Final Project Report
(STUDY OF ASH UTILIZATION AND ASH HANDLING)

By
VIJAY KRISHNA GOSWAMI
M.Tech (Health,Safety& Environment)



College of Engineering
University of Petroleum & Energy Studies
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# STUDY OF ASH UTILIZATION AND ASH HANDLING

A thesis submitted in partial fulfillment of the requirements for the Degree of
Master of Technology
(Health, Safety & Environment)

By
(Vijay Krishna Goswami)

Under the guidance of

... Internal Guide ......................
... Dr D.V.L Rewal....................
...........................................

Approved

.....................................
Dean

College of Engineering
University of Petroleum & Energy Studies
Dehradun
April, 2010.

# APPROVAL SHEET

This is to certify that the project titled

**"Study of Ash utilization and Ash handling."**

Has been satisfactorily completed by the **Vijay Krishna Goswami-R070208013**of M. Tech HSE course at the University of Petroleum & Energy Studies during the academic year 2009 - 2010

This report has been submitted in partial fulfilment of the requirement

For the degree of

**Master of Technology (HSE)**

As prescribed and approved by the University of Petroleum & Energy Studies.

Dr.D.V.L Rewal

University of Petroleum & Energy Studies,

Dehradun

## ACKNOWLEGEMENT


- I am writing this final evaluation report during the Final Year Project 2010 in the program of Master of Technology at the division of HSE (Health, Safety and environment Engineering) at UPES , Dehradun.

- One person without his help and continuing support i can't pursue my project is my project guide **Dr.D.V.L Rewal** Thank you sir for continuous advice, Mentoring and kind support.

- And of course University of Petroleum & Energy Studies, Dehradun both staff for all their help and support.
  **Thank You All!**

VIJAY KRISHNA GOSWAMI

# DECLARATION

I **Vijay Krishna Goswami** hereby state that this final evaluation report has been submitted to University of petroleum & energy studies in partial fulfilment of the requirement of Final Year Project in **M.Tech (Master of Technology)** program class of 2010.

The empirical information of this project is based on my experience in Final year project. Any part of this project has not been reported or copied from any report of the university and others.

Vijay Krishna Goswami (R070208013)

## PREFACE

- This is the final evaluation report for Final Year project commenced from the 1st of January 2010 and will formally close on May 2010.The duration of the project is approx. 2 months.

- In this report intern is totally free to share all his/her experience during Project, good and bad both. So this report reflects originality, the whole truth about intern's working. And i am also putting these all things in this report.

# ABSTRACT


As a socially and environmental constraints ASH UTLIZATION has been a thrust areas where large quantity of Ash utilization is handled and utilized on sustainable basis and primitive action by IPGCL for further enhancement of ash utilization.

Fly ash is generally captured from the chimneys of coal-fired power plant, and is one of two types of ash that jointly are known as **coal ash**; the other, bottom ash, is removed from the bottom of coal furnaces. In the past, fly ash was generally released into the atmosphere, but pollution control equipment mandated in recent decades now requires that it be captured prior to release. In many countries, fly ash is generally stored at coal power plants or placed in landfills. Government of India came out with notification of 100% utilization of ash in the year 1999, providing a time frame of fifteen years for existing power plants and twelve years for power plants commissioned after 1997

Utilisation as opposed to dumping of fly ash can address the problem effectively. Research on utilisation of fly ash has proved its usefulness in various applications. Fly ash could be used in the manufacture of several products for the construction sector like blended cement, fly-ash bricks and mosaic tiles.

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## Introduction about I.P.G.C.L

Generation of electricity in Delhi started with a 2 MW diesel set in 1903. After independence Rajghat Power House 'A' was installed in 1951 with 5 MW capacities. Delhi Electric Supply Undertaking (DESU) came into existence in 1958 and two Units of 9.6 MW capacity each were installed as Rajghat Power House 'B'. In the second five year plan, three diesel generating sets totaling 20 MW were installed at different locations in Delhi. As a first major step towards making Delhi self sufficient in power, first unit of 36.6 MW was installed in 1963 at Indraprastha Power Station. A 15 mw unit was installed at Rajghat in 1966 followed by three units of 67.5MW each in 1967-68 at Indraprastha Power Station. Delhi Electric Supply Undertaking was restructured and Delhi Vidyut Board was formed in 1997.

Indraprastha Power Generation Co. Ltd. came into existence on 1st July, 2002 after unbundling of Delhi Vidyut Board into six entities. The main function of IPGCL is generation of electricity with an installed capacity of 994.5 MW and 3000 MW capacity addition in pipeline.

The present available capacity of this Station is 247.5 MW. Since it is a coal based station, Deshaled coal having ash contents less then 34% is being procured from NCL, Bina. New ESPs have been commissioned recently on all the units at a total cost of Rs.35 crores approx. to restrict the particulate emission below 50mg/NM3.All these units are quite old and need major R&M to remain in operating condition for which certain schemes have been prepared.

# UNDER IPGCL 3 POWER STATIONS ARE IN OPERATION :

1. I.P. STATION

247.5 MW coal based power station was installed and commissioned in 1968. While according to the environmental clearance by Ministry of environment and Forest (MOEF) to the Pragati Power Project, they imposed a condition that I.P. Station should be decommissioned with six months from the date of commissioning of Pragati Power Project.aa

However, Considering the fast rise of power requirement of Delhi. DPCC has now allowed running I.P. Station units subject to maintaining stack emission below 50 mg/NM3 and zero discharge from ash ponds for which action has been initiated.

2. RAJGHAT POWER HOUSE

It has installed capacity of 2x67.5=135 MW. Both the units are performing well. Additional ESPs are being fitted to bring down the SPM level from 150 mg/NM3 to 50 mg/NM3.

3. GAS TRIBUNE POWER STATION

It has installed capacity of 282 MW. Due to gas restriction only 4 gas turbines and 2 steam turbines are generally in operation. Two gas turbines along with one steam turbine are kept on liquid fuel to meet any emergency.

## UNDER PPCL ONE POWER STATION IS IN OPERATION :

**PRAGATI POWER STATION**

a) Gas Turbines 2x104 MW(open cycle)

b) Steam Turbine of 1x122MW (combined cycle)

## IPGCL / PPCL STATIONS AT A GLANCE

| Station | Indraprastha Power Station | Rajghat Power Station | Gas Turbine Power Station | Pragati Power Station |
|---|---|---|---|---|
| **Station Capacity (MW)** | 247.5 | 135 | 282 | 330 (Total 994.5 MW) |
| **Units** | 3x62.5 + 60 | 2x67.5 | 6x30 (GT) + 3x34 (WHRU) | 2x104 (GT) + 1x122 (WHRU) |
| **Year of Commissioning** | 1967-71 | 1989-90 | 1986 & 1996 | 2002 -03 |
| **Coal Fields/Gas** | NCL, BINA | NCL, BINA | GAIL HBJ Pipeline | GAIL HBJ Pipeline |
| **Water Sources** | River Yamuna | River Yamuna | River Yamuna | Treated water from Sen Nursing Home and Delhi |

| | | | | |
|---|---|---|---|---|
| | | | | Gate Sewage Treatment Plants |
| **Beneficiary Areas** | VIP- South & Central Delhi | Central & North Delhi | NDMC-VVIP, DMRC | NDMC, South Delhi |

With the unbundling of D.V.B. on 01.07.2002, two companies came into existence under Genco:

- Indraprastha Power Generation Co. Ltd. (IPGCL)
- Pragati Power Corporation Ltd. (PPCL)

The Power demand in the Capital City is increasing with the growth of population as well as living standard and commercialization. The unrestricted power demand in the summer of year 2000 was 3000 MW and increasing every year @ 6 to 7%. In 2005-2006, it is expected to be 4078 MW and by 2009-10 it will reach 5075 MW. Erstwhile DVB's own generation from RPH, I.P. Station and Gas Turbine Power Station had been around 350-400 MW and Badarpur has been supplying 600-700 MW and the balance was met from the Northern Grid and other sources.

To bridge the gap between demand and supply and to give reliable supply to the Capital City, Delhi Govt. had set up 330 MW Pragati Power Project on fast track basis. To cut down the project cycle duration, turnkey contract was awarded to M/s BHEL in May 2000 based on similar project executed by BHEL at Kayamkulam (owned by NTPC). To further ensure reliable and smooth operation of the plant, experience of NTPC was utilized by retaining them as engineering consultant and specification of the Kayamkulam Project were adopted.

# Ash Utilization

In India coal is a major source of energy for power generation. About 60 % of power is generated by the coal based power stations. In the power generation process huge amount of the ash is also generated .This ash is a raw material for the various types of the materials.IPGCL, one of the largest power utility of India ,presently meeting more than one fourth of power demand by about one fifth generating capacity is also using coal as a main source fuel for power generation.

As a socially and environmental constraints ASH UTLIZATION has been a thrust areas where large quantity of Ash utilization is handled and utilized on sustainable basis and primitive action by IPGCL for further enhancement of ash utilization.

## Introduction:-

India energy supply is predominantly dependent on coal based thermal power station and it will be same for few decades also. Fly ash was considered waste product of coal petroleum. **Fly ash** is one of the residues generated in the combustion of coal. Fly ash is generally captured from the chimneys of coal-fired power plant, and is one of two types of ash that jointly are known as **coal ash**; the other, bottom ash, is removed from the bottom of coal furnaces. Depending upon the source and makeup of the coal being burned, the components of fly ash vary considerably, but all fly ash includes substantial amounts of silicon dioxide($SiO_2$) (both amorphous and crystalline) and calcium oxide($CaO$), both being endemic ingredients in many coal bearing rock strata.

