Calcium Carbide

Detailed Project Report

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INTRODUCTION

Cacium carbide, CaC_2 when pure, is transparent and colourless, with a specific gravity of 2.22 at 180^oC. It may be prepared in the laboratory by the thermal decomposition under vacuum of pure calcium cyanamide in the presence of carbon to produce absolutely white calcium carbide. Pure CaC_2 is variety, and the general properties of calcium carbide have been determined by extrapolation from values obtained on high - purity commercial carbide.

Commercial calcium carbide varies in colour from Steel-grey to reddish brown, depending on impurities and the method of manufacture. It is made from lime and coke in the electric furnace at temperature of 2200 - 2500^oC, using large amount of electric power.

Industrial calcium carbide is about 80% pure remaining is calcium oxide and 2-5% other impurities. Its outstanding property is that of reacting with water to produce acetylene gas.

Commercial calcium carbide is the main source of acetylene, and acetylene is used principally in the synthesis of a series of organic chemicals, resins, and plastics and in oxyacetylene welding and cutting of metals. Large amounts of carbide are also made for the production of calcium cyanamide by the fixation of atmospheric nitrogen. The cyanamide is, in turn, used as a fertilizer and as the basis for a series of chemicals and resins. Smaller amounts of calcium carbide are used as a dehydrating agent and as a reducing and desulfurizing agent in metallurgical processes.

Calcium carbide was made in the laboratory by early workers such as Hare and Wohler. It also was formed as a side reaction product in various industrial processes, but it was not isolated or recognized.

PROPERTIES OF CALCIUM CARBIDE

Crystallography

Commercial calcium carbide occurs in four different crystalline modifications- cube, tetragonal, and two of a lower order of symmetry. The cubic form designated CaC_2 'IV' is stable at 447^{o}C, the tetragonal form, CaC_2'I' is stable between 447^{o}C and 25^{o}C, and the form CaC_2'II' below 25^{o}C, the form CaC_2'III' is known only as a metastable phase. The tetragonal form CaC_2'I' is the one most common in commercial carbide.

Melting Point

The most extensive data on technical carbide are those of all who use more than eighty sample in which the calcium carbide content ranges from 4 to 94%. By extrapolation of the two ends of the curve, the melting points of calcium carbide and calcium oxide were indicated to be about 2300 to 2500^{o}C.

Composition

Microscopic examinations of different samples of the system by all showed clearly the two components CaC_2 and CaO in the form of black crystals in a lighter background of the two autectics. Thus phyical chemical and optical methods of examination have indicated the presence of the compound CaC_2, CaO.This compound is unsuitable and easily decomposed at temperature approaching the melting point of the compound. Its heat of formation from CaO and CaC_2 as determined form its heat of solution in dilute hydrochloric acid in 37.4 Kcal gm-mole (exothermic).

Specific Gravity

Determination of the specific gravity diagram by the pyonometer method, on this series of compounds by all confirm the existence of the compound CaC_2, CaO at about 52% calcium carbide with a specific gravity of 2.54. By extrapolation of the specific volume curve, the sp. gravity of CaC_2 was indicated to be 2.155 within an accuracy of 0.8%. The sp. gravity of commercial calcium carbide thus depends upon its CaC_2 content, and for the 80% commercial carbide the specific gravity of the solid at 15^{o}C is 2.28-2.32, and for the liquid at 2000^{o}C, it is 1.85.

Electrical Conductivity

The electrical conductivity of the system CaO-CaC_2 was determined by AsII at 20^{o}C, and the resulting curve indicates a falling conductivity form calcium carbide. to that of lime, the two minim with abscissas at 75 and 38% CaC_2 correspond to the two eutectics formed by CaC_2 CaO with CaC_2 and with CaO whereas the maximum occurs at about the composition of the compound CaC_2Cao. The electrical conductivity of this compound is indicated to be about 0.30^{-}Cm^{-1}. As also showed that the conductivity of carbide increases with the temperature and that this increase is linear.

Hardness

The hardness curve for the CaC_2-CaCo system was determined by the monotron method, in which the load required to press a diamond indenter a standard depth into the specimen in a measure a generally rising hardness from that of calcium carbide to that of lime, with smooth maxima at 70 and 36% CaC_2 (corresponding to the eutectics) and a minimum at about 50% CaC_2. This composition again indicated the presence of the compound CaC_2Cao which had a hardness of 12.5 kg and hardness for CaC_2 of 5.5 kgs was indicated by extrapolation of the curve. Commercial 80% carbide has hardness by 30-80 Bhn.

Thermal Properties

The theoretical heat of formation of calcium carbide based on the heats of reaction of CaO, Co, and CaC_2 has been calculated as 111.3 kcal/gm-mole for 100% CaC_2 the latent heat of fusion is reported as 120 cal/gm and the average specific heat between 0 and 2000^oC as 0.28 cal/gm. For other grades of carbide this data must be corrected with regard to the lime and impurities content. At 25^oC, the heat content is given as H_{298} = - 14,500 $\pm$ 1200 gal/g-mole.

Reaction with Water

This is one of the most important the chemical reactions of calcium carbide, it is highly reactions of exothermic and is the source of most of the acetylene used in the industry. The reaction equation is given below: -

$$CaC_2 + 2H_2O \longrightarrow C_2H_2 + Ca(OH)_2 + 29.2\ Kcal$$

with a deficiency of water or in the presence of partially slacked carbide, the following reaction occurs.

$$CaC_2 + (CA(OH)_2 \longrightarrow C_2H_2 + 2CaO.$$

The reaction proceeds slowly at ambient temperature but at about 100 - 120^oC it is stoichiometrically complete in 3-4 days. At still higher temperatures (above about 150^oC) the generated acetylene partially decomposes to form acetylene polymers which coat the carbide particles an slow or stop the reactions.

Reaction with Nitrogen

Another important reactions of calcium carbide is that with nitrogen which produces cyanamide according to the following equation: -

$$CaC_2 + N_2 \longrightarrow CaCN_2 + C + 70.7\ kcal$$

The product which contains about 10% carbon plus the impurities originally present in the carbide, is a grey black sintered mass known as industrial cyanamide. The reaction is carried out at 1000- 1200^oF by passing nitrogen through more or less finely crushed carbide heated electrically to initiate the reactions as the reaction in strongly exothermic it proceeds b itself after the initial reaction.

