stroke
4		BAR PROCESSING SOLUTIONS	BAR CUTTING MACHINE	Bar Cutting UTS 65		28 mm
5				Bar Cutting UTS 55		42mm/52 mm
6			BAR BENDING MACHINE	Bar Bending UTS 55		42mm/52mm
7				Bar Bending UTS 65		36 mm
8			BAR CUTTING AND	Bar Cutting and Straightening		50-65mtr/min. wire traction
9		SAND PURIFYING MACHINES	SAND SCREENING	Rotary Sand Screening		2 Cu.m/Hr or 4 Cu.m/Hr
10				Vibratory Sand Screening		6 Cu.m/Hr
11			SAND WASHING	Portable Sand Washing		6 Cu.m/Hr
12				Stationary Sand Washing		15 Cu.m. Input Capacity
13		BLOCK MAKING MACHINES	MANUAL	Manual Block Making Machine		400 Blocks/shift
14			VIBRATORY	Vibratory Block Making Machine		640 Blocks/shift
15			AUTORAMMING	Autoramming Block Making Machine		800 Blocks/shift
16			HYDRAULIC	Hydraulic Block Making Machine		400/hr

4. Excavation Equipment -

The collected details of materials are classified into two types depending on the working condition & features as follows.

Table No.4(JCB Excavators)

SR NO	CLASS	TYPE OF EQUIPMENT	COMPONENT	EQUIPMENTS	BASIC PURCHASE COST (RS)	MAX DIG DEPTH (M)	MAX WORK HEIGHT (M)	MAX DUMP HEIGHT(M)	LOAD OVER HEIGHT (M)	BELOW GROUND DIG DEPTH(M)	DUMP ANGLE (DEGREE)
1	EXCAVATORS	JCB	BACKHOE LOADER & FRONT EXCAVATOR	JCB 2DX	1450000	3.02	3.88	2.2	2.81	0.1	46
2				JCB 3DX	1950000	4.77	5.97	2.74	3.23	0.07	43
3				JCB 3DX XTRA	2350000	5.05	6.01	2.93	3.37	0.12	41
4				JCB 430 ZX	2486000	0.086	1.22	2.806	3.453		45

Table No.5 (Drilling & Balsting Equipments)

SR NO	CLASS	TYPE OF EQUIPMENT	COMPONENT	BASIC PURCHASE COST (RS)	CAPACITY
1	EXCAVATORS	DRILLING	TRACTOR + COMPRESSOR + JACK HAMMER	750000	2.5 ft - 12 ft
2		BLASTING	JELLETIN	5000/BOX (200 JELLETIN EACH BOX)	2.5 ft - 12 ft

5. Compaction Equipment

The details of compaction equipments are collected from various sites & consultancies.The data with respect to rates, working speed & load carriying capacity is collected.

SR NO	CLASS	TYPE OF EQUIPMENT	COMPONENT	EQUIPMENTS	BASIC PURCHASE COST (RS)	CAPACITY (Centrifugal force)KN	WORKING SPEED KM/HR	TRAVEL SPEED KM/HR
1	COMPACTION	COMPACTORS	ROLLERS	MINI TANDEM ROLLER VMT 330	1000000	261	6	11.8
2				SOIL COMPACTOR VM115/D	1000000	282	4.5	10
3				SOIL COMPACTOR VM115PD	1000000	45	5	10.2
4				TANDEM ROLLERR VMT860	1000000	71	5.5	11.5

6. Hauling Equipments

Various hauling equipments details are collected as explained further such as Dump trucks ,Hauling trucks etc.

Table No.3(Hauling Equipments)

SR NO	NAME OF EQUIP	MATERIAL	CAPACITY	RATE
1	TRUCK	Cement	10 Tonne	10 Lakh - 15 Lakh
2	Hyva Truck	Sand	3 Brass- 4 Brass	25 Lakhs
3	Hyva Dumper	Sand	6 Brass	30 Lakhs
4	Tractor with Trolley	1 Brass	7 Brass	Lakhs
5	Trailor	Cement	20 Tonne - 25 Tonne	25 Lakhs

VIIFLOW CHART FOR PROCESS:

VIII. CONCLUSION

In the present work all the details of construction equipments regarding their Costs, Rates & Efficiency have been gathered which has been further formulated in excel sheet in such a format that it becomes easy to all class workers to read it study & conclude about proper equipment selection.Thereby by it reduces & prevent any of the risks approaching the construction project regarding construction equipments.

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Light Weight Floating Concrete for Low Structural Applications

[1] Dr. A.S. Kanagalakshmi, M.E, Ph.D [2] R.Anusuya [3]B.Bharathi [4] T.Divya [5] M.Jothi Priya

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A B S T R A C T

This paper deals with the development of lightweight concrete. This also shows the importance of water/cement ratio as in first type of concrete it produce lightweight structural concrete with the unit weight varying from 1200 to 2000 kg/m³.. The isomer of all the phenyl groups on same side called polystyrene. Now a day's number of researches have been done on lightweight concrete but in this research we have tried to make a concrete having possible lesser density and higher compressive strength. We have taken the following proportions ,

30 % CM and 70 % EPS

40 % CM and 60 % EPS

50 % CM and 50 % EPS

The size of the mould we adopted is 15 X 15 X 15 cm . hence the volume of the cube is 3.375 cm^3 . The plasticizer we used is sulphonate naphthalene formaldehyde. The plasticizer amount is 1.5% on volume of the cement mortar . The main aim of our project is to make a less air voids and densed concrete .

Keywords: Floating concrete,EPS(Expanded Polystyrene), Density, Compressive strength, less air voids, densed concrete

I. INTRODUCTION

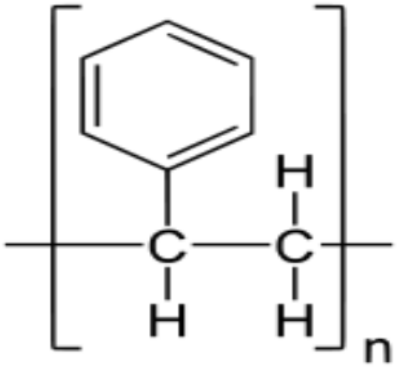
The present day world is witnessing construction of very challenging and difficult civil engineering structures. Lightweight concrete can be defined as a type of concrete which includes an expanding agent in it that increases the volume of the mixture while reducing the dead weight. Researchers all over the world are attempting to develop low density or lightweight concrete by using different admixtures in concrete up to certain proportions. Expanded polystyrene (EPS) is a lightweight cellular plastics material consisting of fine spherical shaped particles which are comprised of about 98% air and 2% polystyrene. It has a closed cell structure and cannot absorb water. It has a good sound and thermal insulation characteristics as well as impact resistance. The main specialties of lightweight concrete are its low density and low thermal conductivity. There are many types of lightweight concrete which can be produced. But ultimately, the application has extended vastly in the building and construction industry such that EPS is now used in road construction, bridges, floatation and drainages. EPS used for building construction are of various types and sizes with the most common ones being for wall panels and for slab. Expanded Polystyrene is one product that can contribute towards achieving good quality, low cost and record time completion of building product.

II. EXPANDED POLYSTYRENE

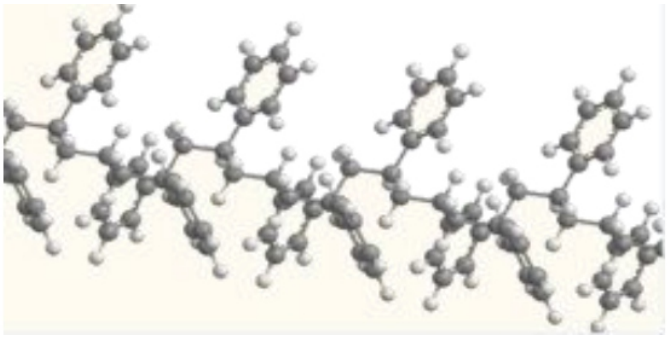
The two-phase material is an ultra-high strength mortar and expanded polystyrene spheres (EPS).

IUPAC name of EPS

Poly (1 – phenylethene – 1 , 2 – diyl)

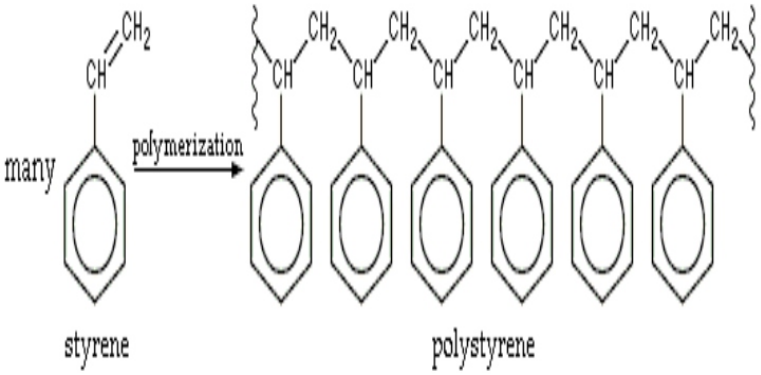


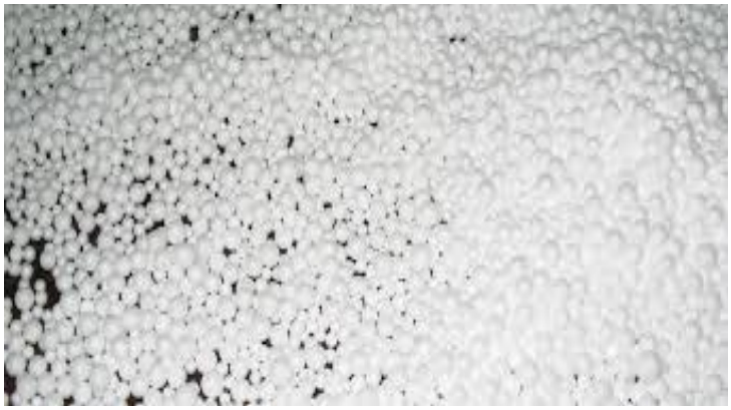
Polystyrene



Polystyrene molecule

EPS is formed by the polymerisation of Benzene and Styrene





Expanded polystyrene beads

III. MATERIAL USED :

OPC cement (grade 53)
Manufacturer sand (MSAND)
Fine sand
Flyash
Water (tap water)
Expanded polystyrene (EPS)
Plasticizer (sulphonate naphthalene formaldehyde)
Mosaic powder

IV. PROPERTIES OF EXPANDED POLY STYRENE :

Stong
Durable
Light weight
Water resistance
Thermal insulation
Flame retardant
Chemically inert
Non - toxic