Toxic constituents depend upon the specific coal bed makeup, but may include one or more of the following elements or substances in quantities from trace amounts to several percent: arsenic, beryllium, boron, cadmium, chromium, chromium VI, cobalt, lead, manganese, mercury, molybdenum, selenium, strontium, thallium, and vanadium, along with dioxins and PAH compounds

In the past, fly ash was generally released into the atmosphere, but pollution control equipment mandated in recent decades now requires that it be captured prior to release. In many countries, fly ash is generally stored at coal power plants or placed in landfills. About 43 percent is recycled, often used to supplement Portland cement in concrete production.

The fly ash produced by burning Indian coal has tremendously used for different applications. Several areas of ash utilization where in technology demonstration projects have been completed or are underway include ash bricks,blocks,tiles,use in agriculture,embankmants,construction of roads, mine filling, raising dykes etching early nineties ash utilization was very low. It was realized that if not managed properly there will be tremendous environmental problems. caused by large scale dumping of fly ash on scarce land resource and associated health hazards. Government of India came out with notification of 100% utilization of ash in the year 1999, providing a time frame of fifteen years for existing power plants and twelve years for power plants commissioned after 1997.All the new power plants provide utilization programme in the initial stages only.

High ash content in the range of 30 to 50% in Indian coals is the major cause of large voluminous quantities of coal ash. India's dependence on coal as a major source of energy had been of prime importance in the past and shall continue in this millennium, and therefore fly ash management would remain an important area of national concern. At present nearly 100 million tonnes of fly ash is being generated annually in India .

Power generation capacity in India has increased by 1362 MW in 1947 to about 1,18,419 MWs as on March 2005 out of which about 67,791 MWs is from coal based power stations.These coal based power stations have generated about 111 million tonnes of ash during the year 2004-05.

In ancient days ash was treated as waste material and was used for cleaning utensils in houses.But in Twentieth century world,over a number of research activitied are carried out in the field of ash utilization generated from thermal power stations by scientists and they have proved taht fly ash is not a waste but a very good resource material and can be utilised in in variety of uses such as manufacture of cement,bricks,blocks,road embankment construction,waste land development as a soil amender and source of micro nutrient in agriculture.

IPGCL produced 34 million tonnes of ash during the year 2004-05.The additional coal based thermal power station commissioned in 2007 produced ash to the tune of 7-8 metric ton.

The Centre for Ash Utilisation Technology and Environment Conservation (CASHUTEC), situated adjacent to the Raichur Thermal Power Station (RTPS), is bustling with activity. In one section of the big shed, new mosaic tiles are being pressed into shape; in another, batches of air-dried tiles are being transferred into big water tanks where they will cure for a period under water. While the procedure for manufacturing these tiles is the same as that for the conventional ones, the difference is in the ingredients used.

A significant quantity of fly ash has been used in place of cement; doing so , almost 30 per cent of cement has been saved without compromising on the tile quality. In fact, tests show that tiles made with a mix of cement and fly ash are stronger than those made with cement alone, and can be used for heavy-duty floors as well.

RTPS, one of Karnataka's major power plants, is owned by Karnataka Power Corporation Ltd and consists of seven units, each capable of generating 210 MW of power.

Deep inside the underbelly of the power plant, is an ongoing challenge that needs to be addressed on a daily basis. RTPS uses coal to generate power, in the process generating about 1.5 million tonnes of fly ash annually. This translates to more than 4,000 tonnes of ash requiring proper disposal every day.

This situation is not unique to RTPS alone. Seventy per cent of India's thermal power plants use coal to generate power. Indian coals are known to have very high ash contents — almost 40-45 per cent; an estimated 100 million tonnes of fly ash are collectively generated from India's thermal power plants per year. Of this, 80 per cent is fly ash and 20 per cent bottom ash.

The conventional method used to dispose both fly and bottom ash is to convert them into wet slurry, and dump them into specially built ash-ponds around the thermal plants. While this may solve immediate disposal needs, it is fraught with long-term environmental problems.

Fly ash is a very fine powder and is known to pollute air and water, cause respiratory problems when inhaled and reduce yields when it settles on leaves and crops in agriculture fields around the power plant.

Ash-ponds require large tracts of land that could otherwise be used for agriculture. Water consumption also goes up while converting ash to slurry. Dumping of fly ash pollutes groundwater, as it contains many salts and metals, which, when dissolved in rainwater, can contaminate the groundwater

Utilisation as opposed to dumping of fly ash can address the problem effectively. Research on utilisation of fly ash has proved its usefulness in various applications. Fly ash could be used in the manufacture of several products for the construction sector like blended cement, fly-ash bricks and mosaic tiles.

While the use of cement cannot be completely avoided, for certain products like mosaic tiles the substitution can go up to 50 per cent. This results in substantial savings on raw materials and the products are proven to be stronger and more cost-effective.

Fly-ash products are also environment friendly. A case in point is fly ash bricks. When conventional clay bricks are produced, they consume large amounts of clay. This results in the removal of topsoil and deterioration of the quality of agricultural land. Fly-ash bricks, on the other hand, do not require clay and result in the preservation of topsoil, as well as productive utilisation of fly ash.

In recognition of the problems that arise out of fly ash dumping, and to encourage its use by the construction industry, the Ministry of Environment and Forests has passed stringent notifications on the utilisation of fly ash. It has also set a time limit for compliance with the notifications. Notable among the attempts being made to utilise fly ash in the country is the effort at RTPS.

"Despite the established uses of fly ash and stringent policies to support its utilisation, overall fly ash utilisation in India stands at about 15 per cent of the quantity generated. Efforts are on to improve the situation, and we have sought to initiate sustainable optionsat RTPS," says R.R. Chousalkar, Executive Director (Thermal), RTPS.

RTPS, in collaboration with the Indo-Norwegian Environment Programme (INEP), has set up CASHUTEC, a technology demonstration centre, in Raichur. The centre aims to demonstrate the varied applications for fly ash in the construction sector including fly-ash bricks, blocks, interlocking pavers and mosaic tiles.

## Fly ash characteristics, composition and classification:-

They consist mostly of silicon dioxide ($SiO_2$), which is present in two forms: amorphous, which is rounded and smooth, and crystalline, which is sharp, pointed and hazardous; aluminium oxide ($Al_2O_3$) and iron oxide ($Fe_2O_3$). Fly ashes are generally highly heterogeneous, consisting of a mixture of glassy particles with various identifiable crystalline phases such as quartz, mullite, and various iron oxides.

Fly ash also contains environmental toxins in significant amounts, including arsenic (43.4 ppm); barium (806 ppm); beryllium (5 ppm); boron (311 ppm); cadmium (3.4 ppm); chromium (136 ppm); chromium VI (90 ppm); cobalt (35.9 ppm); copper (112 ppm); fluorine (29 ppm); lead (56 ppm); manganese (250 ppm); nickel (77.6 ppm); selenium (7.7 ppm); strontium (775 ppm); thallium (9 ppm); vanadium (252 ppm); and zinc (178 ppm).

| **Component** | **Bituminous** | **Sub bituminous** | **Lignite** |
|---|---|---|---|
| $SiO_2$ (%) | 20-60 | 40-60 | 15-45 |
| $Al_2O_3$ (%) | 5-35 | 20-30 | 20-25 |
| $Fe_2O_3$ (%) | 10-40 | 4-10 | 4-15 |
| CaO(%) | 1-12 | 5-30 | 15-40 |
| LOI (%) | 0-15 | 0-3 | 0-5 |
| MgO | 1.2 | 4.5 | 6.8 |

## Fly ash classes:-

Two classes of fly ash are defined: Class F fly ash and Class C fly ash. The chief difference between these classes is the amount of calcium, silica, alumina, and iron content in the ash. The chemical properties of the fly ash are largely influenced by the chemical content of the coal burned (i.e., anthracite, bituminous, and lignite).

### Class F fly ash

The burning of harder, older anthracite and bituminous coal typically produces Class F fly ash. This fly ash is pozzolanic in nature, and contains less than 10% lime (CaO). Possessing pozzolanic properties, the glassy silica and alumina of Class F fly ash requires a cementing agent, such as Portland cement, quicklime, or hydrated lime, with the presence of water in order to react and produce cementitious compounds. Alternatively, the addition of a chemical activator such as sodium silicate (water glass) to a Class F ash can lead to the formation of a geopolymer.

### Class C fly ash

Fly ash produced from the burning of younger lignite or subbituminous coal, in addition to having pozzolanic properties, also has some self-cementing properties. In the presence of water, Class C fly ash will harden and gain strength over time. Class C fly ash generally contains more than 20% lime (CaO). Unlike Class F, self-cementing Class C fly ash does not require an activator. Alkali and sulfate ($SO_4$) contents are generally higher in Class C fly ashes.

## Potential of ash utilization

About 95 % of ash produced in the thermal power station i nm our country is disposed every year . without being utilized, even though technology exist for making world class value added product like brick ,cement etc.

Fly ash also finds use in roads in embankment bunds, alumina extraction, soil conditioning for agricultural purposes,it can be used :

- As a pozzolanic material for manufacture of Portland cement.
- Fro for manufacture of coal ash based bricks and blocks.
- As a part of replacement of cement in ready mix concentrate.
- For manufacture of cellular concrete building blocks and slabs
- For manufacture of base and sub base course for roads, highways and runways for airports.
- Manufacturing asbestos fly ash based sheets.
- As filler for asphalt-bitumen mixture.
- As a structural fill material.
- For manufacture of light weight aggregates.
- As a filler for low grade refractory bricks.
- For soil improvement
- For land reclamation and land fill cover.
- For lining of irrigation canals.
- As a filler in paints,plastics,rubber
- For afforestation.