USES AND APPLICATIONS

The chief applications of calcium carbide are in the manufacture of calcium cyanamide, acetylene required in oxyacetylene welding, synthesis of solvents and organic compounds required in the pharmaceutical and dyestuff industries and manufacture of synthetic rubber and plastics. It is also used in signal fires. Sodium cyanide used for the recovery of gold in the ore-treatment process is manufactured from calcium carbide.

As a dehydrating agent, calcium is employed in electrostatic work and in the food and solvent industries. It finds application in the steel hardening, in the manufacture of graphite and hydrogen, and in the reduction of copper sulphide and metallic oxide.

The carbide goes directly from the crushing and screening plant, and then, after purification, to the synthesis of organic chemicals such as acetaldehyde, acetic acid, acetic anhydride vinyl acetate, polyvinyl compounds, butanol, and chlorinated derivatives.

Another important use of calcium carbide is in the production of cyanamide, where it serves as a nitrogen fixative. Cyanamide, $CaCN_2$ is used as a fertilizer and as a raw material for the production of a series of nitrogenous compounds of which dicyanamide, guaniddine, and melamine are the most important. Carbide is used in metallurgy as a disulfurizing and deoxidizing agent as a modulizing agent in the production of domulr graphite in iron, and as a finishing slag component in ferrous and non-ferrous refining.

It is also used in certain industrial process as a reducing and dehydrating agent.

B.I.S. SPECIFICATION

IS: 1040 - 1978 - Calcium Carbide Technical.

This standard prescribes the requirements and the methods of test for calcium carbide. Technical in graded sizes. The material at present is used for the production of acetylene gas for illumination, welding, and cutting of steel.

According to this standard, the material shall be graded so that the size of pieces graded are within one of the following limits.

mm	mm
1 - 2	15 - 25
2 - 4	25 - 50
4 - 7	50 - 80
7 - 15	80 - 120

When tested according to the method prescribed in Appendix, all the pieces ranging in original and previously unbroken and unopened factory packages, in each and the quantity of dust shall comply with requirement of the following table.

TABLE

Screen analysis of various grades of calcium carbide technical:

Sl. No.	Characteristic	Requirement	Method of test (ref.) to clause No. in mapp. B
1.	Passing through a sieve having round holes of a size equal to larger dimension, per cent by weight min,	100	B – 2.1
2.	Retained on the sieve having round holes of the smaller dimension % by weight min.	86	B - 2.1
3.	Dust per cent by wt. max.	5	B - 2.3

When tested according to the method prescribed in Appendix 'C' the material shall yield the volume of gas (measured day or corrected to dry basis) calculated at 27^{o} and 760 mm pressure appropriate to its quality as specific in the following table.

Material within the tolerance of minus 5 per cent shall be deemed to comply with the requirement of gas yield given in the following table.

TABLE

GAS YIELD OF CALCIUM CARBIDE

Sl. No.	Grade Size	Quantity A.	GAS YIELD Litre per kg. Quantity B.	Cu. ff per lb. Quantity A.	Quantity B
1.	15 – 120	311	288	4.98	4.60
2.	7 – 15	301	275	4.81	4.42
3.	4 – 7	287	267	4.59	4.28
4.	2 – 4	273	251	4.36	4.01
5.	1 – 2	257	236	4.25	3.77

Acetylene gas obtained from the material shall also comply with the requirements in the following tables, when tested according to the methods prescribed in Appendices D and E.

TABLE

Sl. No.	Characteristics	Requirements for	
		Quality A	Quality B.
1.	Acetylene % by vol. min	99.0	99.0
2.	Sulphur compounds as (H_2S) % by Vol. Max.	0.15	0.15
3.	Phosphorous compounds as (PH_3) % by vol. Max	0.06	0.08
4.	Arsenic compounds as (A_3H_3)% by vol. max.	0.001	0.0001
5.	Nitrogen compounds as (NH_3)% by vol. max	0.10	0.10

PACKING AND MARKING

1. Subject to the regulations made from time to time by the authorities governing the transport, storage and use of calcium carbide, the material shall be packed in moisture proof, suitable steel containers as agreed between the purchaser and the manufacturer.

2. Each container shall be securely sealed and marked with the manufacturers name weight and grade size of the material in the package, registered trademark if any, and the month and year of manufacture of the material.

3. Each container shall contain only one size grade, the size limits of which shall be clearly marked on the outside of the package.

4. The container shall also be clearly marked with the wording calcium carbide dangerous if not kept dry.

5. The packages may also be marked with Indian Standard Certification mark.

INTERNATIONAL STANDARDS

Standard sizes of calcium carbide in the U.S. specifications are given in Table below, together with the yield of acetylene at $60^{O}F$ and 30 inch barometric pressure.

TABLE - 1

Name and size of U.S. Specification Carbide

Name	Screen size (Square to pass opening)	Screen size in (Square opening retained)	Min. Average C_2H_2 evolved at $60^{0}F$ and 760 in Ft/lb.
Lump	4.20	1.50	4.5
Engg.	2.00	0.375	4.5
Nut	1.06	0.250	4.5
1/2 x 1/4 (Mineral)	0.500	0.250	4.5
1/2 x 1/12	0.265	0.066	4.5
Rice	0.132	0.033	4.3
14 ND	0.066	0.0165	4.3

The U.S. Specification state that the acetylene evolved shall contain not more than 0.05% by volume phosphine, where as the British specify a maximum of 0.06% phosphine, 0.15% hydrogen sulphide, and 0.001% origin by volume.

The U.S. specification states that unless otherwise specified, calcium carbide for domestic shipment shall be packed in industrial with mouth, screw cover, 100 lbs., 26 gauge metal drums. The drums must be marked calcium carbide “Dangerous” if not “Keep dry”. In the carbide trade, contracts are usually based on size specification and gas yield specification, with penalties for carbide, which fails to meet specified gas yields. In general gas yields range from 4.60 to 4.80 ft^3lb., depending on the screw size of the carbide.

Methods of testing are specified in the U.S. specifications and the British specification. The most important test is the gas - yield test. Standard sampling, sample preparation procedure, slaking the prepared sample in specified equipment and collecting and measuring the volume of evolved acetylene. This volume is calculated to standard conditions. The phosphorus, sulphur and arsenic content of the calcium carbide is checked by determining the phosphine, by hydrogen sulphide and arsine content of the evolved acetylene according to the same U.S. Federal or British standard specified procedures.

Phosphine may be determined by absorption in iodine solution followed by precipitation of the phosphomolybdate complex. Sulphur and arsenic are determined by absorption in sodium hypochlorite solution followed by precipitation of barium sulphate in the case of sulphur and by acidification of the solution and volatilization by arsine by Gutzeit procedure in the case of arsenic.