V. PROCEDURE

For 30 % cement mortar and 70 % EPS is given by
The quantity of 30 % cement mortar = 1.67 kg
The quantity of 70 % EPS = 32 gm
volume of water = 226 ml
volume of plasticizer = 25 .05 ml
Take 1.67 kg of cement mortar
Mix the water and superplasticizer simultaneously in the jar .
Add the mixture of water and superplasticizer in the cement mortar . mix the cement mortar until it attains the consistency . Add 32 gm of EPS to the mix . continue the mix of concrete .
After attaining the normal consistency , put the concrete in the mould
Fill the concrete in the mould by 1 / 3 rd of the volume .The mould is filled in three equal Tamp the concrete by giving 25 blows on the corners and center . By tamping the concrete the airvoids is reduced and the concrete is compacted . similar procedure is adopted for the full mould . At the top of the mould levelthe concrete by using the shovel.
Similar procedure is adopted for all the proportions

During the mixing of concrete

USING M sand
In 30 % CM we taken cement + Msand and 70 % EPS
In 40 % CM we taken cement + Msand and 60 % EPS
In 50 % CM we taken cement + Msand and 50 % EPS

USING fine sand
In 30 % CM we taken cement + fine sand and 70 % EPS
In 40 % CM we taken cement + fine sand and 60 % EPS
In 50 % CM we taken cement + fine sand and 50 % EPS

USING flyash
In 30 % CM we taken cement + flyash and 70 % EPS
In 40 % CM we taken cement + flyash and 60 % EPS
In 50 % CM we taken cement + flyash and 50 % EPS

USING mosaic powder
In 30 % CM we taken cement + mosaic powder and 70 % EPS
In 40 % CM we taken cement + mosaic powder and 60 % EPS
In 50 % CM we taken cement + mosaic powder and 50 % EPS

From the above proportions
30 % CM we taken cement + Msand and 70 % EPS
In 40 % CM we taken cement + Msand and 60 % EPS
In 30 % CM we taken cement + fine sand and 70 % EPS
In 30 % CM we taken cement + mosaic powder and 70 %
EPS
In 30 % CM we taken cement + flyash and 70 % EPS

These proportions of mix are floating in water . the unit weight of this cube is less than the unit weight of water which tends the cube to float in water .

Research Siginificance

Light weight concrete
To reduce the self weight of the structure
Constructions on water bodies
Used as an acoustic medium
Low thermal conductivity

VI. CONCLUSIONS:

World energy consumption is rising to meet the demands of the growing world's population and increasing development, particularly in the emerging economies. Both consumers and government

authorities are becoming more aware of the global sustainability issues due to this soaring demand and high price associated with the fossil energy.

The Aerated concrete is a much lighter concrete and can float on water. It does not contain coarse aggregates. It is composed of cement, sand, high watercement ratio.

Just as we mix the cement-sand slurry with EPS, the expansion in the volume can be observed. Within 5 minutes it expands by 30%. It consists of many pores and thus is not structurally strong. It is a good insulator of heat and sound and thus can be used in place of conventional bricks or at the places which does not bear any load.

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BOOKS

Concrete technology (Theory and Practice) by M.S.Shetty. Concrete technology by A.R.Santha Kumar. Engineering materials (Including construction materials) by R.K.Rajput

Development of Self Balancing Prototype of Two Wheeled Vehicle by Using Gyro Stabilizer

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A B S T R A C T

Gyrostabilizers are anticipated to be as appropriately desired system to provide stability for two wheeled vehicles. This paper focuses on the concept of developing the two wheeled vehicle prototype to exhibit the working of gyrostabilizer (or gyroscope) for providing stability. The stabilization of two wheeled vehicle works as torque applied externally on vehicle isneutralized by torque produced by gyroscope. When torque is applied vertically on the gyroscope normally to its spin axis, this causes to develop precession motion which process the gyroscope along its perpendicular axis. As following, the torque developed by gyroscope will counter the applied torque causes vehicle to be in equilibrium (i.e., gyroscopic effect). This paper exemplifies the latter described system in static condition. But, the paper also introduces further the development of the vehicle in dynamic condition. In this system, sensors with modified gyro wheel are implemented. Sensors actuate the gyro wheel according to the tilt of the vehicle to provide same magnitude of the torque exerted, externally.

Index Terms— Gyrostabilizer, Gyroscopic effect, Precession motion, Static condition.

I. INTRODUCTION

Two wheeled vehicles do not have enough point of contact to stabilize themselves [2]. To provide directional stability, gyroscopic effect has been widely used in several terrain vehicles such as land, sea and space. Gyrostabilizers have been used for attitude control of vehicles in many situations such as in underwater vehicle, Bicycle, Monorail, Robots and Control Moment Gyroscope (CMG) [6] used in spacecraft for motion control.

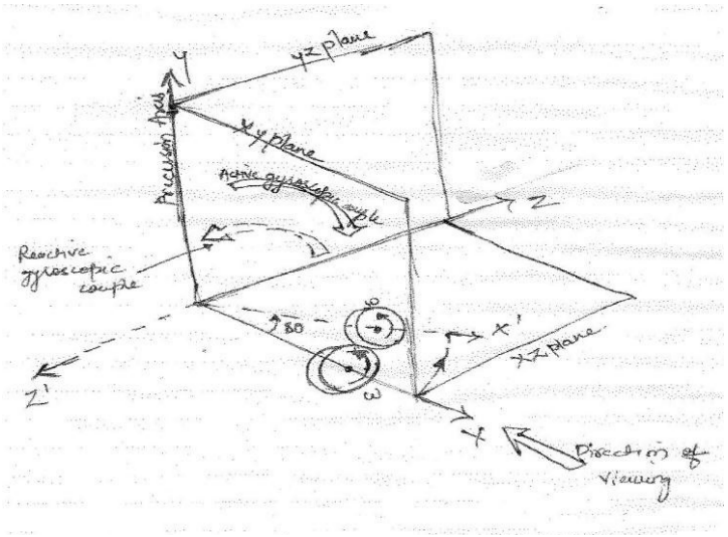
In recent period, Gyrostabilizer systems are anticipated to become widely adopted in land vehicles to provide better stability by reducing extraneous supporting wheels from vehicle. It helps to develop the vehicle with economical advantage of assisting the cars to take sharper curves with using low space and low cost in manufacturing and maintenance. Inline or two wheel vehicles offer high efficiency than four wheel cars. This increased efficiency is mainly due to reduced weight, fewer friction surfaces and reduced drag.

Two wheel vehicle with gyrostabilizer can be demonstrate as- Consider a disc rotating in X-axis (in ZY plane) and its axis of rotation is forced to precess in one of its perpendicular direction (.i.e., about Y-axis or XZ plane).

The couple induces, will act on the third perpendicular plane (i.e., XY plane or about Z- axis). This couple caused by the phenomenon called as gyroscopic effect and the couple induced is known as reactive gyroscopic couple. On the other hand ,this phenomenon can be defined as- When the torque (gravity or excitation moment) is applied to an axis normal to the spin axis, causing gyroscope (disc) to precess, a moment is produced about the third axis which is orthogonal to its spin axis or applied torque[4].

This tendency of a rotating body about an axis of symmetry offers resistance to change in its direction of

axis of spin is due to change in rate of change of angular momentum of the body [1]. The reactive gyroscopic couple is the product of change in angular momentum. This change of angular momentum (i.e., cause of precession of spin axis) is known as active gyroscopic couple. This resultant reactive gyroscopic couple will be equal in magnitude but will be opposite in direction of active gyroscopic couple. This overall describes the phenomenon provides an effective means of motion control.
This similar concept to stabilize the inline wheel vehicle was developed by Louis Brennan in 1905[3] as monorail but that was unable to commercialize due to safety and design complexity [3]. This paper concentrates over the specific manner of motion control on vehicle in rest condition.



1: Basic illustration of Gyroscopic Effect [4]

II. CONCEPT GENERATION

This paper is based on the concept of stabilization of two wheel vehicle in idle condition. This could be exemplified by using gyroscopic effect on suitable prototype of two wheel vehicle.

A. Construction

This prototype is made up of an in-house material which was easy to obtain and reduces the overall experimental cost. And, I had to build two prototypes because first was failed.

This prototype is created by following parts as:
1. Wooden plank as base
2. Plastic scale as frame for gimbal support
3. Four fixed compact disc as gyroscope flywheel
4. DC motor as power supplier
5. Wooden pencil as Gimbal
6. Rounded surface wheel

1. Base and Wheel Support

Base support for the prototype should be able to endure the stress and vibration occurs while experimentation. Firstly, the base support provided to the prototype was too heavy which caused unable to stabilize the vehicle. Then, lighter wooden plank was used which was able to endure the stresses and of less weight. Therefore, it is necessary to choose as much as possible lighter material to provide better

stability.
Wheel is bolted into wooden plank. In first prototype, I used the wheel which was of approximately 4.5 cm diameter with slightly rounded surface. This causes the prototype to stand vertically without any support and reactive couple. When the motor starts, it felt down due to higher centre of gravity caused by larger height of wheel and reduces the ability of gyrostabilizer of stabilization. Therefore, wheel should be well rounded on surface and of fewer diameters. Thus, I used wheel of 2cm diameter in second prototype.

2. Gyroscope or flywheel and Frame

The most significant device in the prototype is gyroscope or flywheel. For a specific vehicle weight and centre of gravity (COG), a flywheel should be of suitable size so that the vehicle's vertical stability may be indefinitely while in idle condition. The major variables of this component are diameter, thickness and mass. In this prototype, four compact disc are of enough mass to provide the appropriate moment of inertia for resultant couple.
Plastic frame is used to provide the support for gimbal. Plastic material is lighter and able to withstand on stresses and keeps the whole vehicle lighter. This plastic frame is made up of plastic scales joined by L-shaped supports.

3. Motor and Gimbal

Motor provides a torque which is essential for gyroscope to produce a reactive couple. Therefore, Motor possess variables i.e., torque and mass which can affect the obtained result. Motor is fitted on the top of the gimbal and it is the heaviest part of the vehicle. Therefore, Centre of Gravity (COG) of the prototype lies on it. The speed of the motor plays vital role on the gyroscopic effect. Thus, speed of the motor should be more as much as possible (to a specific point).In this prototype, motor can spin up to 3000 rpm with 12V power input. This motor is small in size and supplies enough amount of rotation.
Motor is supported by a gimbal i.e., wooden pencil. Aligned holes were drilled in the opposite faces of the frame. Bearings are used to provide the rotation for gimbal about the axis, perpendicular to the spin axis of flywheel. This helps to provide precession motion on the gyroscope.