**Area wise break-up of utilisation for the year 2008-09 is as under:**

| |
|---|
| Area of Utilisation Quantity (in Million Tons) |
| Cement Industries- 7.04 |
| Ready Mix Concrete- 0.33 |
| Asbestos -0.20 |
| Clay Ash -1.60 |
| Fly Ash Bricks -1.64 |
| Land Fill- 5.74 |
| Ash Dyke Raising -6.24 |
| Road/ Embankments -1.30 |
| Mine Filling -1.14 |
| Agriculture -0.002 |
| Export- 0.73 |
| Others -0.02 |
| **Total -24.40** |

The quality ash produced conforms to the requirements of IS 3812 – 2003. The fly ash generated at IPGCL stations is ideal for use in cement, concrete, concrete products, cellular concrete, light weight aggregates, bricks/blocks/ tiles etc. This is attributed to very low loss on ignition value. To facilitate availability of dry ash to end users, all the new units of IPGCL are provided with the facility of dry ash collection system. Partial dry ash collection systems have also been set up at the existing stations where these facilities did not exist earlier. Augmentation of these systems to 100% capacity is in under progress.

## Ash utilization:-

As a society and environment conscious utility, IPGCL has taken up ash utilization as a thrust area of its activities. A separate "ASH UTILIZATION DIVISION" has been working at corporate level and "Ash Utilization Cells" at each regional headquarters and operating station with the following primary objectives:

I. To facilitate convenient collection, storage and loading system for dry ash for issue to the potential users.

II. To encourage and persuade potential entrepreneurs for utilizing more and more ash from IPGCL power stations.

III. To organise/conduct studies aimed at finding out and evolving innovative methods of ash utilization.

IV. To facilitate utilization of ash through departmental actions/projects.

Due to concerted action taken in the past few years, ash utilization level is continuously increasing year by year. In year 1991-92 about 2% of total ash generated was gainfully utilized in various areas. In year 2004-05 this has reached to 37%.During 2004-2005, about 12.7 ton of ash has been gainfully utilized in various areas of application. The major areas of utilization are:

1. Issue to the cement and asbestos industries.
2. As a fill in land development.
3. Rising of ash dykes.

Major issues of ash utilization in IPGCL:-

Manufacture of Portland cement and asbestosis cement products is one of the major potential area where in large quantity of fly ash can be gainfully utilized on sustainable basis. These industries mainly require dry fly ash. To meet their demand, IPGCL has set up dry fly ash collection and storage system in its thermal power stations so that fly ash can be directly loaded in open/closed tankers. These facilities have increased multi fold utilization of ash in this area of use. In 1993-94, only about .1m ton of ash was used in this area, this has reached to about 4.6 m Ton in year 2004-05.

It has been observed that production of PPC is continuously registering upward trend. Split location cement plants are becoming popular where in clinker production unit is located adjacent to lime deposits and grinding units is suitably located near to coal based thermal power plant and cement composition and consumption centres.

INVITATION OF TECHNOLOGY SCALE UP/APPLICATION PROJECT PROPOSALS BY DEPARTMENT OF SCIENCE AND TECHNOLOGY, GOVERNMENT OF INDIA IN THE AREA OF FLY ASH

It has been decided to provide an increased impetus and thrust to already being supported R & D and technology development activities including up gradation / preparations of new standards / specifications, policy issues, disseminations of information and knowledge etc. in the area of fly ash. In addition fly ash technology / know how transfer/application and facilitation mechanisms are also to be developed and facilitated that would inter-alia undertake capacity building at all levels of stakeholder agencies.

The new focus and thrust to fly ash activities would be provided by Fly Ash Utilization (FAU), the Department of Science and Technology (DST) in addition to continuing the on-going fly ash related activities initiated under the earlier programmes (Fly Ash Mission & Fly Ash Utilization Programme).

Realizing that major quantity of fly ash could be utilized for stowing, in lieu of sand, which is the present practice, into the underground mines after extraction of coal, the Board initiated a collaboration with Fly Ash Mission of Department of Science and Technology, Government of India, to establish a technology demonstration using pond ash as a stowing material for the underground mines at Manu guru, Andhra Pradesh.

This application will also help the country in saving precious sand which is needed for important developmental activities, as well as for the conservation of large quantities of water. This activity has a potential of full utilization of fly ash from coal based power plants for many years as the capacity of mines to receive fly ash/pond ash is commensurate with the quantity of coal being extracted.

The IPGCL has also encouraged local entrepreneurs by providing land, water, power, free fly ash for setting up fly ash brick manufacturing units which have been producing quality bricks which are being utilized by mining industry as well as by the public of the nearby villages. It is also exploring to initiate a demonstration project in the field of agriculture for finding acceptance by the farmers for the use of fly ash. Use of fly ash not only increases the yield of the crops but also acts as pesticides for preserving the loss of crops from insects.

Since the fly ash has suitable pozzolanic properties, efforts are also being made towards encouraging cement-manufacturing entrepreneurs for using fly ash for manufacture of cement.

# Legal Provisions

**Legal Notification on fly ash utilization dated 14-09-99**

**by The Ministry of Environment and Forest, Govt. of India**

A. No person within the radius of 50 km. from coal based Thermal Power Plants can manufacture clay bricks/tiles/blocks without mixing 25% of fly ash or bottom ash or pond ash.

B. Coal based Thermal Power Plants commissioned subject to environmental clearance condition for full utilization of fly ash shall achieve 100% use within 9 years from the date of notification and those who are not covered by stipulation in the environmental clearance shall achieve 100% fly ash utilization within 15 years from the date of notification.

C. Construction agencies and local authorities shall prescribe use of ash and its products in their schedules of specifications, building byelaws and regulations.

D. The Thermal Power Plants shall make available ash without any payment for producing ash based products - cement, concrete blocks, bricks panels, construction of roads, embankments, dam, dykes or any construction activity.

E. The action plan for 9 years utilization shall include 30% of fly ash use within initial 3 years and 10% progressively every year onwards and the action plan for15 year utilization shall include 20% fly ash utilization within initial 2 years.

F. The authority for ensuring the use of fly ash for the manufacture of bricks and other construction activities shall be the concerned Regional Officer of the State Pollution Control Board and in case of non-compliance, the state pollution control board in addition to the cancellation of consent order issued to establish the brick kiln, shall move the district administration for cancellation of mining lease, after due hearing.

**Fly ash reuse**

The reuse of fly ash as an engineering material primarily stems from its pozzolanic nature, spherical shape, and relative uniformity. Fly ash recycling, in descending frequency, includes usage in:

- Portland cement
- Embankments and structural fill
- Waste stabilization and solidification
- Raw feed for cement clinkers
- Mine reclamation
- Stabilization of soft soils
- Road subbase
- Aggregate
- Flowable fill
- Mineral filler in asphaltic concrete
- Other applications include cellular concrete, geopolymers, roofing tiles, paints, metal castings, and filler in wood and plastic products.

**Portland cement**

Owing to its pozzolanic properties, fly ash is used as a replacement for some of the Portland cement content of concrete.The use of fly ash as a pozzolanic ingredient was recognized as early as 1914, although the earliest noteworthy study of its use was in 1937 Before its use was lost to the Dark Ages, Roman structures such as aqueducts or the Pantheon in Rome used volcanic ash (which possesses similar properties to fly ash) as pozzolan in their concrete. As pozzolan greatly improves the strength and durability of concrete, the use of ash is a key factor in their preservation.

Use of fly ash as a partial replacement for Portland cement is generally limited to Class F fly ashes. It can replace up to 30% by mass of Portland cement, and can add to the concrete's final strength and increase its chemical resistance and durability. Recently concrete mix design for partial cement replacement with High Volume Fly Ash (50 % cement replacement) has been developed. For Roller Compacted Concrete (RCC)[used in dam construction] replacement values of 70% have been achieved with POZZOCRETE (processed fly ash) at the Ghatghar Dam project in Maharashtra, India. Due to the spherical shape of fly ash particles, it can also increase workability of cement while reducing water demand .The replacement of Portland cement with fly ash is considered by its promoters to reduce the greenhouse gas "footprint" of concrete, as the production of one ton of Portland cement produces approximately one ton of $CO_2$ as compared to zero $CO_2$ being produced using existing fly ash. New fly ash production, i.e., the burning of coal, produces approximately twenty to thirty tons of $CO_2$ per ton of fly ash. Since the worldwide production of Portland cement is expected to reach nearly 2 billion tons by 2010, replacement of any large portion of this cement by fly ash could significantly reduce carbon emissions associated with construction, as long as the comparison takes the production of fly ash as a given.

## Embankment

Fly ash properties are somewhat unique as an engineering material. Unlike typical soils used for embankment construction, fly ash has a large uniformity coefficient consisting of clay-sized particles. Engineering properties that will affect fly ash's use in embankments include grain size distribution, compaction characteristics, shear strength, compressibility, permeability, and frost susceptibility.Nearly all fly ash used in embankments are Class F fly ashes.

## Soil stabilization

Soil stabilization involves the addition of fly ash to improve the engineering performance of a soil. This is typically used for a soft, clayey subgrade beneath a road that will experience many repeated loadings. Improvement can be done with both Class C and Class F fly ashes. If using a Class F fly ash, an additive (such as lime or cement) is needed whereas the self-cementing nature of Class C fly ash allows it to be used alone.