HEALTH AND SAFETY FACTORS

There are no undue health or safety factors involved in the manufacture of calcium carbide. The usual precautions must be observed around the high-tension electrical equipment, which supplies power to the furnace. The carbon monoxide formed in the carbide reaction, if collected in closed furnaces, is usually handled through blowers, scrubbers, and then to a pipe transmission system. This gas is highly poisonous and explosive, therefore the handling equipment must be maintained in airtight condition and periodic checks of the atmosphere around the equipment and furnace must be made. As calcium carbide exposed to water readily generates acetylene, the numerous cooling sections required in the high temperature furnace equipment require constant maintenance to prevent and detect leaks which might generate sufficient acetylene to cause an explosion. When acetylene is generated proper precautions must be taken to prevent admixture with air due to the explosibility of this mixture over wide range of acetylene concentrations (from 2.5 to 83%) by volume and the flammability of 82-100% mixtures under certain conditions. In the presence of small amount of water, carbide may become incandescent and ignite and evolved acetyulene air mixture. To prevent sparks on opening carbide drums or when working in the neighbourhood of acetylene generating equipment, non- sparking too should be used.

Superficially slaked carbide may provide enough slaked lime to react with the carbide to give acetylene and calcium oxide, this reaction is probably responsible for the acetylene odour which may be noticed when drums of carbide are opened.

MARKET SURVEY

Calcium Carbide is a basic inorganic chemical. It is used in production of Acetylene Gas and PVC Resins and is the starting raw material in the manufacture of many organic chemicals like perchlortrichlorethylene, acetylene black etc. Apart from these three important uses, Calcium Carbide is purchased by garages and service stations to produce acetylene gas. Ordinary acetylene gas from calcium carbide is used in welding of steel and also for the purposes of lighting burners and lamps in villages.

The main raw materials required for the manufacture of the product are limestone containing at least 98 per cent of calcium carbide, charcoal and petroleum coke.

Calcium carbide is produced in large-scale sector only. At present, there are 3 units in India manufacturing calcium carbide with total capacity of 1,18,000 tonnes, The production was 98,826 tonnes in 2002-2003.

The calcium carbide has wide range of industrial as well as miscellaneous applications.

TABLE

NUMBER OF UNITS, INSTALLED CAPACITY, PRODUCTION & CAPACITY UTILISATION

YEARS	NO. OF UNITS	INSTALLED CAPACITY	PRODUCTION
1	2	3	4
1999-00	10	1,32,000	81,200
2000-01	10	1,32,000	84,700
2001-02	10	1,32,000	86,500
2002-03	10	1,32,000	92,100

TABLE ESTIMATED DEMAND

SL. NO.	END USE INDUSTRY	DEMAND	
		2003 - 2004	2000 - 2001
1.	Dissolved Acetylene Gas	69,236	74,775
2.	PVC Resins	59,900	59,900
3.	Miscellaneous uses	32,284	44,892
TOTAL		**1,61, 420**	**1,79,567**

PRESENT MANUFACTURERS

1. **M/s. Calcium Carbide & Gases Ltd.**
   Birla Building
   9/1, R.N. Mukherjee Road
   Kolkata - 700001
   Phone: (033) - 2201680, 2202380, 2204370
   Fax: (033) - 2482872, 2487988, 2489110
   E-mail: bjilbs@giascl01.vsnl.net.in

   Regd. Office:
   Uco Bank building
   4th Floor, Parliament Street
   Delhi - 1
   Phone: 3714851, 2, 3, 4, 5, 3716221

2. **M/s. DCM Shriram Consolidated Ltd.**
   5th Floor, Kanchenjunga
   18 Barakhamba Road
   New Delhi - 110001
   Phone: 011 - 3316801-8
   Fax: 011-3318072.
   E-mail: dscl@dscl.com
   Website: http://www.dscl.com

3. **M/s. Kadiravam Chemicals (P) Ltd.**
   Ambasamudram Road
   Munneerpallam
   Tirunelveli - 627356
   Phone: (0462) - 352531

There is a good market for production and to satisfy the demand of different industries a new entrepreneur can well venture in this field by installing project of calcium carbide.

RAW MATERIALS

For commercial production the requirements per ton of Calcium Carbide are :-

Anthracite or coke	0.7 MT
Lime	1.1 MT
Coal pitch, retort Carbon and tar	0.05 MT

Retort Carbon, Coal Tar & Pitch:

Retort carbon is used to reduce the ash content of the electrode paste. It is available from Digboi refineries of Assam Oil Company and in small amounts from Oriental Gas Co., Kolkata and Bombay Gas Co. Mumbai, Coal tar and pitch of the required specifications are available in abundance.

PRINCIPLE OF MANUFACTURE

Calcium carbide is produced when lime and carbon are mixed together in proper proportions and heated to a temperature of 2000^{o}C, the lime is reduced, and the liberated calcium combines with excess of carbon to form calcium carbide.

$$CaO + 3C \longrightarrow CaC_2 + CO - 177{,}800 \text{ Cal.}$$

650 tonnes of carbon and 875 tonnes of lime are required for producing 1000 tonnes of commercial carbide.

The successful manufacture of calcium carbide has been rendered possible by the development of the industrial electrical furnace. Arc-resistance furnaces, in which heating is due partly to the resistance offered by the charge and mostly to sparking across, are employed in carbide manufacture.

PROCESS OF MANUFACTURING

The manufacture of calcium carbide, string from limestone, coal and coke can be divided into two section viz.

Section – 1

Manufacture of lime from lime stone and coal and,

Section – 2

Manufacture of calcium carbide from lime and coke.

Each section here will be discussed in details.

Section – 1

Manufacture of lime consists of the following operation.

BREAKING OF LIMESTONE AND COAL

Limestone, as it comes from the mines, is in varying size, starting from 12-14" lumps to 4-6" size. It is broken into a uniform size range of 4-6" manually.

Coal in the same fashion is broken to a uniform size range of 2 x 4" and is screened to remove the dust coal.

CHARGING OF THE VERTICAL SHAFT KILN

Limestone and coal, after breaking and screen are mixed in the desired proportion so that mix can contain around 80% of limestone and 20% coal. This mix is transferred to the kiln-top by means of vertical hoist and fed continuously to the kiln.