4. Other several considerations

Mass of gyroscope plays a vital role in stabilization of prototype. Angular momentum and Mass of Inertia depends on the mass of gyro or flywheel. But, vehicle width, vehicle thickness, gyro width and gyro thickness are the parameter that do not affect the stabilization i.e., their effect is negligible. Centre of Gravity of vehicle, gyro and motor varies the ability of stabilization of vehicle [2].
Therefore, to obtain the desired result of the system, it should be considered that [2]:

Centre of Mass of the cart should be as low as possible .
Centre of Mass of the gyro should be as low as possible.
Rotation of the gyro should be increased as possible, up to specific limits.
Decrease the mass of the gyro(to a point)

B. Working

In this prototype, the motor is fitted downwardly on the gimbal. This whole core as heaviest part represent as Centre of gravity which tries to attain the position and move downward. But, the gimbal has fitted on the frame and bearing allows gimbal to rotate about the axis (in the rolling plane of vehicle).Therefore, motor can only lean forward or backward about the gimbal. So, when motor starts rotating external excitation or active gyroscopic couple occurs. This gyroscopic couple occurs due to

falling of vehicle on its one of a side. A motor started, falls either on forward or backward, causes the precession motion for gyro or flywheel. Due to this precession of the spin axis, reactive gyroscopic couple acts on the frame which is equal on magnitude and opposite in direction to the active gyroscopic couple and stabilizes the vehicle. The vehicle attains the equilibrium state while in an idle condition.

III. THEORETICAL DESCRIPTION

Consider a disc of mass moment of inertia (I) to be spinning with angular velocity about the axis OX in clockwise direction as seen in the direction from O to X. The plane of the disc is normal to the X axis. As shown in Fig.2 , let the axis of disc rotate about Y axis in the plane XOZ as to occupy a new position OX' after a short interval of time t. Let, the angle XOX' be equal to [1].

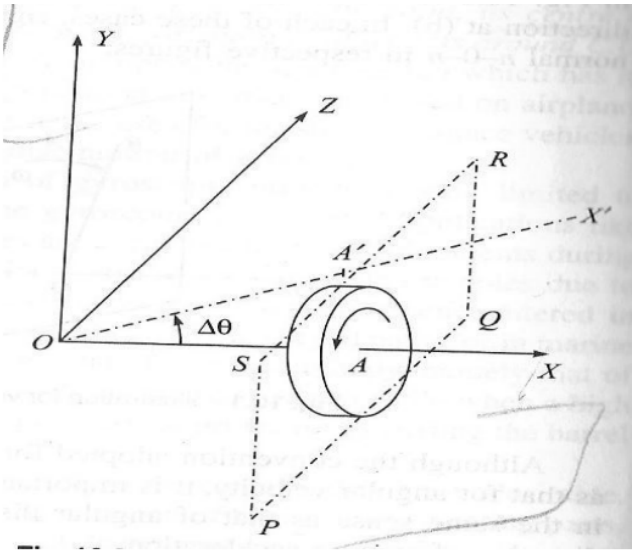


Fig 2: Precessional motion of a disc[1]

The mass moment of inertia can be expressed by . Then,
Angular momentum can be given by $I\omega^2$.
As shown in fig2, the axis of spin has precessed through an angle $\Delta\theta = \angle XOX'$.

The sense of angular velocity vectors, as obtained by applying right hand screw rule to the disc in two positions, as shown in Fig.3(b.)

In vector triangle,

Vector oa represents an angular velocity, ω.
Vector ob represents an angular velocity, $(\omega+\Delta\omega)$.
Vector ab represents a total change in angular velocity, both in magnitude and direction.

As shown in Fig3 (b), ac and bc are the components of ab and mutually perpendicular to each other. Component ac presents increase in magnitude of angular velocity while component bc presents change in direction of angular velocity.
As we know that couple or torque is necessary for producing an angular acceleration in a rotating disc. This angular acceleration represents change in angular moment and produces precessional motion[1].

Therefore, Change in angular momentum can be represented by, ab

And, the rate of change of angular momentum produced by gyroscopic couple C can be given by[1],

$$C = \lim_{\Delta t \to 0} \left(\frac{ab}{\Delta t}\right)$$

But, ab ≈(oa)Δθ (for small angleΔθ).And the line ab is assumed to be perpendicular to oa, as shown in fig.3

Hence, From above equation, $C = (oa)\frac{d\theta}{dt}$

Or, $C = (oa)\omega_p$

Or, $C = I\omega\omega_p$ (Since, oa = Iω)

This above equation represents an active gyroscopic couple and also represents the counter couple or torque of gimbaled flywheel assembly [1].

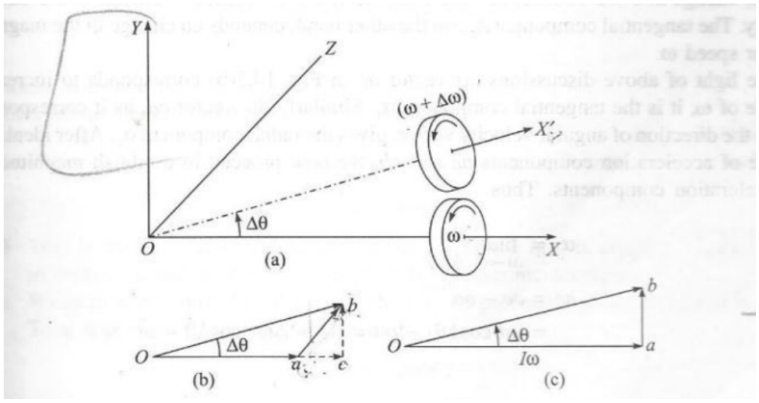
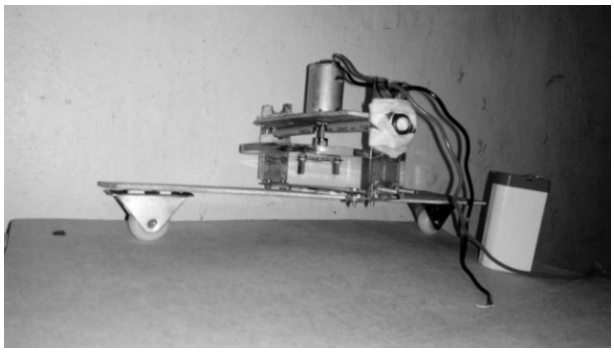


Fig 3(a): An illustration of angular speed of a disc with time[1], Fig 3(b): Angular velocity vector diagram[1], Fig3(c):An illustration of vector diagram when angular velocity remains constant[1].

IV. OBSERVATION

When the prototype (as shown in Fig.4) achieve the state of equilibrium i.e., stabilizes. But, it starts to oscillate at certain frequency. This phenomenon occurs due to cheap and flexible material. And, Compact discs are difficult to fix together and balance properly. This shaking was also due to improper calculation of each aspect of manufacturing the prototype. The other problem came out that the motor or gyroscope sometimes turns around completely about the gimbal axis. This situation came because gyroscopic effect becomes less effective after the specific angle (approximately 90°) of rotation around the gimbal axis.

However, the main objective of the prototype to demonstrate the ability of gyrostabilizer to stabilize the inline or two wheel vehicle is achieved successfully.



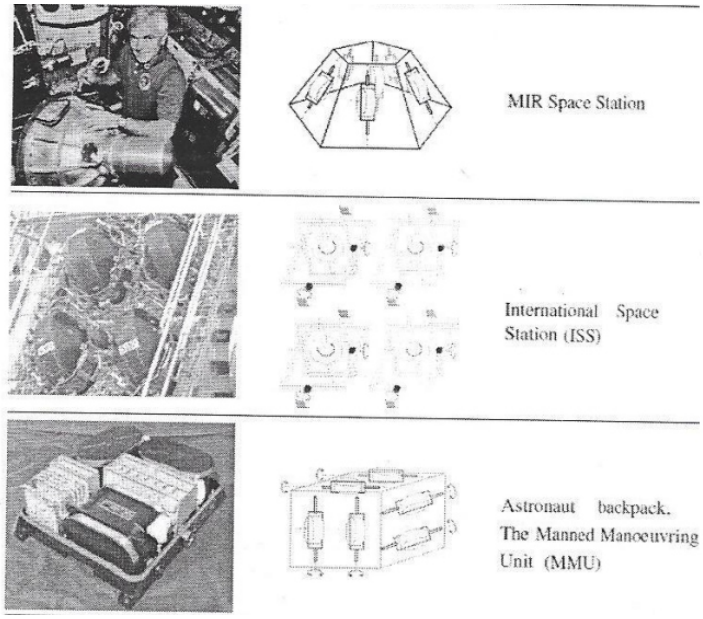
: Final Prototype of Two Wheeled Gyroscope(Side view)

As mentioned, I have made two prototypes due to failure of first prototype. To accomplish the desired goal, I made some changes in second prototype such as:
1. I replaced 1000rpm 12V DC stepper motor with 3000 rpm 12V motor because 1000 rpm was less capable to provide sufficient rotation for angular momentum.
2. I have trimmed the upper portion of frame to make vehicle lighter and, also replaced heavy and thick wooden base from very thin wooden plank base.
3. Replaced a large diameter wheels with small diameter wheel to reduce the height of the vehicle.

V. GYROSTABILIZER APPLICATION IN DIFFERENT FIELDS

A. Types of gyrostabilizer implemented in various vehicles

The first recorded construction of gyroscope device was in 1817[5]. Since, gyroscope has been implemented in many systems for several purposes. Marine vehicles and spacecraft are the primary vehicles in which gyrostabilizer have been used. But, implementation of gyrostabilizers in wheeled vehicle has also started. In marine vehicle, gyrostabilizers have been used to attitude control or to control orientation specially roll motion control. In spacecraft, it has vital importance to control orientation of vehicle with low energy consumption



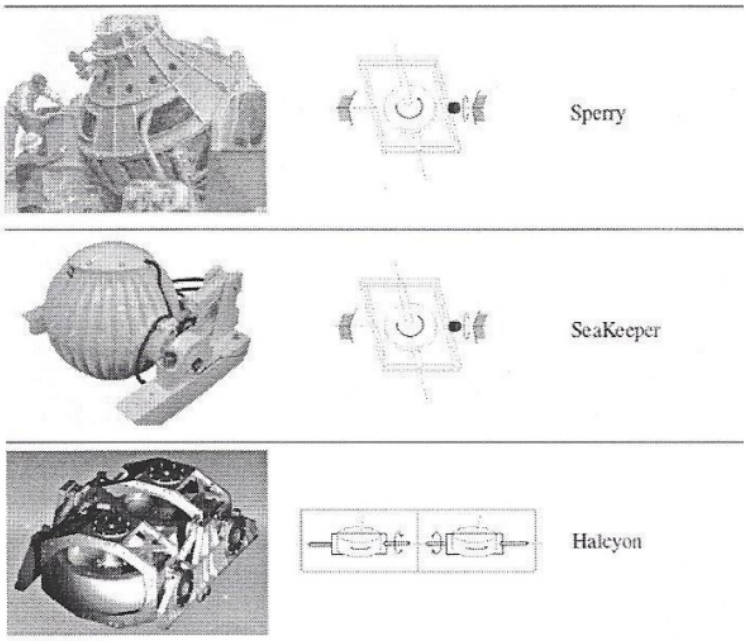


Fig6: Marine gyro stabilization systems[5]In wheeled vehicle, gyrostabilizers were used to stabilize the vehicle on two or one vehicle to reduce the unnecessary space like in Ford Gyron, Brennan monorail, Gyrover, etc. In fig.5, Fig.6, Fig.7, various gyrostabilizer systems have been showed which has been used.