## Flow able fill

Fly ash is also used as a component in the production of flowable fill (also called controlled low strength material, or CLSM), which is used as self-leveling, self-compacting backfill material in lieu of compacted earth or granular fill. The strength of flowable fill mixes can range from 50 to 1,200 $lbf/in^2$ (0.3 to 8.3 MPa), depending on the design requirements of the project in question. Flowable fill includes mixtures of Portland cement and filler material, and can contain mineral admixtures. Fly ash can replace either the Portland cement or fine aggregate (in most cases, river sand) as a filler material. High fly ash content mixes contain nearly all fly ash, with a small percentage of Portland cement and enough water to make the mix flowable. Low fly ash content mixes contain a high percentage of filler material, and a low percentage of fly ash, Portland cement, and water. Class F fly ash is best suited for high fly ash content mixes, whereas Class C fly ash is almost always used in low fly ash content mixes.

## Asphalt concrete

Asphalt concrete is a composite material consisting of an asphalt binder and mineral aggregate. Both Class F and Class C fly ash can typically be used as a mineral filler to fill the voids and provide contact points between larger aggregate particles in asphalt concrete mixes. This application is used in conjunction, or as a replacement for, other binders (such as Portland cement or hydrated lime). For use in apshalt pavement, the fly ash must meet mineral filler specifications outlined in ASTM D242. The hydrophobic nature of fly ash gives pavements better resistance to stripping. Fly ash has also been shown to increase the stiffness of the asphalt matrix, improving rutting resistance and increasing mix durability.

**Geopolymers**

More recently, fly ash has been used as a component in geopolymers, where the reactivity of the fly ash glasses is used to generate a binder comparable to a hydrated Portland cement in appearance and properties, but with dramatically reduced $CO_2$ emissions.

**Roller compacted concrete**

Another application of using fly ash is in roller compacted concrete dams. Many dams in the US have been constructed with high fly ash contents. Fly ash lowers the heat of hydration allowing thicker placements to occur. Data for these can be found at the US Bureau of Reclamation. This has also been demonstrated in the Ghatghar Dam Project in India.

**Bricks**

Fly ash has been used for over fifty years to make concrete building blocks. They are widely used for the inner skin of cavity walls. They are naturally more thermally insulating than blocks made with other aggregates.

Ash bricks have been used in house construction in Windhoek, Namibia since the 1970s. There is, however, a problem with the bricks in that they tend to fail or produce unsightly pop-outs. This happens when the bricks come into contact with moisture and a chemical reaction occurs causing the bricks to expand.

In May 2007, Henry Liu, a retired 70-year old American civil engineer, announced that he had invented a new, environmentally sound building brick composed of fly ash and water. Compressed at 4,000 psi and cured for 24 hours in a 150 °F (66 °C) steam bath , then toughened with an air entrainment agent, the bricks last for more than 100 freeze-thaw cycles. Owing to the high concentration of calcium oxide in class C fly ash, the brick can be described as "self-cementing". The manufacturing method is said to save energy, reduce mercury pollution, and costs 20% less than traditional clay brick manufacturing. Liu intends to license his technology to manufacturers in 2008.[20][21] Bricks of fly ash can be made of two types. One type of brick are made mixing it with about equal amount of soil and proceeding through the ordinary process of making brick. This type of formation reduces the use of fertile sand in making bricks.

Another type of brick can be made by mixing soil, plaster of paris and fly ash in a definite proportion with water and allowing the mixture to dry. Because it does not need to be heated in a furnace this technique reduces air pollution.

**Metal Matrix Composites**

Hollow fly ash can be infiltrated by molten metal to form solid, alumina encased spheres. Fly ash can also be mixed with molten metal and cast to reduce overall weight and density, due to the low density of fly ash. Research is underway to incorporate fly ash into lead acid batteries in a lead calcium tin fly ash composite in an effort to reduce weight of the battery.

### Waste management

Fly ash, and its alkalinity, may be used to process human waste sludge into fertilizer.

## Environmental problems

### Present production rate of fly ash

About 131 million tons of fly ash are produced annually by 460 coal-fired power plants. A 2008 industry survey estimated that 43 percent of this ash is re-used.

### Groundwater contamination

Since coal contains trace levels of arsenic, barium, beryllium, boron, cadmium, chromium, thallium, selenium, molybdenum and mercury, its ash will continue to contain these traces and therefore cannot be dumped or stored where rainwater can leach the metals and move them to aquifers.

Where fly ash is stored in bulk, it is usually stored wet rather than dry so that fugitive dust is minimized. The resulting impoundments (ponds) are typically large and stable for long periods, but any breach of their dams or bunding will be rapid and on a massive scale.

### Contaminants

Fly ash contains trace concentrations of heavy metals and other substances that are known to be detrimental to health in sufficient quantities. Potentially toxic trace elements in coal include arsenic, beryllium, cadmium, barium, chromium, copper, lead, mercury, molybdenum, nickel, radium, selenium, thorium, uranium, vanadium, and zinc. Approximately 10 percent of the mass of coals burned consists of unburnable mineral material that becomes ash, so the concentration of most trace elements in coal ash is approximately 10 times the concentration in the original coal.

### Contamination in Byker

In the 1980s and 1990s, around 2,000 tons of fly ash from local incinerators (used to burn garbage - not coal) were used by the local council deliberately to surface footpaths around the Byker and Walker districts of Newcastle upon Tyne, England.Considerable concern was raised in the local community when this was discovered. Later studies found contamination by dioxins and furans from this fly ash, although no strong evidence for heavy metals (the area has an industrial past that may itself explain the levels that were found).

### Exposure concerns

Crystalline silica and lime along with toxic chemicals are among the exposure concerns. Although industry has claimed that fly ash is "neither toxic nor poisonous," this is disputed.

Exposure to fly ash through skin contact, inhalation of fine particle dust and drinking water may well present health risks. The National Academy of Sciences noted in 2007 that "the presence of high contaminant levels in many CCR (coal combustion residue) leachates may create human health and ecological concerns.

Fine crystalline silica present in fly ash has been linked with lung damage, in particular silicosis. OSHA allows 0.10 $mg/m^3$, (one ten-thousandth of a gram per cubic meter of air).

Another fly ash component of some concern is lime ($CaO$). This chemical reacts with water ($H_2O$) to form calcium hydroxide [$Ca(OH)_2$], giving fly ash a pH somewhere between 10 and 12, a medium to strong base. This can also cause lung damage if present in sufficient quantities.

## What is Ash Handling?

The most common types of ash include bottom ash, bed ash, fly ash and ash clinkers resulting from the combustion of coal, wood and other solid fuels.

Ash handling is a method of, conveying, collection, interim storage and load out of various types of ash residue left over from solid fuel combustion processes.

.Ash handling systems may employ mechanical ash conveyors or pneumatic ash conveyers.

Coarse ash material such as bottom ash is most often crushed in clinker grinders (crushers) prior to being transported in the ash conveyor system.

Very finely sized fly ash often accounts for the major portion of the material conveyed in an ash handling system. It is collected from bag house type dust collectors, electrostatic precipitators and other apparatus in the flue gas processing stream.

A typical pneumatic ash handling system will employ vacuum pneumatic ash collection and ash conveying from several ash pick up stations-with delivery to an ash storage silo for interim holding prior to load out and transport. Pressurized pneumatic ash conveying may also be employed.

Ash mixers (conditioners) and dry dustless telescopic devices are used to prepare ash for transfer from the ash storage silo to transport vehicles.

**Electrostatic Precipitator**

The hourly consumption of coal of a 200 MW unit is about 110 tons. With this, the hourly production of ash will be 33 tons. Indian coal contains about 30% of ash. If such large amount of ash is discharge in atmosphere, it will create heavy air pollution thereby resulting health hazards and other environmental problems. Hence it is necessary to dispose ash dust and other residues of the flue gases.

Precipitation of ash has another advantage too. It protects the wear and erosion of ID fan.

To achieve the above objectives, Electrostatic Precipitator (ESP) is used. As they are efficient in precipitating particle form submicron to large size they are preferred to mechanical precipitation.

**Construction**

An ESP has series of collecting and emitting electrons in a chamber collecting electrodes are steel plates while emitting electrodes are thin wire of 2.5mm diameter and helical form. Entire ESP is a hanging structure hence the electrodes are hung on shock bars in an alternative manner.

It has a series of rapping hammer mounted on a single shaft device by a motor with the help of a gear box at a speed of 1.2 rpm. At the inlet of the chamber there are distributor screens that distributes the gas uniformly throughout the chamber.

There are transformer and rectifiers located at the roof of chamber. Hopper and flushing system form the base of chamber.

**Working:**

Flue gases enter the chamber through distributor screen and get uniformly distributed. High voltage of about 40 to 70 KV form the transformer is fed to rectifier. Here ac is converted to dc. The negative polarity of this dc is applied across the emitting electrode while the positive polarity is applied across the collecting electrodes. This high voltage produces corona effect negative (–ve) ions from emitting electrode move to collecting electrode. During their motion, they collide with ash particles and transfer their charge. On gaining this charge, ash particles too move to collecting electrode and stock to them. Similar is the case with positive (+ve) ions that moves in opposite direction.