KILN-OPERATION OR CALCINING

The vertical shaft kiln is of cylindrical shape and half-open top circumferentially to feed the raw material into it. The discharge is taken out intermittently from the four holes provided at the bottom of the kiln for this purpose. The calcination takes around 48-72 hrs. by the time the raw material travels from the top to the bottom. The temperature in the calcination zone is around $900^{O}C$. The gases evolved in the combustion preheats the incoming raw-mix and is vented off. The kiln is kept more than 3/4th of its height filled with the limestone coal mix. The level of the furnace is kept horizontal to avoid any over-heating or under-heating of the raw materials.

SORTING OF GOOD QUALITY LIME

The lime, discharged from the bottom of the kiln, is spread over the ground and is sorted out for good burnt lime. The undesired under-burnt limestone and coal are separated out and reefed to the kiln.

STORAGE OF LIME

Lime so obtained of desired quality is stored in water -proof covered space to check it from hydrating the contact of water. From here it is transferred continuously to the carbide kiln site.

SECTION 'B'

The manufacture of calcium carbide from lime and coke consists of the following steps. : -

1.	Weighing and mixing of raw materials.
2.	Charging the mix into the furnace
3.	Furnace operation
4.	Tapping
5.	Crushing and screening
6.	Product packing
7.	Storage

WEIGHING AND MIXING OF THE RAW MATERIALS

The lime and coke are proportioned from stock bins by automatic weighing scales. The charge generally receives sufficient mixing in the weighing and subsequent handling to the mix-bins above the furnace so that no special mixing equipment is necessary. The composition of the mix is usually kept as :-

Anthracite or coke	0.7 MT
Lime	1.1 MT
Coal, Pitchretort carbon and tar	0.5 MT

Per tonne of calcium carbide to be produced. This ratio, however, has to be adjusted according to the purity of the raw materials, the operating characteristics of the furnace and the grade of carbide desired.

FURNACE

Calcium Carbide is made in the electro thermal low shaft furnace. Its main components are the furnace vessel with the tapping device and the devices for the introduction of electric power and raw materials. The furnace vessel is made of welded or riveted iron and reinforced against distortions. The bottom of the vessel is covered with carbon bricks or lined with refractory material.

Most furnaces are operated by three phase - current electric power supplied by three electrodes. These may be arranged in series in which case the furnace vessel is rectangular. They may also be arranged at the corners of an equilateral triangle, in which case the vessel is round or has the form of triangle rounded off at the corners.

All furnace vessels have three tap holes through which the liquid carbide flows into cast iron crucibles.

All the electrodes used in most open-arc furnaces are prefabricated and are made either of dense graphite or of regular graphite. Carbon electrodes seldom are used in melting furnaces and those that are used are being replaced by graphite electrodes because of the latter's higher conductivity, smaller diameter, lower weight and smaller diameter electrode circle for a given size transformer. Regular density electrodes are available in sizes of 178-610 mm diameter. Carbon electrodes are usually rated at electric current or current density of 4.5 - 9 A/cm^2 and graphite electrodes at 15.5 - 46.5A/Cm^2. The electrode diameter normally is selected on the basis of its current carrying capability and its mechanical strength.

The standard three phase furnaces are available in sizes of 200 kg to 500 t and shell diameters of 1-12 m. Furnace transformer ratings are available from 200 to > 150,000 KVA. The electrode arms are raised or lowered to maintain the desired arc characteristics, arc voltage, and arc current. This action takes place within fraction of a second after the error signals are generated; the degree of movement depends upon the strengths of these signals. Each electrode arm is continually moving because its characteristics are changing continually as scrap falls away from or against the electrodes as the electrode erodes, and the atmosphere in the furnace changes. Each electrode arm's electrical conductors are connected through flexible cables to the bars or tubes of the delta closure extensions and onto a multi voltage tap transformer. Furnace transformers of $\leq$7500 KVA also contain a multitap reactor to provide sufficient inductive reactance to offset the negative characteristic of the arc.

FURNACE CHARGING

The level of the charge in the furnace is controlled by adding fresh mix every few minutes to open furnace or continuously to the closed furnace. In the open furnace the fresh charge must be rabbled around the electrodes to replace the charge descending to the reaction zones, for the closed furnace the charge is delivered by feed pipes located above and around the electrodes.

FURNACE OPERATION

At the surface of the charge the coke and lime are heated only by the escaping gases. As the charge descends it becomes progressively hotter and from 10 to 12 inch below the surface it is hot enough to carry on appreciable part of the current from electrode to electrode. About 36-40 inch below the surface the charge reaches the electrode tips, where, at a temperature of 1600-2000^{O}C it is conductive but not hot enough to melt the lime. Below the level of the electrode tips, the mix is still solid and granular. About 10-20 inch below the electrodes tips the temperature is not enough to melt the lime (2200- 2500^{O}C), the coke does not melt but does react with the required liquid lime to form liquid calcium carbide and carbon monoxide. As this liquid carbide travels towards the hearth of the furnace, the calcium carbide liquid becomes richer in its carbide content. The ease with which the furnace gas escapes has an important bearing on the smooth operation of the furnace. An evenly operating furnace is essential for the efficient production of carbide. Smooth operation is indicated by: -

1. Steady electrode penetration of the charge as indicated by the distance of electrode tip above the tap-hole.
2. Regular descent of the mix through the charging chute and,
3. Regular tapping of carbide.
4. Constant coke to lime ratio in the mix.

TAPPING

The carbide from the furnace is tapped from each of the 3 tap holes in turn, usually at 20-40 minutes intervals thereby maintaining on temperature profile and uniform about the electrode.

The liquid carbide tapped from the carbide furnace is collected in cast-iron crucible. In some plants, the blocks are allowed to cool in the crucibles, whereas in others they are removed after 2-4 hours and allowed to cool. In order to avoid losses of acetylene, the blocks are crushed at 400^{O}C

CRUSHING AND SCREENING

The treatment of carbide pigs requires special machinery. For use in acetylene production the clean ingots are broken to lumps first in jaw crusher and later is slow rolls to minimize dust formation. The pieces are screened to 2" size for large acetylene generators, peasize for miners' lamps, and 16-30 mesh size for atmosphere automobile lamps. For the production of sodium cyanide the crushed carbide is passed through a pebble mill to yield a power 80% of which passes through a 40-mesh screen. It is further powdered in a tube mill to milled carbide, 85% of which passes through a 200-mesh screen. The grinding is carried out in an atmosphere of nitrogen to prevent the formation of an explosive mixture.

PACKING

The ground carbide is filled in steel drums of cap. of 100,110,2000 and 220 lbs. of cap. net and small tins containing 1 - 25 lb. of carbide.