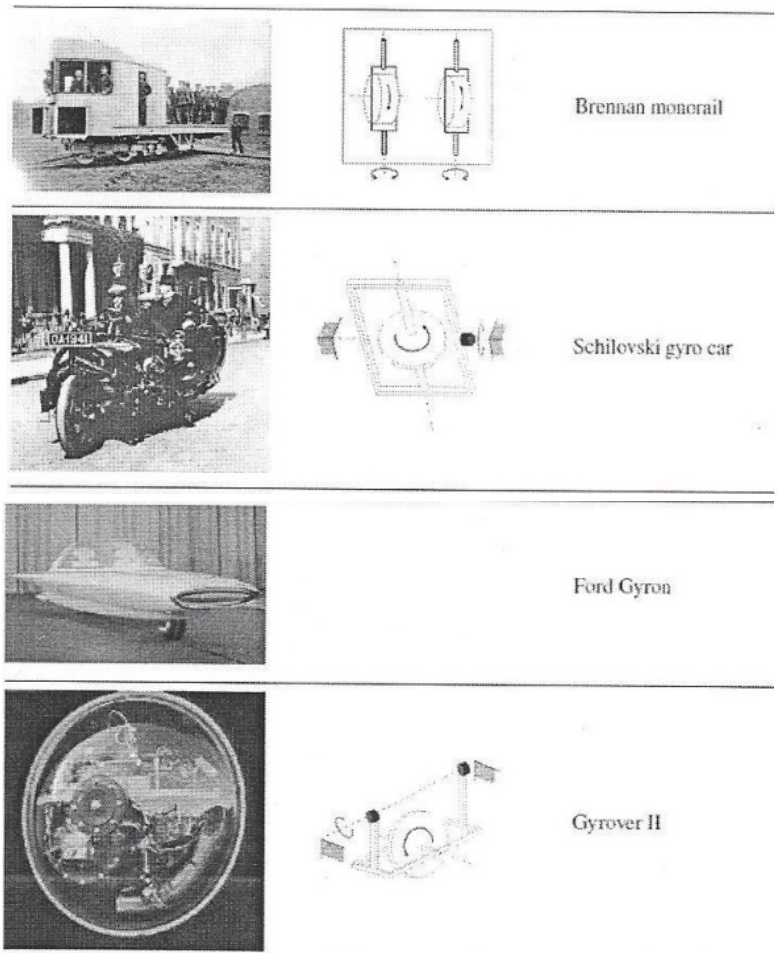


Fig7: Wheeled vehicle Gyrostabilizer systems [5]

B. Future prospect

Gyrostabilizer has been developed with modern technological aspect which allows it to use safely in vehicles. Now, it has started to be used in two wheeled vehicle for future transporting aspects such as lit motors C1, Hoverboard
etc.

Fig.8: Lit motors concept bike(Exploded Image)

Lit motors concept bike C-1 offers the features of bike and car together. This vehicle works on the concept of above illustrated prototype in many aspects. But this vehicle uses two gyro wheels which have been precessed by the sensors according to its rolling movement. This sensor provide aid to several microprocessor to know the exact magnitude of the precession of spin axis of gyro wheels to induce the equal amount of reactive gyroscopic couple for stabilization for both static and dynamic motion.

VI. CONCLUSION

Gyroscopic stabilization has used widely to stabilize the variety of systems. As proved in this experimentation, this technology can also be used for stabilization of two wheeled vehicle in idle condition. However in dynamic condition, the stabilization can also achieved by gyrostabilizer as used in Lit motors C-1 vehicle by using sensors , microprocessor and feedback system. This paper also addresses the several applications of gyrostabilizer which provides better configuration to analyze its aspects.

And, the stabilization of an in-house built prototype of two wheeled vehicle was validated by the gyrostabilizer by using gyroscopic effect.

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Contribution of Carbon Credits for Financial Feasibility of a Biogas Project

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ABSTRACT

The environmental change and ecological preservation are the principle issues of this century. India ranks as the second biggest in the populace, the fourth biggest in energy utilization and third biggest greenhouse maker and blazes ten folds fuel wood when contrasted with the United States. With a specific end goal to control the greenhouse outflows and for empowering countries for taking applicable measures the UN has concocted the matter of carbon exchanging on the premise of discharge moderation accomplished by the government and corporate firms by employing environmentally friendly technology for their production activity. The coal fired power generation in India is the greatest polluter and in the meantime gives the greatest chance to outflow lessening and procuring of carbon credits. In no time, India is creating the second most astounding number of carbon credits on the planet and is next just to China. In contrast with the developed countries the carbon emission level in India is substantially less. This gives enough opportunities to its industry to convey carbon units and seat points of interest out of its exchanging. With this vast potential to acquire carbon credits, India has a enormous degree for carbon consultancy organizations to flourish and is going to add another extent to the environmental and wealth related organizations zone. This paper presents an estimation of emission mitigation and carbon credit for a biogas electricity plant located in Maharashtra.

Index Terms:— Renewable energy, bio-energy, emission mitigation, certified emission reduction

I. INTRODUCTION

Energy is the essential driver of the world's economies. Increasing populaces and wishes of upgraded lifestyles are enlivening the enthusiasm for energy. The present general energy supply is remarkably subjected to fossil sources (unrefined petroleum, lignite, hard coal, normal gas). These are fossilized stays of dead plants and creatures, which have been displayed to warmth and weight in the Earth's outside over an immense number of years. The multifold increment in the fossil fuel based force era in the course of the most recent couple of decades has undoubtedly gone about as a driver for financial development of countries, yet in the meantime it has accompanied its own particular weight of carbon impressions. Scholars have perceived the positive or direct relationship between money related advancement and greenhouse gas (GHG) outflows.

One of the key variables influencing this positive relationship builds energy demand as a result of economic well-being. Additionally, the world's fossil fuel stores are not boundless and they will undoubtedly be totally exhausted in the near future. The world’s economies are dependent today on crude oil. There is some disagreement among researchers on to what extent this fossil asset will last however, as indicated by scientists, the “peak oil production” has already occurred or it is expected to occur within the next period of time. The peak oil production is defined as the point in time at which the maximum rate of global production of crude oil is reached, after which the rate of production enters its terminal decline [1].

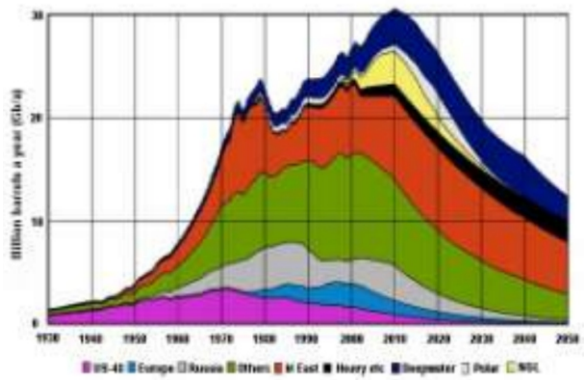

Fig 1. Plot of world oil production and "peak oil" (ASPO 2008) [1]

II. CARBON EMISSIONS

a. Global Warming

It is an unnatural weather change issue realized by a great deal of improvement of greenhouse gas emissions that transforms into the blazing point. Hence, the atmospheric concentrations of greenhouse gases must be kept steadily at a legitimate level and forestall sensational climate change causing harm to human. Carbon dioxide and other gases warm the surface of the planet. Actually by trapping the solar heat, keeping the Earth livable; however when we blaze fossil energizes, for example, coal, gas and oil and clear woods, we drastically expand the measure of CO2 in the air and temperature rises rapidly [2]. The relative commitment of the major GHG i.e. CO2, CH4 and N2O to a worldwide temperature alteration is 80%, 9.5% and 5.8% separately [2].

b. Carbon Footprint

Carbon impression (CF) is a total discharge of greenhouse gases, which created straightforwardly or in a roundabout way through the whole life cycle of the items and/or administrations, communicating in carbon dioxide equals CO2. The essential greenhouse gas Carbon dioxide (CO2) is for the most part transmitted through human exercises. It is actually present in the air as a feature of the Earth's carbon cycle (the normal flow of carbon among the air, seas, soil, plants, and creatures). Human exercises are changing the carbon cycle both by adding more CO2 to the environment and by affecting the capacity of common sinks, similar to woodlands, to expel CO2 from the air [2].

III. EMISSION MITIGATION

The three most essential methods for reducing the extent of carbon dioxide in the atmosphere are as follows:

1) Efficiency and Conservation: There are numerous energy proficiency and protection methods that lessen the utilization of carbon-based powers (for e.g., regular gas, oil, coal, or gas), diminishing carbon dioxide outflows. Energy protection is the act of diminishing the amount of energy utilized. It might be accomplished through productive energy use, in which case energy use is reduced while accomplishing a comparative result, or by lessened utilization of energy services [4].

2) Carbon-Free and Reduced-Carbon Energy

Sources: The other approach to decrease carbon dioxide discharges is to utilize sans carbon or lessened carbon roots of energy. Carbon-free sources of energy have their own related effects, however when all is said in done, these advancements create energy without delivering and discharging carbon dioxide to

the climate. Without carbon energy sources incorporates solar power, wind power, geothermal energy, low-head hydro power, hydro kinetics (e.g. wave and tidal power), and also the nuclear power. On the other hand, changing from high-carbon powers like coal and oil, to condensed carbon fills, for instance, regular gas will bring about diminished carbon dioxide releases. The extent to which biomass energy is thought to be without carbon or a decreased carbon fuel depends on upon the sort of biomass used and the methods by which it is changed over to vitality. [4].