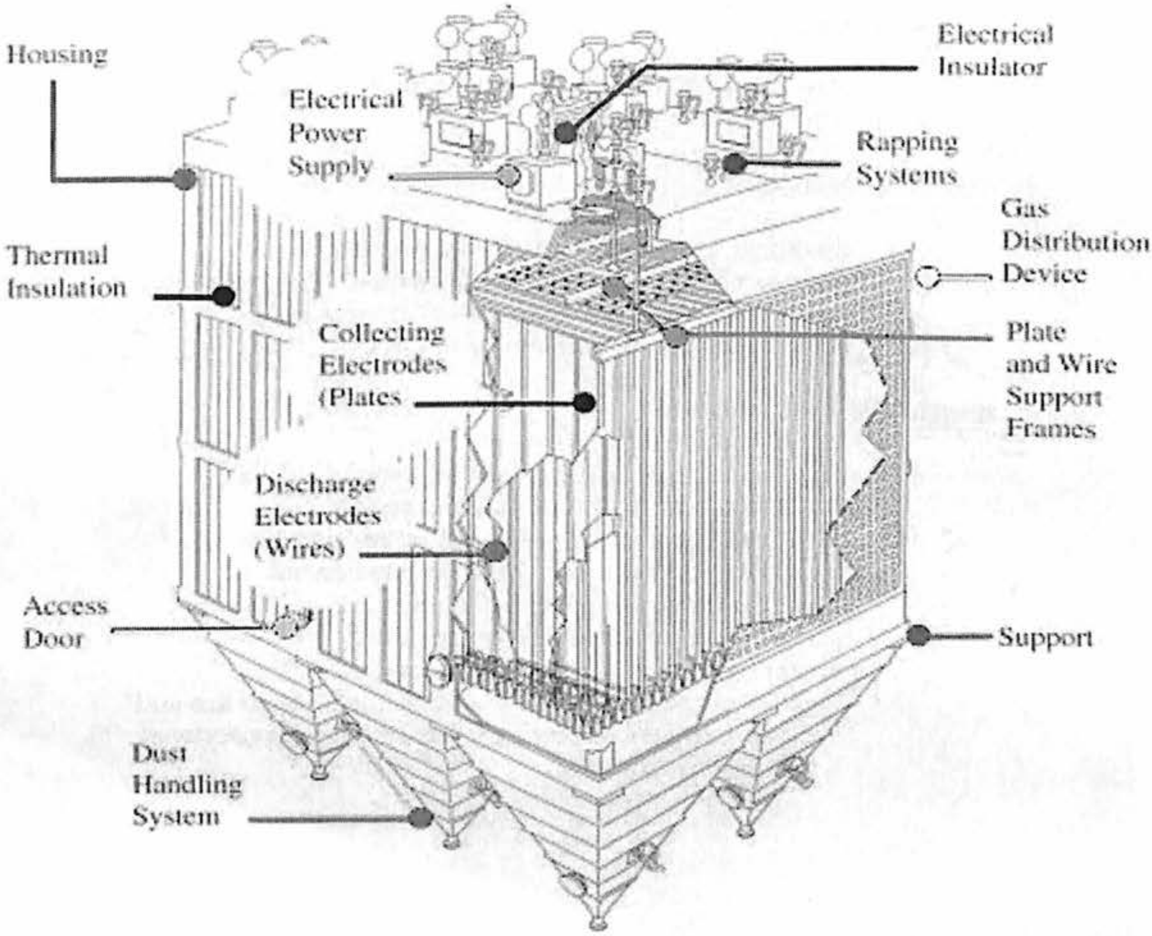
The rapping hammers hit the shock bars periodically and dislodge the collected dust from it. This dust fall into hopper and passes to flushing system. Here it is mixed with water to form slurry which is passed to AHP.

Efficiency of ESP is approximately 99.8%.

**Theory of Precipitation**

Electrostatic precipitation removes particles from the exhaust gas stream of Boiler combustion process. Six activities typically take place:

- ✓ **Ionization** - Charging of particles
- ✓ **Migration** - Transporting the charged particles to the collecting surfaces
- ✓ **Collection** - Precipitation of the charged particles onto the collecting surfaces
- ✓ **Charge Dissipation** - Neutralizing the charged particles on the collecting surfaces
- ✓ **Particle Dislodging** - Removing the particles from the collecting surface to the hopper
- ✓ **Particle Removal** - Conveying the particles from the hopper to a disposal point


Housing
Electrical Power Supply
Electrical Insulator
Rapping Systems
Gas Distribution Device
Thermal Insulation
Collecting Electrodes (Plates
Plate and Wire Support Frames
Discharge Electrodes (Wires)
Access Door
Support
Dust Handling System

**Inside view of E.S.P**

**Components of ESP**

- Discharge Electrodes
- Power Components
- Precipitator Controls
- Rapping Systems
- Purge Air Systems
- Flue Gas Conditioning
- Emitting Electrodes
- Collecting Electrodes
- High Voltage Equipment
- Rapping Mechanism
- Hoppers
- Heaters
- ALI
- Gas Distribution Screen
- Segregating Gates

## Ash Handling Plant

**(AHP)**

The ash produced on the combustion of coal is collected by ESP. This ash is now required to be disposed off. This purpose of ash disposal is solved by Ash Handling Plant (AHP).

There are basically 2 types of ash handling processes undertaken by AHP:

- Dry ash system
- Ash slurry system

***Dry ash system***

Dry ash is required in cement factories as it can be directly added to cement. Hence the dry ash collected in the ESP hopper is directly disposed to silos using pressure pumps. The dry ash from these silos is transported to the required destination.

***Ash slurry system***

Ash from boiler is transported to ash dump areas by means of sluicing type hydraulic system which consists of two t ypes of systems:

- Bottom ash system
- Ash water system

***Bottom ash system***

In this system, the ash slag discharged from the furnace is collected in water impounded scraper installed below bottom ash hopper. The ash collected is transported to clinkers by chain conveyors. The clinker grinders churn ash which is then mixed with water to form slurry.