STORING

The product is stored in water- proof covered sheds.

PRECAUTION

In normal furnace operation, the calcium forming according to these reactions is converted into carbide in the cooler regions of the furnace by reacting with carbon.

However the partial pressure of calcium rises rapidly above 2000^{o}C, and above 2200^{o}C, the carbide decomposes by violent eruption. As a result, the operation of the furnace is interrupted and considerable damage may be caused.

Furnace operation is effected by dissociation of the carbide.

CaC_2 ----------> Ca + 2C

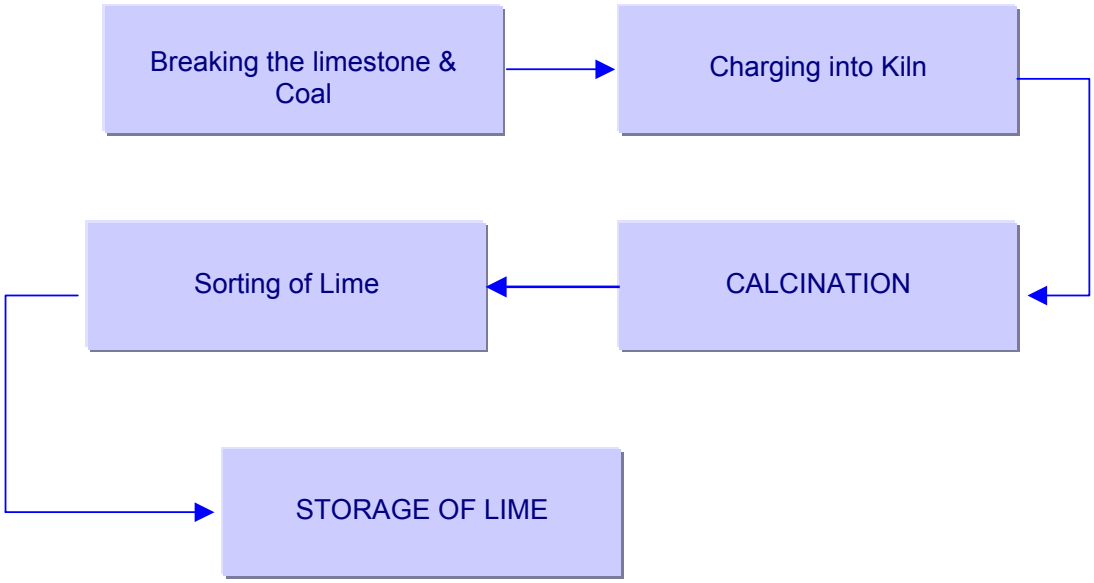
and by the reaction of carbide with excessive CaO.

Cac_2 + 2Cao ---------> 3Ca + 2Co

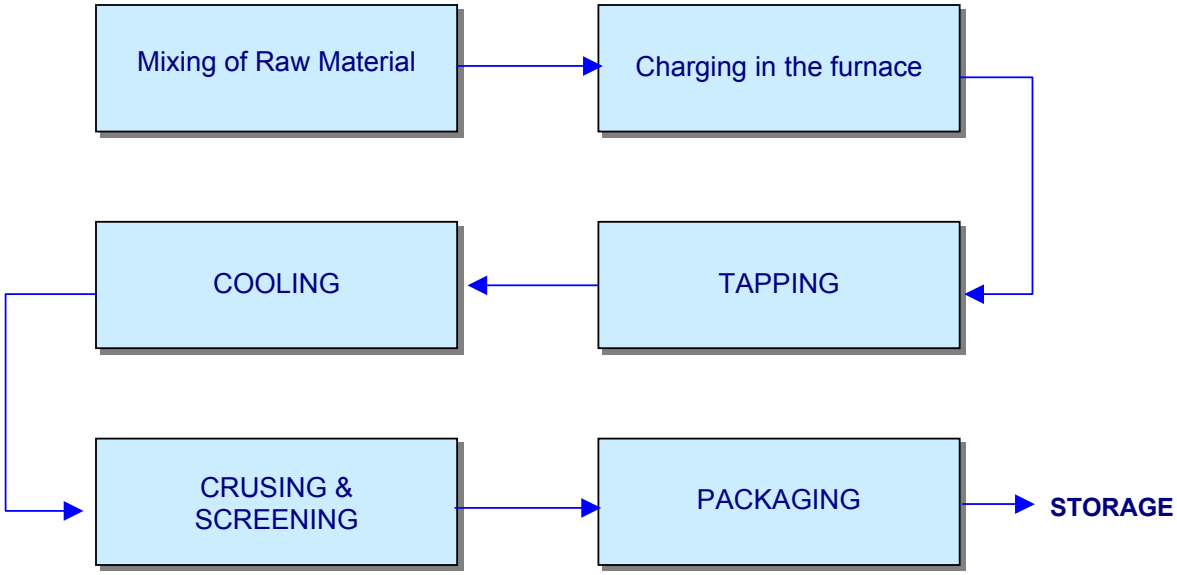
For these reasons, the temperature in the melting zone must not increase excessively. This can be avoided by feeding the raw material in such a way that the carbon concentration remains stable and by ensuring that the components, in particular carbon, react rapidly enough at lower temperatures.