3) Carbon Capture and Sequestration: A third option to minimize carbon dioxide in the atmosphere is carbon sequestration. It involves the capture and storage of carbon dioxide that would otherwise be present in the atmosphere, contributing to the greenhouse effect. Carbon dioxide can be removed and held inside plants and soil supporting the plants. On the other hand, carbon dioxide can be caught (either before or after fossil fuel is burnt) and afterwards stored (sequestered) inside the earth [4]

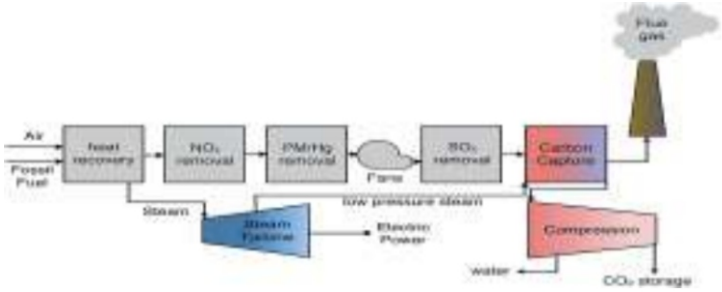

Fig 2: Carbon Capture and Sequestration (Source: Energy & Environ. Sci., 2014, 7, 4132-4146)

IV. INDIA'S POTENTIAL FOR RENEWABLE ENERGY

India has a substantial future for the adoption of renewable energy technologies that goes beyond addressing environmental concerns. The underlying principle is to gain from the current worldwide interest in renewable energy for three reasons [3]:

1. To take care of the developing demand for energy inside the nation, particularly in provincial territories
2. To diminish GHG outflows and add to environmental change mitigation.
3. To gain by the extending market for renewable energy and secure an early market advantage

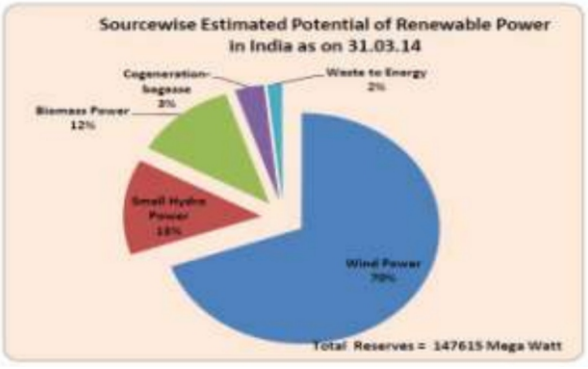

Fig 3. Sourcewise Assessed Potential of Sustainable Power in India as on March 31, 2014 (Source: Energy Statistics 2015)

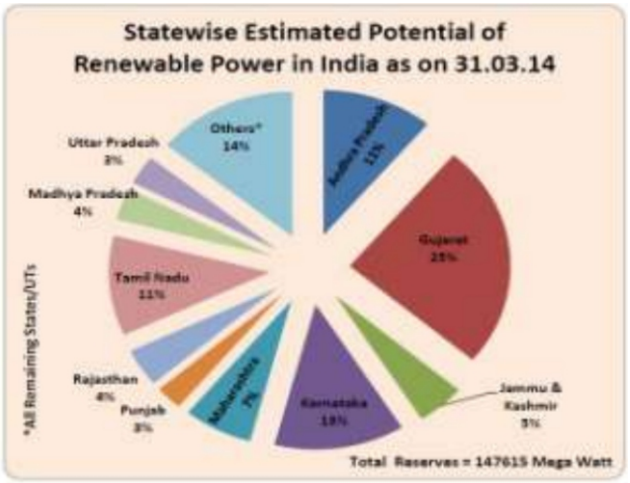

Fig 4. Statewise Assessed Potential of Sustainable Power in India As on March 31, 2014 (Source: Energy Statistics 2015)

The different sources of renewable energy comprising of Solar, Wind, Biomass, Small Hydro and Co generation Bagasse provides a high potential for generation of renewable energy. The aggregate potential for nonconventional power generation in the country as on March 31, 2014 is evaluated at 147615 MW. This incorporates wind power capability of 102772 MW (69.6%), SHP (little hydro power) capability of 19749 MW (13.38%), Biomass power capability of 17,538 MW (11.88%) and 5000 MW (3.39%) from bagasse-based cogeneration in sugar factories. The geographic circulation of the evaluated capability of renewable power as on 31.03.2014 uncovers that Gujarat has the most astounding offer of around 25.04% (36,956 MW), trailed by Karnataka with 13.08% offer (19,315 MW) and Tamil Nadu with 11.17% offer (16,483 MW), primarily by virtue of wind power potential [3].

V. CLEAN DEVELOPMENT MECHANSISM

The Clean Development Mechanism (CDM) under the Kyoto Protocol has accepted a significant part in supporting Greenhouse Gas (GHG) discharge decrease ventures in India [5]. Till December 2012, the CDM and other business sector components have bolstered the progress and execution of around 3,000 projects from India, out of which around 40% have been selected with UNFCCC [6]. These enlisted ventures represents an investment of over INR 1.6 trillion and have generated more than 170 million Certified Emission Reductions (CERs) that can be utilized by the developed nations to meet their consistence prerequisites under the Kyoto Protocol [6].

The Kyoto Protocol contrived three innovative mechanisms [7], [8]:

Joint Implementation (JI)
International Emission Trading (IET)
Clean Development Mechanism (CDM)

VI. INDIA'S CDM PERFORMANCE

In 1997, the administrations taking an interest in the United Nations Framework Convention on Climate Change (UNFCCC) concurred in the Kyoto Protocol. Amongst the developed and developing nations The Protocol chips away at the rule of regular however separated obligations. [6].

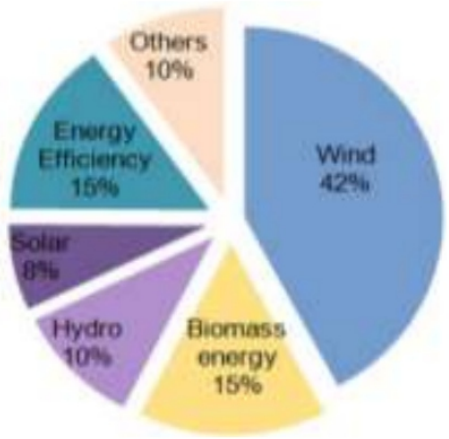

Fig 4: CDM projects in India by type as on March 1, 2015 (Source: UNEP DTUCDM/JI Pipeline Analysis and Database.)

38 Number of nations that settled to honestly required focuses for their outflows of a pack of six greenhouse gases in the affirmation stage 2008-2012 [6]. India has the second rank to hold number of enlisted CDM ventures under the Kyoto Protocol. The campaign of India's CDM is nothing less than remarkable. The majority of the CDM ventures in India are moved in a couple of divisions, specifically, those identified with the renewable energy segment (Fig 4).

VII. CARBON CREDIT THROUGH BIOGAS ENERGY: The Indian Context

Biogas Energy

Biogas is a fuel gas, a mix containing 65% methane (CH4) and of 35% carbon di-oxide (CO2) and is formed from the anaerobic bacterial deterioration of natural mixes of common blends, i.e. without oxygen, creating a renewable energy resulting from biomass. The gases formed are the waste products of the breath of these decomposer microorganisms and the content of the gases relies on upon the substance that is being disintegrated [5].

Composition of Biogas

Biogas is mainly a mixture of methane (CH4) and inert carbonic gas (Co2). However the name "biogas" assembles an expansive assortment of gases resulting because of particular treatment forms, beginning from different natural wastes - commercial enterprises, animal or residential source wastes and so forth. The table below shows a typical composition of biogas:

Table I: Typical Composition of Biogas [5]

Compound	Molecular Formula	Percentage (%)
Methane	CH_4	50-75
Carbon Dioxide	CO_2	25-50
Nitrogen	N_2	0-10
Hydrogen	H_2	0-1
Hydrogen Sulphide	H_2S	0-3
Oxygen	O_2	0-0

Significance of Biogas Energy for India

Biogas innovation is being advanced in India primarily overwhelmingly under the segment of vitality. The emphasis on this gets from the critical energy supply circumstance for the people in the Country. India is the distinct nation where the improvement of uncomplicated biogas plants for the Tropics which are easy to work began, after China. Biogas covers an assortment of business sectors, which includes the electricity power, heat and transportation fills. Despite the fact that using the gas for direct burning in family unit stoves and gas lights is normal in a few nations, delivering power from biogas is still moderately uncommon in most developing nations. Power generation is the principle motivation behind biogas plants; change of biogas to power has turned into a standard imaginative innovation in the industrialized nations,. To enhance general productivity of biogas use, consolidated heat and power plants are regularly utilized [5].

VIII. GLOBAL WARMING POTENTIAL, GLOBAL WARMING MITIGATION POTENTIAL AND CARBON CREDIT

A. The Global Warming Potential (GWP):

Global Warming attributes to the general increment in the world's normal temperature, which causes changes in climate patterns across the globe. GWPs are utilized to assess the environmental change effects of different GHG outflows and express them in a solitary unit – carbon dioxide reciprocals (CO2e) – and are essential part to report associations to mull over[10].

Table II: GWP of Various Green House Gases on 100 Years' Time Horizon [9]

Sr No.	Greenhouse Gases	Global Warming Potential (GWP)
1	Carbon dioxide	1
2	Methane	21
3	Nitrous Oxide	310
4	Hydroflouro-carbons	140-1170
5	Perfluoro carbons	6500-9200
6	Sulphur	23900

Each GHG has a substitute breaking point for catching and re-transmitting active infrared radiation in the air, in this way adding to radiative constraining [9]. The net effect of the shorter lifetime and higher energy absorption is reflected in the GWP. It's obvious that the Global Warming Potential (GWP) of the first three greenhouse gases in the above table taken together will be given by the following equation [9]:

$$GWP = CH4 \times 21 + N2O \times 310 + CO2 \times 1 \ldots\ldots\ldots (I)$$

B. The Global Warming Mitigation Potential (GMP):

The term Global Warming Mitigation Potential is used in context of a renewable energy generation project which is designed as an alternative to a conventional fossil fuel based source of energy. The GMP of such a project is the total amount of greenhouse gases that would have been emitted by the conventional source converted to the equivalent amount of carbon dioxide (Co2) that will have the same global warming potential. This can be the total GMP of a mixture of greenhouse gases emitted from a project will be equal to the sum of their individual Global Warming Potentials [9]. This can be expressed

in terms of the following equation:

$$\left\{\begin{matrix}\text{GMP of a renewable}\\ \text{Energy Project}\end{matrix}\right\} = \left\{\begin{matrix}\text{GWP of } CO_2 \text{ equivalent}\\ \text{of total emission reduction}\end{matrix}\right\}$$

$$= \left\{\begin{matrix}\text{GWP of } CO_2\\ \text{Emission reduction}\end{matrix}\right\} + \left\{\begin{matrix}\text{GWP of } CO_2 \text{ equivalent}\\ \text{of } CH_4 \text{ Emission reduction}\end{matrix}\right\}$$

$$+ \left\{\begin{matrix}\text{GWP of } CO_2 \text{ equivalent}\\ \text{of } N_2O \text{ Emission reduction}\end{matrix}\right\} \quad \text{.....(ii)}$$

C. Carbon Credit

It's also known as certified emission reduction (CER). It's a type of reward to the savers of emanation of carbon dioxide. One carbon credit is equal to one ton of carbon dioxide or its proportionate greenhouse gases (GHG). "privileged certificates" in the form of carbon credits are issued by the united nations framework convention on climate change (UNFCCC) to the implementers of the endorsed clean development mechanism (CDM) ventures. The considered carbon credits is set up in the KYOTO protocol, which licenses industrialized countries that agree to carbon tops to meet their sums in part by bank moving emission reducing endeavors at areas where the undertaking will be less unreasonable [9].