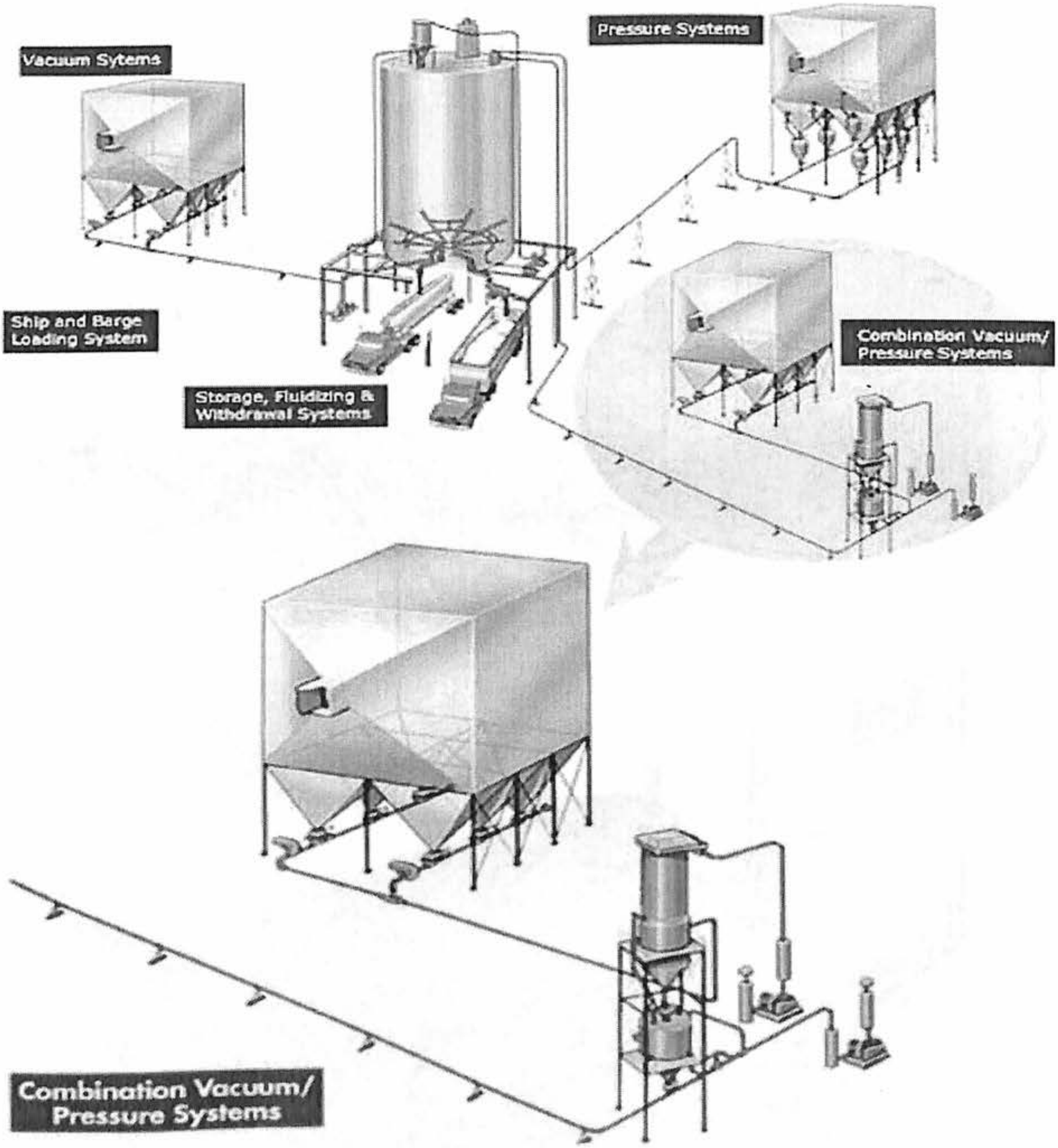
*Ash water system*

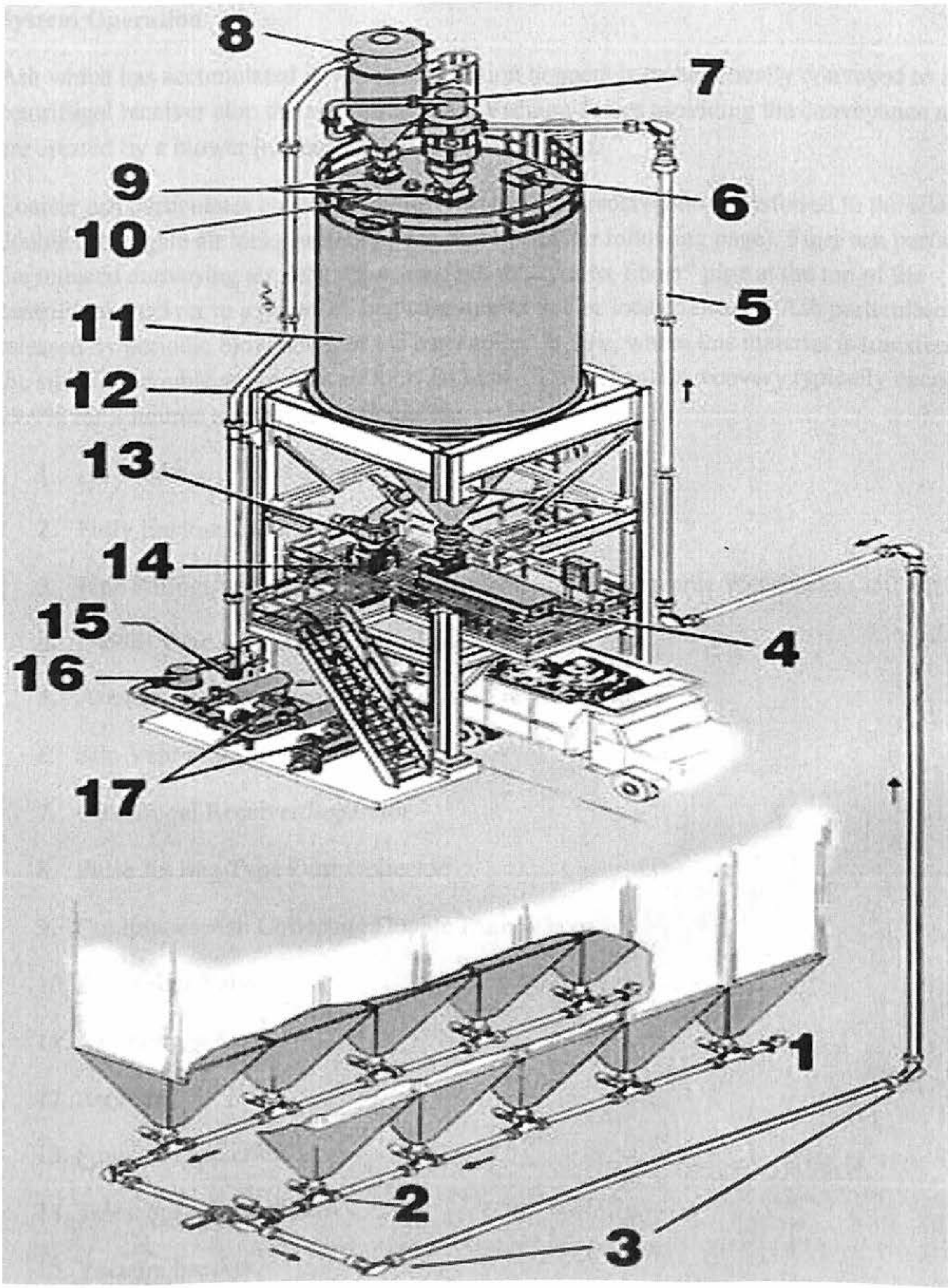
In this system, the ash collected in ESP hopper is passed to flushing system. Here low pressure water is applied through nozzle directing tangentially to the section of pipe to create turbulence and proper mixing of ash with water to form slurry.

Slurry formed in above processes is transported to ash slurry sump. Here extra water is added to slurry if required and then is pumped to the dump area.

*Fly ash system*

Even though ESP is very efficient, there is still some ash, about 0.2%, left in flue gases. It is disposed to the atmosphere along with flue gases through chimney.


Vacuum Sytems
Pressure Systems
Ship and Barge Loading System
Storage, Fluidizing & Withdrawal Systems
Combination Vacuum/ Pressure Systems
Combination Vacuum/ Pressure Systems




Vacuum pneumatic ash collection & ash conveying system

**System Operation**

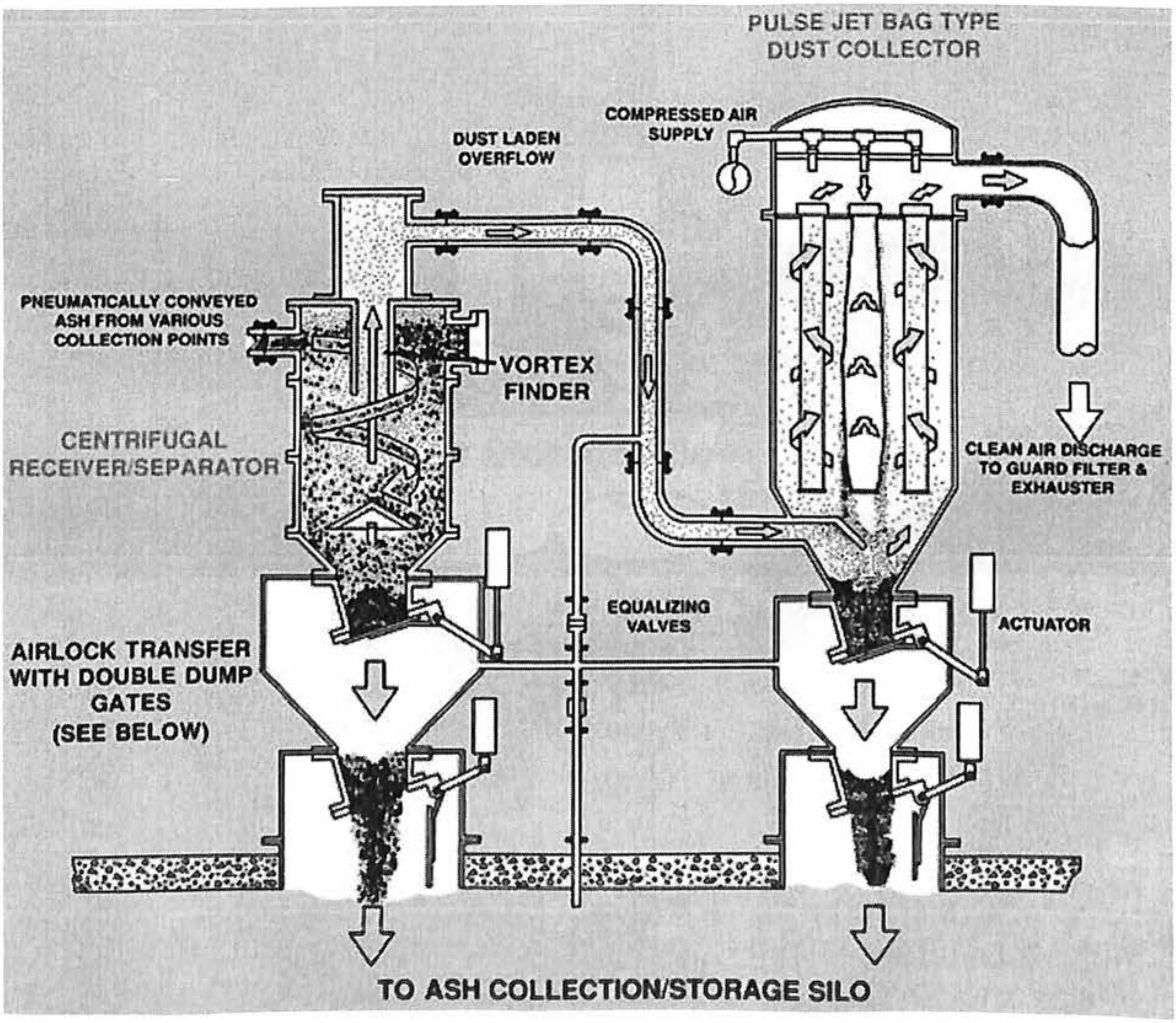
Ash which has accumulated in various collection hoppers is pneumatically conveyed to a centrifugal receiver atop the ash storage silo. Vacuum forces providing the conveyance air flow are created by a blower (exhauster) located near the silo.

Coarser ash particulates collecting at the bottom of the receiver are transferred to the silo via a double dump gate air lock assembly ( see description on following page). Finer ash particles and the induced conveying air flow report through the "vortex finder" pipe at the top of the centrifugal receiver to a pulse jet, bag type dust collector located nearby. Ash particulates released by periodic blow down of the bags collect below, where this material is transferred to the silo via a double dump gate air lock assembly. Overall solids recovery typically exceeds 99.9% for 2 micron and larger particulates.