FLOWSHEET OF CaC_2 MANUFACTURING PROCESS

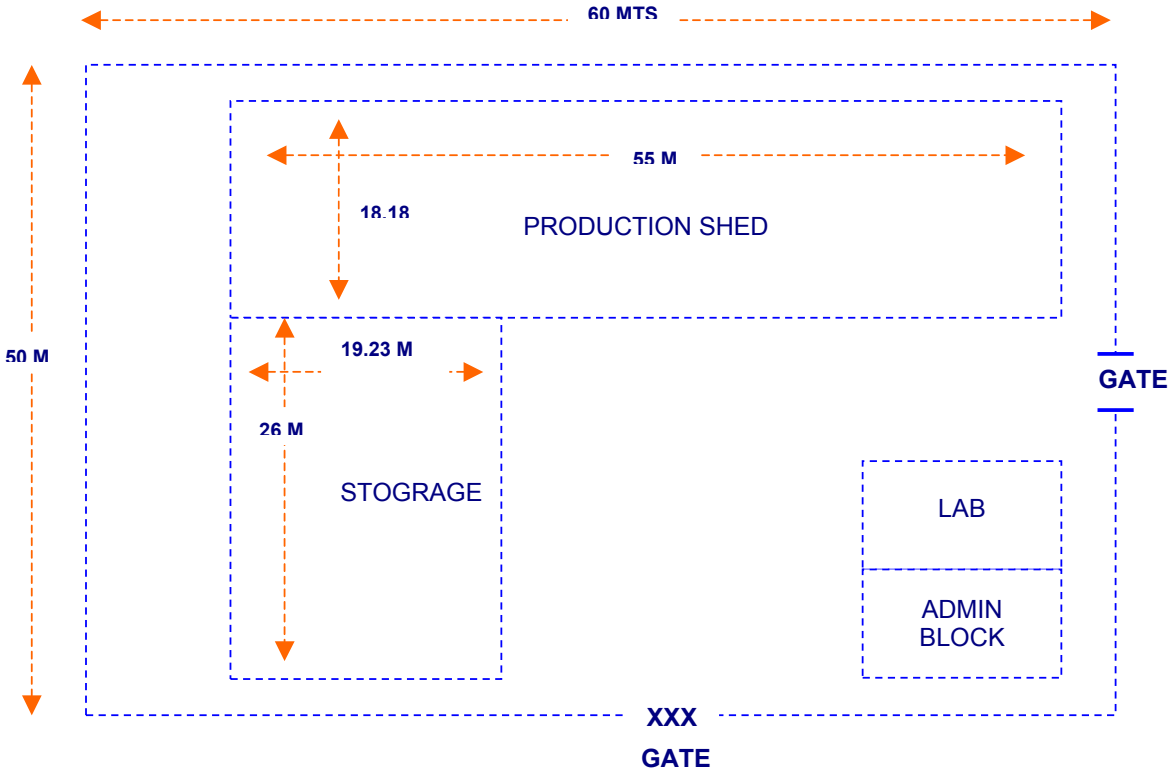
LIME PRODUCTION FROM LIMESTONE



CALCIUM CARBIDE PRODUCTION



PLANT LAYOUT



PLANT LOCATION FACTORS

Factors which generally apply to the economic and operability aspect of plant site location are classified into two major groups. The primary factors listed apply to choice of a region, whereas the specific factors looked at in choosing an exact site location within the region. All factors are important in making a site location selection.

Primary Factors

1. Raw-material supply:

a.	Availability form existing or future suppliers
b.	Use of substitute materials
c.	Distance

2. Markets:

a.	Demand versus distance
b.	Growth or decline
c.	Inventory storage requirements
d.	Competition - present and future.

3. Power and fuel supply:

a.	Availability of electricity and various type of fuel
b.	Future reservers
c.	Costs

4. Water supply:

a.	Quality - temperature, mineral content, bacteriological content
b.	Quantity
c.	Dependability - may involve reservoir construction
d.	Costs

5. Climate:

a.	Investment required for construction
b.	Humidity and temperature conditions
c.	Hurricane, a tornado, and earthquake history

Specific Factors

6. Transportation:
   a. Availability of various services and projected rates

1.	Rail - dependable for light and heavy shipping over all distances
2.	Highways - regularly used for short distance and generally small quantities
3.	Water - cheaper, but may be slow and irregular
4.	Pipeline - for gases and liquids, particularly for petroleum products
5.	Air - for business transportation of personnel

7. Waste disposal:

a.	Regulations laws
b.	Stream carry-off possibilities
c.	Air-pollution possibilities

8. Labor:

1.	Availability of skills
2.	Labor relations - history and stability in area
3.	Stability of labor rates

9. Regulatory laws:

a.	Building codes
b.	Zoning ordinances
c.	Highway restrictions
d.	Waste-disposal codes

10. Taxes:

a. State and local taxes

1.	Income
2.	Unemployment insurance
3.	Franchise
4.	Use
5.	Property

b. Low assessment or limited term exemptions to attract industry

11. Site characteristics:

a.	Contour of site
b.	Soil structure
c.	Access to rail, highway, and water
d.	Room for expansion
e.	Cost of site
f.	Site and facilities available by expansion on present company-owned property

12. Community factors:

a.	Rural or Urban
b.	Housing costs
c.	Cultural aspects - churches, libraries, theaters
d.	School system
e.	Recreation facilities
f.	Medical facilities - hospitals, doctors

13. Vulnerability to wartime attack:

a.	Distance form important facilities
b.	General industry concentration

14. Flood and fire control:

a.	Fire hazards in surrounding area
b.	Floor history and control

SUPPLIERS OF LIMESTONE

PLANT ECONOMICS

Rated Plant capacity	=	4.00 MT/day
	=	1200.00 MT/annum
		CALCIUM CARBIDE

Basis

No. of working days	=	25 days/month
	=	300 days/annum
No. of shifts	=	1 per day
One shift	=	8 hours

Currency - Rs.

LAND & BUILDING

1.	Land Area Required 4000 sq.mts. @ Rs.500/- per sq.mtr.	Rs.	20,00,000.00
2.	Covered Area: production shed 1500 sq.mts. @ Rs.3000/-per sq.mtr.	Rs.	45,00,000.00
3.	Storage of raw material and finished product 500 sq.mts. @ Rs.2000/-per sq.mtr.	Rs.	10,00,000.00
4.	Office & Laboratories 150 sq.mts. @ Rs.4000/-per sq.mtr.	Rs.	6,00,000.00
5.	Storage Silos	Rs.	2,00,000.00
6.	Site development, Roads, Sewage Boundary wall, gate, etc.	Rs.	5,50,000.00
	TOTAL	**Rs.**	**88,50,000.00**

PLANT & MACHINERY

1. A) LIME SECTION:			
1. Vertical Shaft kiln, equipped with vertical hoist, motor half-		Rs.	0.01
2. Covered roof (platform) trolly and rolls for the movement of trolly, limed with high temperature-		Rs.	0.01
3. Refractory bricks in the calenining zone, provided with four outlet at the bottom reinforced with steel-		Rs.	0.01
4. Strips cap. 1.00 Mt per hour	1 No.	Rs.	0.01
5. 2. Vibrating Screen b) Section of Carbide 1. Three-phase electric Arc furnace		Rs.	0.01
6. Continuous type equipped 3 Nos. provided with vertical hoist motor, platform provided at the top of the		Rs.	0.01
7. Furnace, hopper to feed the raw materials limed with high temp. refractory bricks & pitch cap. -		Rs.	0.01
8. = 0.5 MT per hour output.	1 No.	Rs.	0.01
9. Jaw crusher cap. 0.5 MT/hr in put size 4-8 inch out put size 2"1	1 No.	Rs.	0.01
10. Rolling mill slow movement, cap. 0.5 MT/hr output 20-30 mesh.	1 No.	Rs.	0.01
11. Pebble mill input size less than 2" output size 85 % to pass through 300 mesh cap. 0.5 MT per hr.	1 No.	Rs.	0.01
12. Vibrating screen with a set of sieves cap. 0.5 mt/hr.	1 No.	Rs.	0.01
13. GENERAL SECTION 1. Automatic weighing scale	2 Nos.	Rs.	0.02