IX. THE CASE STUDY

A case study had been carried out at a BioMethanation Plant in the state of Maharashtra. The objective was to assess the global warming mitigation potential (GMP) of the plant and the resulting carbon credits.

A. About the Plant

The plant under study was 1.5 tons per day (TPD) limit decentralized biomethanation-cum power generation plant sustained by metropolitan waste. The essential objective of setting up this plant was to treat the wet disconnected regular metropolitan solid waste decentralized at source point itself in a most circumstance neighborly way. Consequently, the city municipal corporation of Pune is aided straightforwardly as far as saving money on transportation of such wastes to the landfill site which is just about 22 km from the site [10].

B. The Biomethanation Process

The genuine segment of Municipal Solid Waste (MSW) is the common division (40-60%) which can be easily treated by anaerobic assimilation. the solid wastes conveyed in urban zones from vegetable markets, lodgings, motels, kitchen waste and so on are most appropriate for this approach, in view of the proximity of high moistness and common parts (up to 90%).The aggregate solids in the natural waste break down quickly and subsequently these wastes can be dealt with by Biomethanation process (all the more usually called Anaerobic Digestion, AD) in more successful way [10].

Fig 7: The biomethanation-cum power generation plant [10]

C. Data Collection

Table III. Plant Operation Details [10]

Particulars	**Product**
Plant capacity	5 TPD per day segregated organic biodegradable municipal solid waste
Type of Process	Bio-methanation through two stage process
Biogas Generation	300 Cum/day
Electricity Generation	375 kWh/day
Manure Generation	500 kg/day (50% moisture basis)

Table IV: Major Component and specifications of the Plant [10]

Component Name	**Quantity**	**Remarks**
Waste Reception and Fine Segregation Section	1	-
Mechanical Crushers	2	5 HP Motor
Two Stage Anaerobic Reactors	200 m^3	With Aeration, Biogas and Leachate Recirculation facility
Manure Handling Section	35 m^2	In BBM
Biogas Collection Section	2 Nos. 75 m^3 each	Neoprene Rubber with enclosure

Biogas Cleaning System	1	CO_2 and H_2S Scrubbers, Pressure Vessel and Vacuum Pump.
Power Generation	40kVA	100% Biogas based Indian Engine
Leachate Recirculation System	1	-
Solar Water Heating System	500 Litres/day	-

2. Calculation of GMP and Carbon Credits

The bio-energy project under study effects emission mitigation in the following three ways:

Through renewable energy generation: This is the direct mitigation achieved through avoidance of equivalent energy generated through fossil fuels. In the plant under consideration, assuming a power factor of 1, power generation can be taken as 375kW.

Through the replacement of chemical fertilizers with organic fertilizers: This is indirect mitigation achieved through composting of biogas slurry and its use as organic fertilizer. One ton of manure from the biogas plant is equal to 5.4 kg of Urea (MNRE, 2010). The carbon dioxide emissions from Nitrogen, Phosphorus and Potassium fertilizer production in the units kg kg−1 have been sourced from [8]. The following table shows the complete calculation for the total emission in terms of CO2 equivalent per kg of fertilizer production of each type:

Table V: Calculation of Emission due to production of different fertilizers

Fertilizer Type	Emission in kg kg^{-1}			
	CO_2	N_2O	N_2O in terms of CO_2 i.e. N_2O x 310	Total in terms of CO_2 Equivalent
Nitrogen	1.30	0.07	21.70	23.00
Phosphorus	0.20	-	-	0.20
Potassium	0.20	-	-	0.20

Through a solar water heating system: The biomethanation plant has a 500 litre capacity solar water heating system for heating water to a temperature of 50ºC. The hot water is used for accelerating the bio-methanation process. The amount of emission reduction due to this solar heating system has been computed on the basis of heat imparted to the water that is

$$Q = m \times Cp \times \Delta T \ldots\ldots\ldots \quad (iii)$$

With yearly average temperature of the city as 22ºC, the value of ΔT is 33ºC and the amount of heat transferred to 500 litre of water is 69085.5 kJ/day of energy. With this is equivalent to an annual electrical energy saving of 7004.5MWH approximately. This is equivalent to 5806.316 tons of emission

mitigation per annum [11].

Estimations:

1. 100% CO2 is produced from exhaust of the engine.
2. Biogas formed after scrubbing is 70-75 % pure
3. Methane and CO2 as 25 %.
4. Methane produced = 225 m3and Carbon dioxide =75m3.

According to Equation (I),
The calculation of Global Warming Potential is for the Bio-Methanation Plant is calculated as

GWP = CH4 × 21 + N2O × 310 + CO2 × 1

= 225 x 21 + 0 x 310 +75 x1

= 4800 m3.

Thus, Global Warming Potential for the Plant is 4800m3.

According to Equation (ii),

The calculation of Global Warming Mitigating Potential is calculated as

GMP = 1.3* 250 + 0.2* 250 + 0.2 * 250 + 0.07 * 250

= 325 + 50 + 50 +17.5

= 442.5kg CO2 per day

Therefore the GMP for this renewable Energy project turns out to be 442.5kg CO2 per day.

V. CALCULATION OF CARBON CREDIT FOR THE PUNE BIO-METHANATION PLANT:

One carbon credit is equivalent to one tonne of carbon dioxide or its equivalent greenhouse gas (GHG)[12].

In India, €24 i.e. 26$ is equal to one carbon credit i.e. `1765 = `1765 x 0.4425 = ` 781per day [12]The table below comprises the Carbon credits can be earned:-

Table VII: Carbon Credits Earned By Pune BioMethanation Plant

SR NO.	CO_2 PRODUCED IN TONNES		CREDITS EARNED IN `
1	DAILY	0.4425	` 781
2	MONTHLY	13.275	` 23430
3	ANNUALLY	161.5	` 285065

Therefore, it is observed that, the annual carbon credits earned will give the maintenance cost, and other expenses involved such as transportation etc. of the plant very efficiently.

VI. CONCLUSION

1.Biogas innovation gives a superb chance to alleviation of GHG and decreasing an Earth-wide temperature boost i.e. global warming. Biogas plant is a valuable innovation for the asset poor agriculturists in developing nations. By a wide margin it has been seen as another vitality source yet now it assumes a noteworthy part in relieving in global warming by substituting cooking fuel and chemical compost.

2. Carbon credit may be the cost reducer or cost gainer. It should be considered as intangible assets as it is invisible and can be sold.

3. The GWP, GMP and Carbon Credits for the Bio Methanation Plant have been finished dynamically and it offers rise to become such diverse plants in various parts of India. India has a broad potential to obtain carbon credits and in this setting the carbon consultancy organization connection the carbon consultancy administration has a larger part to play and is going to add another measurement to the Environmental consultancies and financial related administrations enclosure.

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Comparative Study of Various Digesters for a Rural Community Biogas Plant

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A B S T R A C T

Energy requirement is increasing and fossil fuels resources are limited, therefore we should consider renewable energy as solution to our problem; but till today renewable energy is economically not an attractive option. Biogas is renewable fuel which generates from decomposition of bio-degradable waste under anaerobic condition; such condition can be maintained by biogas digester, which is important part of biogas plant and having 60-70% cost of total plant cost. Biogas and slurry produced from digester are renewable fuel and organic fertilizer; which makes it economical option, by choosing right digester it can be more economical, therefore The objective of this paper is to discuss the performance of various types of digester and a comparisonbetween different digester. This comparison gives idea of which digester is better option for community Biogas Plant. Also it can empower communities by providing them with tools they can maintain and use themselves.

Index Terms - Bio-degradable Waste, Anaerobic Digestion Process and Parameter, Biogas Digester, Field Study

I. INTRODUCTION

Problems of growing energy requirement and increasing cost of fossil fuels has lead us to find and use renewable energy sources and the development of new technological processes of energy production. One of the renewable energy sources is the biogas. Biogas is an environmentally friendly fuel which is part of nature‟s own cycle. When organic materials such as animal, agricultural, domestic, and industrial wastes decompose under anaerobic conditions then biogas produced.

Biogas digesters have low cost and maintenance is easy. This makes them an excellent tool for organizations which attempt to empower communities by providing them with tools they can maintain and use themselves [1].

II. LITERATURE REVIEW

The discovery of biogas can be first traced back to the 17th century when Van Helmot noticed flickering lights under the surface of swamps and connected it to a flammable gas produced by decaying organic matter [4]. The chemical composition of methane was established by Henry and Davy Dalton in 1810 via methane from coal mines. By 1884, a student of Pasteur in France, Gayon, had anaerobically produced biogas by suspending cattle manure in a water solution at 35 Celsius. At that time he was able to obtain 100 liters of biogas per meter cubed of manure [4]. The discovery and separation of certain kinds of bacteria involved in the digestion process were begun as early as 1906 by Sohngen. By the 1920‟s Buswell was able to track and record the movement and uses of nutrients such as nitrogen through the digestion process [4].