1. Air Intake
2. Fully Enclosed, Quick Acting, Swing Disc valve
3. Pipe Fittings with Replaceable, Reversible, Interchangeable Wearbacks (550 BHN)
4. Paddle Type Ash Conditioning Unit
5. Abrasion Resistant centrifugally Cast Conveyor Pipe
6. Silo Vent Filter
7. Centrifugal Receiver/Separator
8. Pulse Jet Bag Type Dust Collector
9. Continuous Ash Collecting Double Dump Gates
10. Silo Relief Valve
11. Ash Storage Silo
12. Air Pipe
13. Fugitive Dust Filter
14. Telescopic Dry unloader
15. Vacuum breaker
16. Guard filter
17. Mechanical exhausters

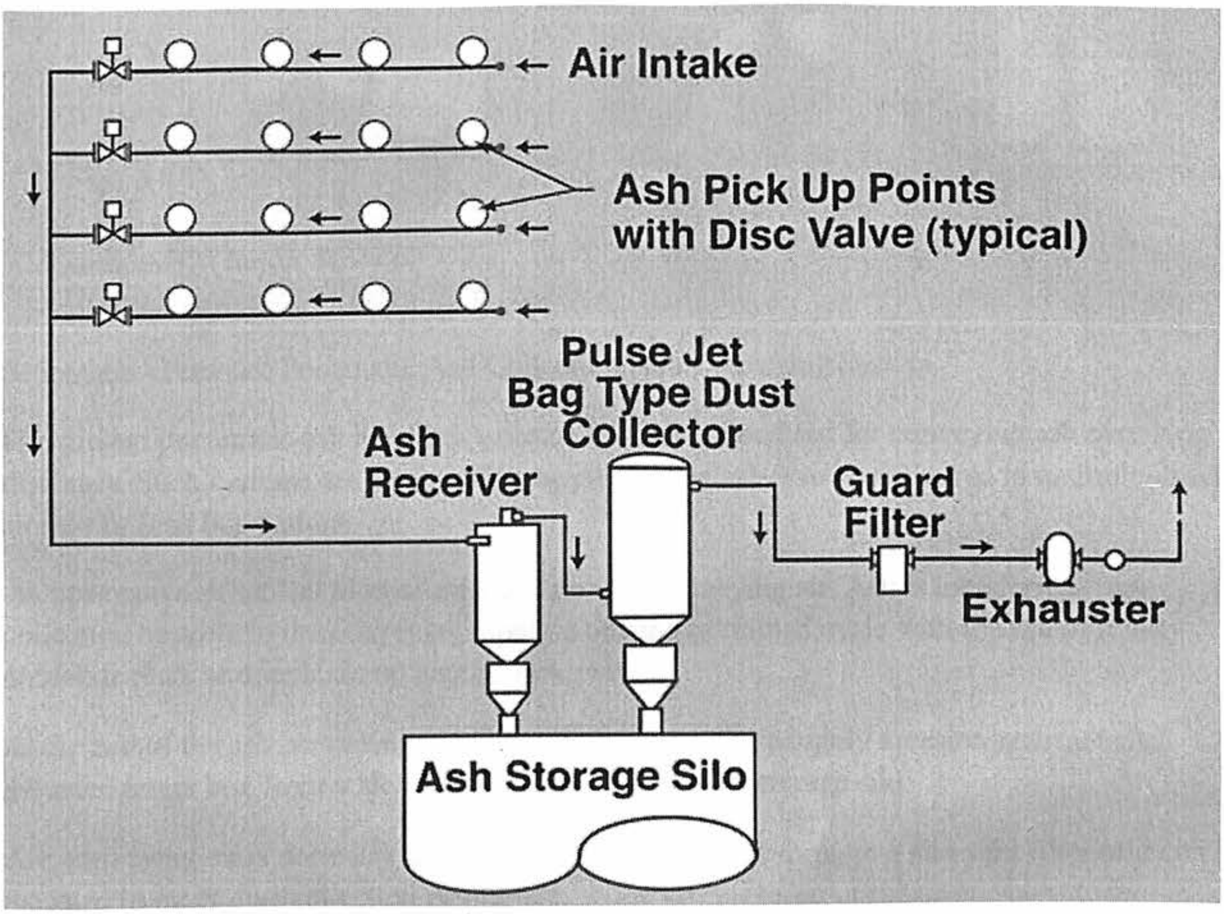
**Vacuum Pneumatic Ash Handling Systems**

Silo Top Equipment/Ash Receiver/Dust Collector

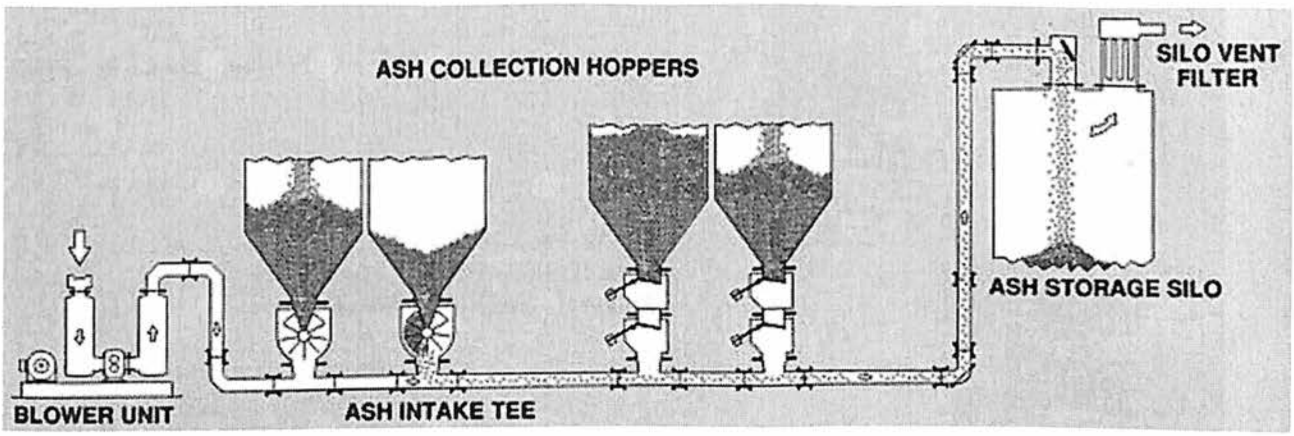


Drawing shows typical arrangement of equipment at top of ash storage silo -- for a vacuum pneumatic ash collection & ash conveying system.

**Typical System Schematic Diagram**



**Pressure Pneumatic Ash Handling Systems**




Schematic - Pressure Pneumatic Ash Collection/Ash Conveying System

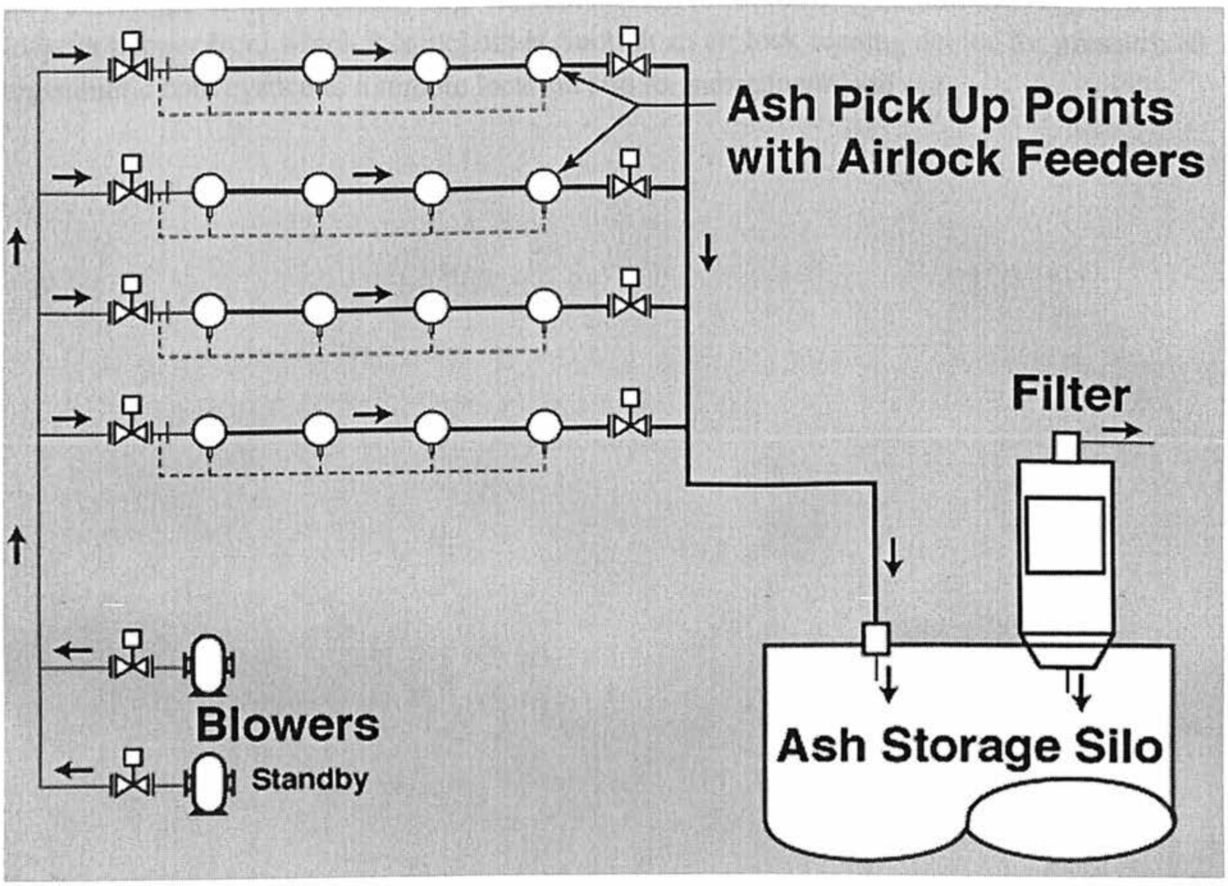
Pressurized pneumatic ash handling systems are most often used for conveying ash over long distances. Such systems are also usefully applied when ash is to be delivered to multiple interim storage or load out stations.