14. 2. Workshop tools M/c and auxiliary		Rs.	0.01
15. Laboratory set-up with all equipment testing materials		Rs.	0.01
16. Electric Insulation charges		Rs.	0.01
17. Service facilities charges		Rs.	0.01
18. Other miscellaneous M/c as pipe, valve, cooling system, etc.		Rs.	0.01
19. Total Machineries Cost		Rs.	25,00,000.00
	TOTAL	**Rs.**	**25,00,000.19**

OTHER FIXED ASSETS

1.	Office equipment, furniture plus other equipment & accessories	Rs.	50,000.00
2.	Installation costs for water, electricity, fuel etc.	Rs.	2,00,000.00
3.	Pre-operative & preliminary expenses	Rs.	2,00,000.00
4.	Installation erection, commissioning	Rs.	4,00,000.00
5.	Technical Knowhow	Rs.	3,00,000.00
6.	Miscellaneous Expenses	Rs.	2,00,000.00
	TOTAL	**Rs.**	**13,50,000.00**

FIXED CAPITAL

1.	LAND & BUILDING	Rs.	88,50,000.00
2.	PLANT & MACHINERY	Rs.	25,00,000.19
3.	OTHER FIXED ASSETS	Rs.	13,50,000.00
	TOTAL	**Rs.**	**1,27,00,000.19**

WORKING CAPITAL REQUIREMENT/MONTH

RAW MATERIALS

1.	Lime stone 220 MT @ Rs.1000/-per MT	Rs.	2,20,000.00
2.	Coal, Steam Coal 44 MT	Rs.	70,400.00
3.	Coke 70 MT @ Rs.2000/-per Mt (Incld. Transport)	Rs.	1,40,000.00
4.	Coal pitch, retort carbon and tar. Total 50 MT @ Rs.2000/-per MT (average)	Rs.	1,00,000.00
	TOTAL	**Rs.**	**5,30,400.00**

SALARY & WAGES / MONTH

1. Manager	1 No.	Rs.	15,000.00
2. Plant Supervisors	1 No.	Rs.	5,000.00
3. Electrical fitter	1 No.	Rs.	5,000.00
4. Mechanic	1 No.	Rs.	5,000.00
5. Furnace operators	2 No.	Rs.	8,000.00
6. Kiln operator	1 No.	Rs.	4,000.00
7. Chemists	1 No.	Rs.	6,000.00
8. Accountant	1 No.	Rs.	4,500.00
9. Typist/Clerk	1 No.	Rs.	3,500.00
10. Store Keeper	1 No.	Rs.	3,500.00
11. Time Clerk	1 No.	Rs.	2,500.00
12. Skilled workers	4 No.	Rs.	16,000.00
13. Unskilled workers	10 No.	Rs.	30,000.00
14. Security guards	1 No.	Rs.	2,500.00
15. Peon	1 No.	Rs.	2,500.00
	TOTAL	**Rs.**	**1,13,000.00**
Plus perks @ 33% p.a.		Rs.	37,290.00
	TOTAL	**Rs.**	**1,50,290.00**

UTILITIES AND OVERHEADS

1.	Power Consumption of 4000Kwatt hrs @ Rs. 4.50 per Kwatt hr.	Rs.	18,000.00
2.	Water Consumption of 500 KLs @ Rs. 2.00 per KL	Rs.	1,000.00
3.	Stationery, Postage, Telephone etc.	Rs.	5,000.00
4.	Conveyance & Transportation etc.	Rs.	7,000.00
5.	Publicity & Sales Promotion	Rs.	15,000.00
6.	Repairs & maintenance	Rs.	10,000.00
7.	Miscellaneous	Rs.	3,000.00
8.	Electrode consumption 3125 kgs. per month @ Rs.40/-per kg.	Rs.	1,25,000.00
9.	Packaging drum 50 kgs. each cap 3000 Nos. @ Rs.80/-per drum	Rs.	2,40,000.00
	TOTAL	**Rs.**	**4,24,000.00**

Total load is 22 Kwatts

TOTAL WORKING CAPITAL/MONTH

1. RAW MATERIAL	Rs.	5,30,400.00
2. SALARY & WAGES	Rs.	1,50,290.00
3. UTILITIES & OVERHEADS	Rs.	4,24,000.00
TOTAL	**Rs.**	**11,04,690.00**

1. WORKING CAPITAL FOR 3 MONTHS	Rs.	33,14,070.00
2. MARGIN MONEY FOR W/C LOAN	Rs.	8,28,517.50

COST OF PROJECT

TOTAL FIXED CAPITAL	Rs.	1,27,00,000.19
MARGIN MONEY	Rs.	8,28,517.50
TOTAL	**Rs.**	**1,35,28,517.69**

TOTAL CAPITAL INVESTMENT

TOTAL FIXED CAPITAL		Rs. 1,27,00,000.19
TOTAL WORKING CAPITAL FOR 3 MONTHS		Rs. 33,14,070.00
	TOTAL	**Rs. 1,60,14,070.19**

COST OF PRODUCTION/ANNUM

1. Working Capital for 1 year		Rs. 1,32,56,280.00
2. Interest @ 12.00% on T.C.I.		Rs. 19,21,688.42
3. Depreciation @ 6.50% on buildings		Rs. 4,45,250.00
4. Depreciation @ 25.00% on Plant and Machinery		Rs. 6,25,000.05
5. Depreciation @ 20.00% on office equipment & furnitures		Rs. 10,000.00
	TOTAL	**Rs. 1,62,58,218.47**

TURN OVER/ANNUM

1.	By sale of calcium carbide 1200 MT @ Rs.16600/-per MT.	Rs. 1,99,20,000.00
	TOTAL	**Rs. 1,99,20,000.00**

PROFIT = RECEIPTS - COST OF PRODUCTION

= 1,99,20,000.00 - 1,62,58,218.47

= 36,61,781.53

PROFIT SALES RATIO = Profit / Sales x 100

$$= \frac{36,61,781.53}{1,99,20,000.00} \times 100$$

= 18.38 %

RATE OF RETURN = Operating profit / T.C.I x 100

$$= \frac{36,61,781.53}{1,60,14,070.19} \times 100$$

= 22.87 %

BREAK EVEN POINT (B.E.P.)