III. ANAEROBIC DIGESTION PROCESSES

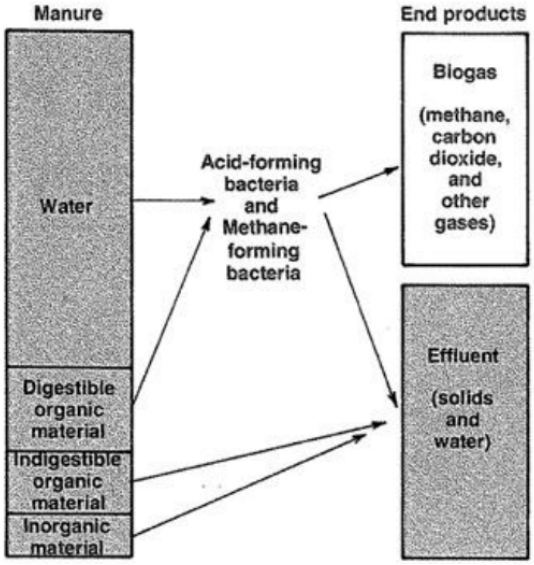

Fig. 1. The breakdown of manure in an anaerobic digester

A. Hydrolysis

Hydrolysis is the first step of Anaerobic Digester, in which polymers like carbohydrates, lipids, nucleic acids and proteins are converted into glucose, glycerol, and pyridines. Micro-organisms excrete hydrolytic enzymes, converting bio-polymers into simpler and soluble compounds. Different micro-organisms are involved in hydrolysis, which decompose the undissolved particulate material. The products resulted from hydrolysis are further decomposed by the micro-organisms involved and used for their own metabolic processes [1].

B. Acidogenesis

During Acidogenesis, simple and soluble polymers are converted by acidogenic (fermentative) bacteria into methanogenic substrates. Simple sugars, amino acids and fatty acids are converted into acetate, carbon dioxide and hydrogen (70%) as well as into volatile fatty acids (VFA) and alcohols (30%) [1].

C. Acetogenesis

Simple and soluble compound, which cannot be directly converted to methane by methanogenic bacteria, are converted into methanogenic substrates during Acetogenesis. VFA and alcohols are oxidized intomethanogenic substrates like acetate, hydrogen and carbon dioxide [1].

D. Methanogenesis

Methanogenesis is an important step in the entire anaerobic digestion process, as actual biogas production takes place in it. It is the slowest bio-chemical reaction of the process. Methanogenesis is severely affected by operation conditions. Composition of feedstock, feeding rate, temperature, pH, Digester overloading, temperature changes and large entry of oxygen can result in termination of methane production [1].

IV. ANAEROBIC DIGESTION PARAMETER

The effectiveness of AD is affected by some basic parameters, thus it is important that favorable conditions for anaerobic micro-organisms are provided. The development and activity of anaerobic micro-organisms is significantly affected by conditions such as exclusion of oxygen, temperature fluctuation, pH-value, nutrient supply, agitation intensity as well as presence of amount of inhibitors (e.g. ammonia). The methane bacteria are anaerobic in nature, so that the presence of oxygen into the digestion process must be strictly avoided [1].

A. Temperature

The AD process can work at different temperatures, there are three temperature ranges: psychrophilic (below 250C), mesophilic (25oC – 45oC), and thermophilic (45oC – 70oC) [1].
In thermophilic range biogas production per unit weight is maximum. Ammonia toxicity rises with rising temperature and can be relieved by decreasing the process temperature, but temperature should not decrease to 50°C or below, if it does then growth rate of the thermophilic micro-organisms will drop [1].

B. Volatile Fatty Acid (VFA)

The VFA are intermediate compounds which produced during acidogenesis, with a carbon chain of up to six atoms. Acetate, propionate, butyrate, lactate are present inside digester. Accumulation of VFA occurs due to instability in AD process, which can lead to a drop of pHvalue. However, the accumulation of VFA will not always lead to drop of pH value, due to the buffer capacity of the digester [1]. Biogas production is directly proportional to amount of VFA inside digester.

C. pH value

In acidogenesis and Methanogenesis stages optimal pH values are different. In acidogenesis, pH falls because acetic, lactic and propionic acids are formed. Acidic environment as pH below 6.4 is toxic for methane-forming bacteria. An optimal pH range for all stages is between 6.4 and 7.2 [1].

D. Carbon to Nitrogen Ratio (C:N)

C: N ratio represents how much amount of carbon and nitrogen present in organic material and relationship between them. If C: N ratio is high then rapid consumption of nitrogen takes place by the Methanogenesis and results in a lower gas production. On the other hand, if C: N ratio is lower than ammonia is accumulated and pH values exceed 8.5, which is toxic to methanogenic bacteria. Optimum C: N ratios in anaerobic digesters are between 20 and 30, which can be achieved by mixing waste of low and high C: N ratio [1].

V. BIOGAS DIGESTER

In a biogas digester, anaerobic digestion of biodegradable waste take place and biogas is produced, and then gas is stored in storage container. The biogas can be used as fuel for cooking, process heating, and electricity generation. The slurry which comes out from biogas digester after the fermentation process is complete can be used as fertilizer in farm; it helps to reduce use of chemical fertilizer [1].
There are many digester design present today, so we will consider digester with basic design.

A. Floating Drum Biogas Digester (KVIC Model)

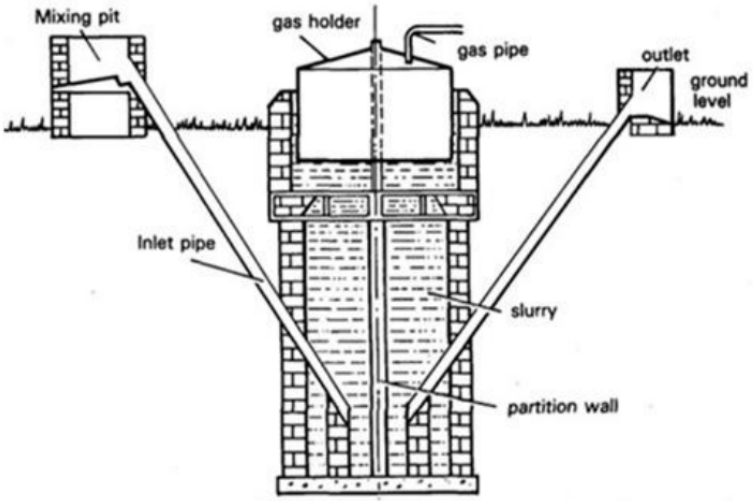

Fig. 2. Floating Drum Biogas Digester (KVIC Model) [7]

In figure 2 we can see that partition wall help to optimize gas production from two stages. In the first stage, acid forming bacteria cut down complex, organic polymers present in bio-degradable waste in to small chain of volatile fatty acid. In second stage, methane forming bacteria digest volatile fatty acid and generate methane and carbon dioxide [7].

The floating drum in which gas is stored is made up of mild steel sheets or reinforced fiber glass can be used to save some cost. When gas is not in floating drum then it sinks in due to its own weight and when gas is generated then drum rises and floats freely on the surface of slurry [7].

In water-jacket plants drum floats on water jacket outside digester instead of slurry. They are easy to maintain and drum never get stuck in a scum layer. Waterjacket plants has long useful life and aesthetic appearance. They are recommended for use in the fermentation of night soil.

B. Fixed Dome Biogas Digester (Janata Model)

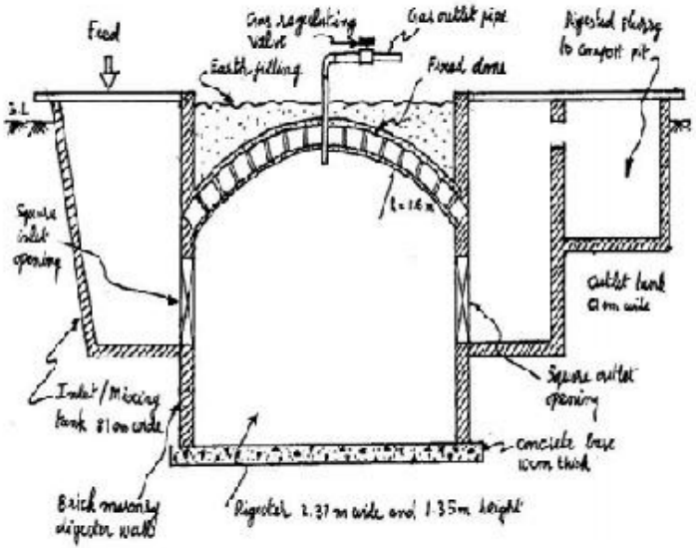

Fig. 3. Fixed Dome Biogas Digester (Janata Model)[13].

Design of this plant is very simple so local mason can construct it. While constructing locally available good quality material like bricks and cement should be used otherwise due to pressure fluctuation cracking may occur in dome and it will lead to leakage of biogas.

In this model higher total solid waste can be used when compared with KVIC model. This plant life is longer than KVIC models if plant is built with good quality material. In this plant MSW (municipal solid waste) and plant residues can also be used. The plant design has well sort of digester build by bricks and cement. It has dome shaped roof which remains below the ground level [13].

At two sides of digester, there are rectangular openings confronting each other and coming up to somewhat over the ground level, they work as inlet and outlet of the plant. For gas outlet pipe with valve is given on dome top. The biogas is gathered in the limited space of the altered dome; henceforth the weight of gas is much higher, which is around 90 cm of water section [13].

C. Fixed Dome Biogas Digester (Deenbandhu Model)

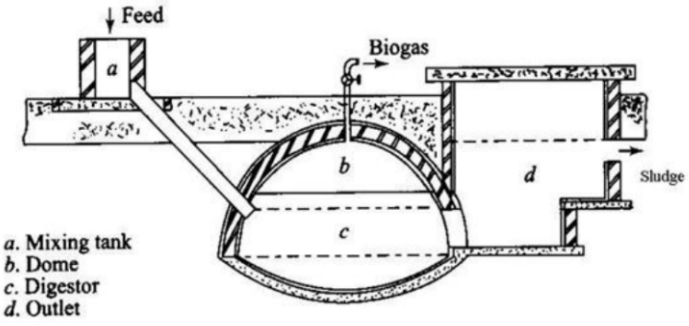

Fig. 4. Fixed Dome Biogas Digester (Deenbandhu Model)[AFPRO].

Deenbandhu model was created in 1984, by Action for Food Production (AFPRO), a deliberate association situated in New Delhi. Whole biogas program get success in India as it reduce the expense of the plant by half of that of KVIC model and therefore poor farmers can get benefited. By joining the fragments of two circles of various diameters across their bases, they minimizing the surface area and therefore cost also decreases [AFPRO].

The Deenbandhu biogas plant has a hemispherical dome sort of gas holder, not like the floating drum of the KVIC model. The dome is produced using premanufactured fortified concrete and appended to the digester, which has a bended base. The slurry is allowed to flow from a blending tank through a channel funnel associated with the digester. After maturation, the biogas gathers in the space under the dome. It is taken out for use through a channel associated with the highest point of the dome, digested slurry, turns out through an opening in the side of the digester. Around 90 percent of the biogas plants in India are of the Deenbandhu type. The expense of a Deenbandhu plant having a limit 2 m3/day is about Rs.8000 [AFPRO].