Fixed Costs of the plant are as under -

1.	Interests	Rs. 19,21,688.42
2.	Depreciation	Rs. 10,80,250.05
3.	40.00% of salaries	Rs. 7,21,392.00
4.	40.00% of overheads	Rs. 20,35,200.00
	TOTAL	**Rs. 57,58,530.47**

$$B.E.P. = \frac{\text{FIXED COSTS}}{\text{FIXED COSTS + PROFIT}} \times 100$$

$$= \frac{57,58,530.47}{57,58,530.47 + 36,61,781.53} \times 100$$

$$= 61.13\ \%$$

LAND MAN RATIO = Total land / Manpower

4000 : 28 :: 143 : 1

RESOURCES FOR FINANCE

1.	Term loans from Financial institutions (65.00 % of fixed capital) at @12.00% p.a. rate of interest	Rs.	82,55,000.12
2.	Bank loans for 3 months (65.00 % of working capital) at @ 12.00% p.a. rate of interest	Rs.	21,54,145.50
3.	Self raised capital from even funds & loans from close ones to meet the margin money needs at a @ 12.00% p.a rate of interest	Rs.	56,04,924.57
	TOTAL	**Rs.**	**1,60,14,070.19**

INSTALMENT PAYABLE IN 5 YEARS

Year	To Financial institutions (Rs. 8255000)	To Commercial banks (Rs. 2154146)	To others (Rs. 5604925)	Total
1	16,51,000.02	4,30,829.10	11,20,984.91	32,02,814.04
2	16,51,000.02	4,30,829.10	11,20,984.91	32,02,814.04
3	16,51,000.02	4,30,829.10	11,20,984.91	32,02,814.04
4	16,51,000.02	4,30,829.10	11,20,984.91	32,02,814.04
5	16,51,000.02	4,30,829.10	11,20,984.91	32,02,814.04

INTEREST PAYABLE IN 5 YEARS

Year	On term loans (Rs. 8255000) @ 12.00 % P.A.	On bank loans (Rs. 2154146) @ 12.00 % P.A.	On self loans (Rs. 5604925) @ 12.00 % P.A.	Total
1	9,90,600.01	2,58,497.46	6,72,590.95	19,21,688.42
2	7,92,480.01	2,06,797.97	5,38,072.76	15,37,350.74
3	5,94,360.01	1,55,098.48	4,03,554.57	11,53,013.05
4	3,96,240.01	1,03,398.98	2,69,036.38	7,68,675.37
5	1,98,120.00	51,699.49	1,34,518.19	3,84,337.68

TOTAL REPAYMENT SCHEDULE FOR 5 YEARS

Year	Interest	Instalments	Total
1	19,21,688.42	32,02,814.04	51,24,502.46
2	15,37,350.74	32,02,814.04	47,40,164.78
3	11,53,013.05	32,02,814.04	43,55,827.09
4	7,68,675.37	32,02,814.04	39,71,489.41
5	3,84,337.68	32,02,814.04	35,87,151.72

DEPRECIATION CHART FOR 5 YEARS

Year	Building costs (Rs. 6850000.00) @ 6.50 % P.A.	Plant & Machinery (Rs. 2500000.19) @ 25.00 % P.A.	Fur. & office equip. (Rs. 50000.00) @ 20.00 % P.A.	Total
1	4,45,250.00	6,25,000.05	10,000.00	10,80,250.05
2	4,16,308.75	4,68,750.04	8,000.00	8,93,058.79
3	3,89,248.68	3,51,562.53	6,400.00	7,47,211.21
4	3,63,947.52	2,63,671.90	5,120.00	6,32,739.41
5	3,40,290.93	1,97,753.92	4,096.00	5,42,140.85

PROFIT ANALYSIS FOR 5 YEARS

YR	CAP UTIL	Sales	Mfg. Expenses	Gross Profit	Depreciation @ 38.85%	Interest before tax	Net profit after tax	Net profit
1	70%	13944000	9279396	4664604	1080250	1921688	1662666	1016720
2	80%	15936000	10605024	5330976	893059	1537351	2900566	1773696
3	80%	15936000	10605024	5330976	747211	1153013	3430752	2097905
4	90%	17928000	11930652	5997348	632739	768675	4595933	2810413
5	100%	19920000	13256280	6663720	542141	384338	5737241	3508323

CASH FLOW STATEMENT FOR 5 YEARS

YR	CAP. UTIL	Net profit (after tax)	Depreciation	Cash in hand	Repayment of Instalment	Net surplus
1	70%	1016720	1080250	2096970	2081829	15141
2	80%	1773696	893059	2666755	2081829	584926
3	80%	2097905	747211	2845116	2081829	763287
4	90%	2810413	632739	3443153	2081829	1361323
5	100%	3508323	542141	4050464	2081829	1968635

PROJECTED BALANCE SHEET FOR 5 YEARS

Construction Period	1 Yr. 70 %	2 Yr. 80 %	3 Yr. 80 %	4 Yr. 90 %	5 Yr. 100 %
	Cap. Util.	Cap. Util.	Cap. Util.	Cap. Util.	Cap. Util.

LIABILITIES

1. Promoters capital	56,04,924	56,04,924	56,20,065	62,04,991	69,68,278	83,29,602
2. Net Surplus	0	15,141	5,84,926	7,63,287	13,61,324	19,68,635
3. Term loans	82,55,000	66,04,000	49,53,000	33,02,000	16,51,000	0
4. W/C loans	21,54,145	17,23,316	12,92,487	8,61,658	4,30,829	0
TOTALS	**1,60,14,069**	**1,39,47,381**	**1,24,50,478**	**1,11,31,936**	**1,04,11,431**	**1,02,98,237**

ASSETS

1. W.D.V. of Fixed Asset	94,00,000	83,19,750	74,26,692	66,79,482	60,46,743	55,04,602
2. Working Capital in stock	0	23,19,849	26,51,256	26,51,256	29,82,663	33,14,070
3. Surplus funds	66,14,069	33,07,782	23,72,530	18,01,198	13,82,025	14,79,565
TOTALS	**1,60,14,069**	**1,39,47,381**	**1,24,50,478**	**1,11,31,936**	**1,04,11,431**	**1,02,98,237**