D. Plug Flow Digester

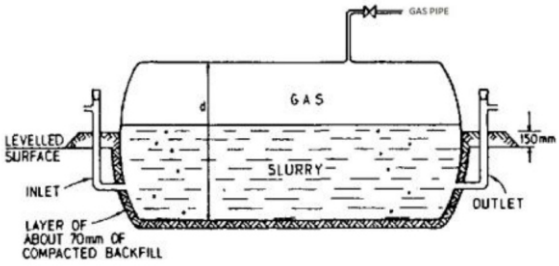

Fig. 5. Plug Flow Digester [7].

Design of Plug flow digesters is horizontal so it has ability to treat animal manure with 11-14% Total Solids. In this design Length to width ratio for flow path for manure should be in the range of 3.5:1 to 5:1 [6].

Plug flow digesters are built either above or under the ground, or half part is above ground and rest is below ground. Above ground digesters made up of steel structures to withstand the pressure. Underground digester is made up of bricks and cement so; it is cheaper to build the digester underground. Above ground digesters are easy to Maintain; a black coating on digester will help provide some heating effect by solar radiation [7].

Mechanical stirrer is usually used in continuously Stirred Tank Reactor (CSTR); as the capacity of the plug flow digester increases it required proper agitation and mixing of feedstock inside the digester; also it helps to increase production rate of Biogas. It increases the operating cost and maintenance cost, but it is balance by increased Biogas production rate.

E. BARC's a Nisargruna plant

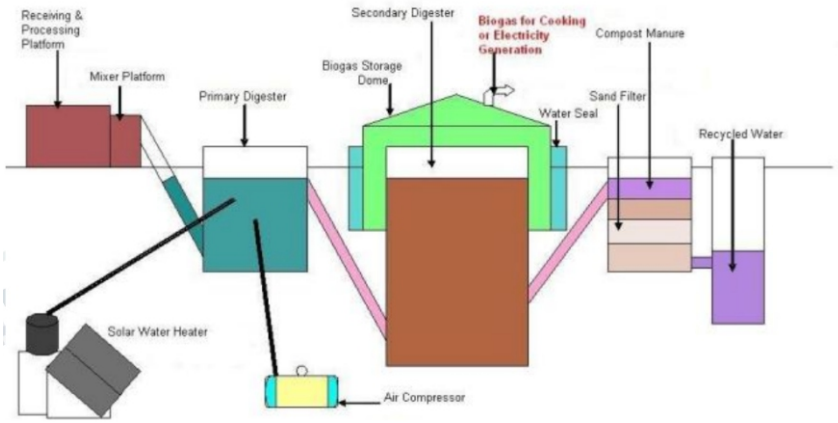

Fig. 6. Basic layout of Nisargrun Biogas Plant [22]

Senior scientist Dr. Sharad Kale at Nuclear Agriculture and Biotechnology Division of Bhabha Atomic Research Centre (BARC) in Mumbai; have developed Nisargruna biogas plant for renewable energy.

Technical details of the plant

A crusher with 5 HP motor(s) for crushing if we are using canteen waste or municipal solid waste, mixing tank, a primary digester tank, an air compressor, a flat plate collector, a secondary digestion tank, a gas delivery system, manure pits, a tank for recycling water, a water pump, slurry pump and a gas utilization system these are major components of BARC‟s a Nisargruna plant. The waste is thoroughly mixed in a mixer using water. (Dr.S Kale, 2005) [23].

Pre-treatment Stage

This slurry enters the primary digester tank and high temperature water is introduce through flat plate collector where aerobic thermophilic bacteria proliferate and convert part of this waste into organic acids like acetic acid, butyric acid, propionic acid and formic acid; they also breakdown some toxic products that may be present in the waste. An aerobic condition is maintained by air compressor

[23].

Anaerobic Digestion Stage

In the second stage strictly anaerobic condition is maintained, where methane forming bacteria produced biogas by digesting organic acids which produced in first stage. The two stage digestion improves the percentage of methane in biogas, up to 90%, thereby increasing its fuel quality when burned. However, this purity is dependent on how effectively the primary digester temperatures are maintained and the quality of the waste that enters thesystem [23].

Table I. Comparative Performance of Various Digesters

SR. NO.	Digesters	Cost Rs.*	Biogas production (lit/kg)	Design	Capacity (m3/day)	Retention Time
1	Floating Drum Biogas Digester	14000	34 [10]	Moderate	1-100 [15]	35-50 days [14]
2	Fixed Dome Digester (Janata Model)	10000-11000	28 [13]	Simple	1-100 [13]	35-45 days [14]
3	Fixed Dome Digester (Deenbandhu Model)	8000	25 [14]	Simple	1-10 [13]	35-45 days [14]
4	Plug Flow Digester	10000 [13]	33.5 [13]	Simple	2-80 [16]	20-25 days [11]
5	BARC's Nisargruna plant	NA	50-60 [22]	Moderate	5-250 [22]	21 days [22]

VI. FIELD STUDY

A. Bio-methanation Plant in Pune

Decentralized Bio-methanation-Cum power Generation Plant of Capacity is 1*5 TPD is situated at Ward No. 34, Pune, to Treat Segregated Organic Municipal Solid Waste (MSW). The basic reason of setting up this plant is to treat the wet organic wastes in a decentralized manner at source point itself in a most environmental friendly manner. This helps Pune Municipal Corporation (PMC) directly in saving on transportation of such wastes to the landfill site which is at 22 Kms [17].

A case study has been carried out at Bio-Methanation Plant, at Model Colony Pune with an objective to estimate Capacity of plant and observation and understanding of different processes done on bio-degradable waste in the plant; also what is biogas scrubbing process. During the observation, various analytical data, has been accumulated from the data collection center of the site.

Bio-methanation Process

The major portion of MSW is the organic waste (40-60%) which can be easily treated by anaerobic digestion in digester.

Apart from this, the solid wastes generated in urban areas from vegetable markets, hotels, hostels, kitchen wastes etc. are best option for this process due to the presence of high moisture and organic fractions (up to 90%).

The total solids in the organic waste decompose rapidly (i.e. is highly putrescible) and therefore these wastes can be treated by Bio-methanation process (more commonly called Anaerobic Digestion, AD) in more effective manner [17].

Data Collected

The Pune Plant involves the following data which includes its process components to its product

generation

Process Components:

Table II. Components of Decentralized Bio Methanation Plant [17]

Sr. No.	Component Name	Quantity	Materials involved with Specification
1	Waste Reception and Fine Segregation Section	1	-
2	Mechanical Crushers	2	5 HP Motor
3	Two Stage Anaerobic Reactors	200 Cum	With Aeration, Biogas & Leachate Recirculation facility
4	Manure Handling Section	35 m^2	In BBM
5	Biogas Collection Section	2 Nos. 75 Cum. Each	Neoprene Rubber with enclosure
6	Biogas Cleaning System	1	CO_2 & H_2S Scrubbers, Pressure Vessel & Vacuum Pump.
7	Power Generator	40 kVA	100% Biogas based Indian Engine
8	Leachate Recirculation System	1	-
9	Solar Water Heating System	500litres/day	-

Expected Biogas, Electricity and Manure Generation:Table III. Product generation at Bio Methanation Plant [17]

1	Plant capacity	1*5 TPD per day segregated organic biodegradable municipal solid waste
2	Type of process	Bio-methanation through two stage process
3	Biogas generation	300 Cum/day
4	Electricity generation	375kWh/day
5	Manure generation	500kg/day(50% moisture basis)

B. Community biogas plant by "SUMUL" in Gujrat

This plant was constructed by Surat District Co operative Milk Producer,,s Union Ltd, abbreviated as "SUMUL" with the support and co-operation of local villagers. The plant produces biogas which is distributed to the villagers through underground pipes. The gas supplied is used as a fuel for cooking by the villagers. The production of vermicompost from the output slurry makes this project economically viable. The Ministry of New & Renewable Energy took a note of this project and formulated a scheme which is known as BFFP (Biogas & fertilizer plant) [15].

Birth of the idea

Idea of the biogas plant was triggered in order to have a proper disposal system for the cow dung. Before the establishment of biogas plant, the dung would be collected in households, streets, empty spaces and left there itself till it was sold to some external contractor. The contractor would collect the dung once in a year which resulted in dung being piled up in large quantities. This was an unhygienic practice and raised health concerns. The health hazard was further emphasized by subsequent outbreak ofbird flu in Navapur. Thus, these public health and sanitation issues were the main contributing factors for the construction and smooth functioning of the plant [15].

Biogas production

Every morning around 6:00 am villagers bring the dung collected during the previous day to the plant.

Normally, this is carried in overhead containers (ghamelas) by men or women. In case the beneficiary‟s stall is far from the plant, he has the option to deliver the cow dung to the plant on a weekly basis. Gas is generated through Floating Drum Bio-Digester having a capacity of 85 m3.
The gas is supplied to the beneficiaries daily twice-once at 6 am and next at 6 pm. The gas generated daily is sufficient enough to give a continuous supply to all the beneficiaries for 2- 2.5 hours each in the morning and the evening. The plant supervisor and 4 workers oversee the plant operations [15].

Expected Biogas and Manure Generation:

Table IV: Product generation at community biogas plants by SUMUL [15].

1	Plant capacity	Two Digester total capacity of 4.5 Ton per day Cow Dung
2	Type of process	Single stage Floating Drum Bio-Digester
3	Biogas generation	2*85 m^3 /day
4	Manure generation	2.5 Ton of slurry per day
5	vermicompost	0.66-1.166 Ton per day

VII. SUMMARY

As we have discussed and compare different digester for biogas generation in rural Indian context, so selecting right digester is important, with the help of some basic criteria we can choose appropriate digester for our system.

Some basic criteria given below:-

Nisargruna Plant has higher efficiency because of two stages; it helps to optimize methane producing condition. Every day operation is easy, no skilled labor required because there is no any complex mechanism involved.
Higher biogas production is obtained as it is working in Thermophilic range. Hot water coming from Flat Plate Collector is mixed with Bio-degradable waste and feed to primary digester. Life of this plant is at least 15 year if proper care is taken of the plant.
Manufacturing cost of Nisargruna plant is not least among discussed bio-digesters, because of two stages its cost higher than single stage digester, but its cost is balance by higher biogas production, 1-5 Ton/day would cost 17-20 lacs per Ton. From this BARC‟s Nisargrun BiogasDigester is most appropriate for community biogas plant.

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