An upstream mechanical blower creates a flow of conveying air. Ash is transferred from collection hoppers to the conveying pipeline on a programmed cycle with the use of rotarty airlock feeders or double dump gate airlock valves.

At the end of the ash conveying pipeline ash is received in a highly abrasion resistant silo mounted target box from which it falls by gravity into the storage silo.

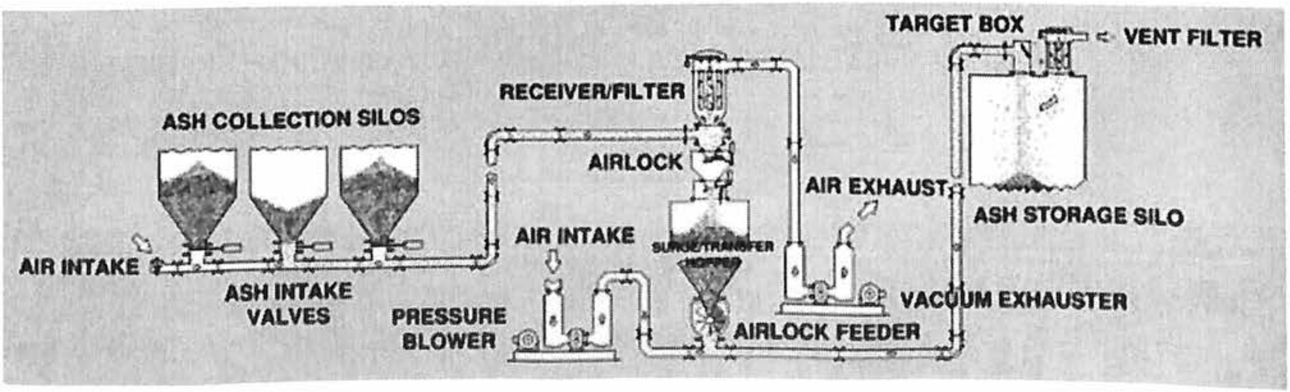
Ash conveying air is normally exhausted to the atmosphere through a silo vent filter or it can be recycled to other dust collection equipment.

## Pressure Pneumatic Ash Conveying Systems



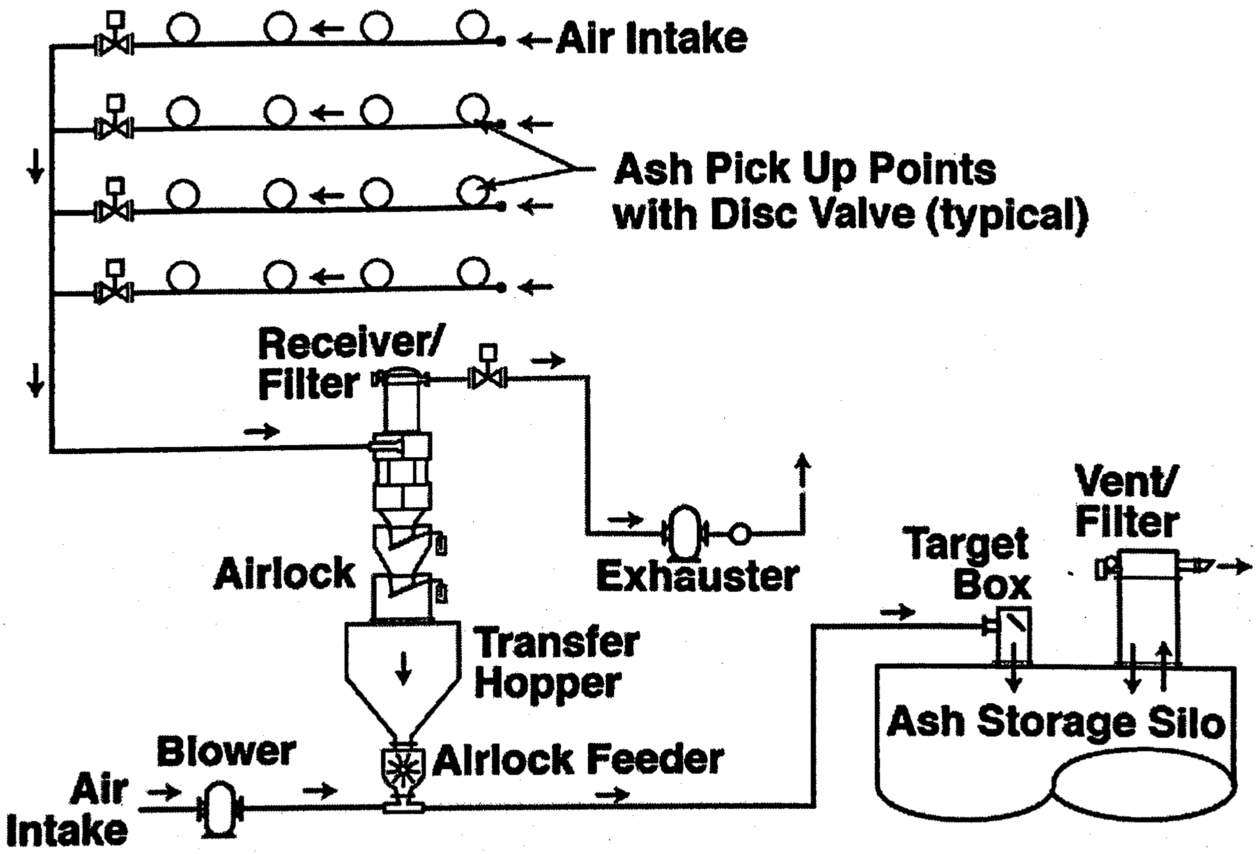

Schematic Diagram -- Typical Pressure Pneumatic Ash Conveying System

## Combination Vacuum/Pressure Ash Handling Conveying Systems



Combination vacuum/pressure pneumatic ash conveying systems can be beneficially applied to take advantage of the simplicity of a vacuum system for the collection and delivery of ash to a transfer hopper from which it is reclaimed through an air lock feeding device for pressurized pnueumatic conveyance to a remote location silo for subsequent load out.

System Schematic




In a combination vacuum/pressure ash handling system, ash is collected at various ash pick up stations by a vacuum ash conveying system which delivers the ash flow to an intermediate ash receiver and transfer hopper. Ash conveying air (vacuum) is developed by a downstream exhauster. A rotary airlock feeder reclaims ash from the transfer hopper from which it is conveyed by pressurized air to a downstream ash storage silo.

**Ash Handling Components**

## Clinker Grinder

A clinker grinder is a useful component in those ash conveying systems where coarse bottom ash or other coarsely sized material must be reduced in size so as to be suitable for pneumatic conveyance or other means of ash handling.

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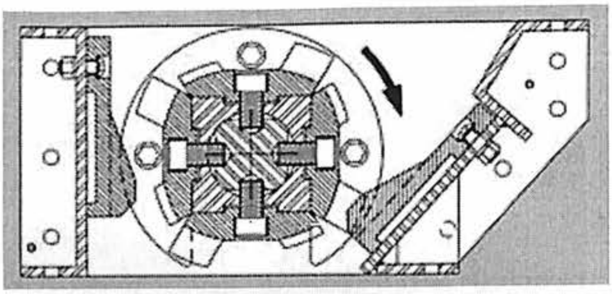
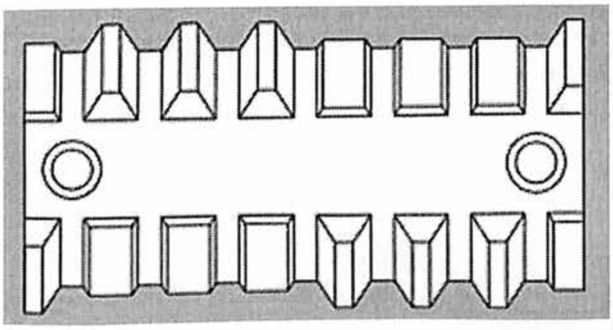
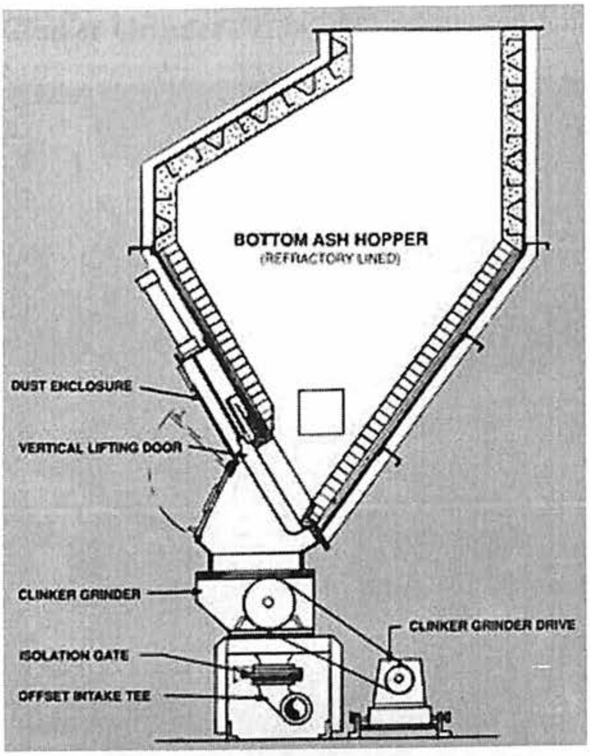


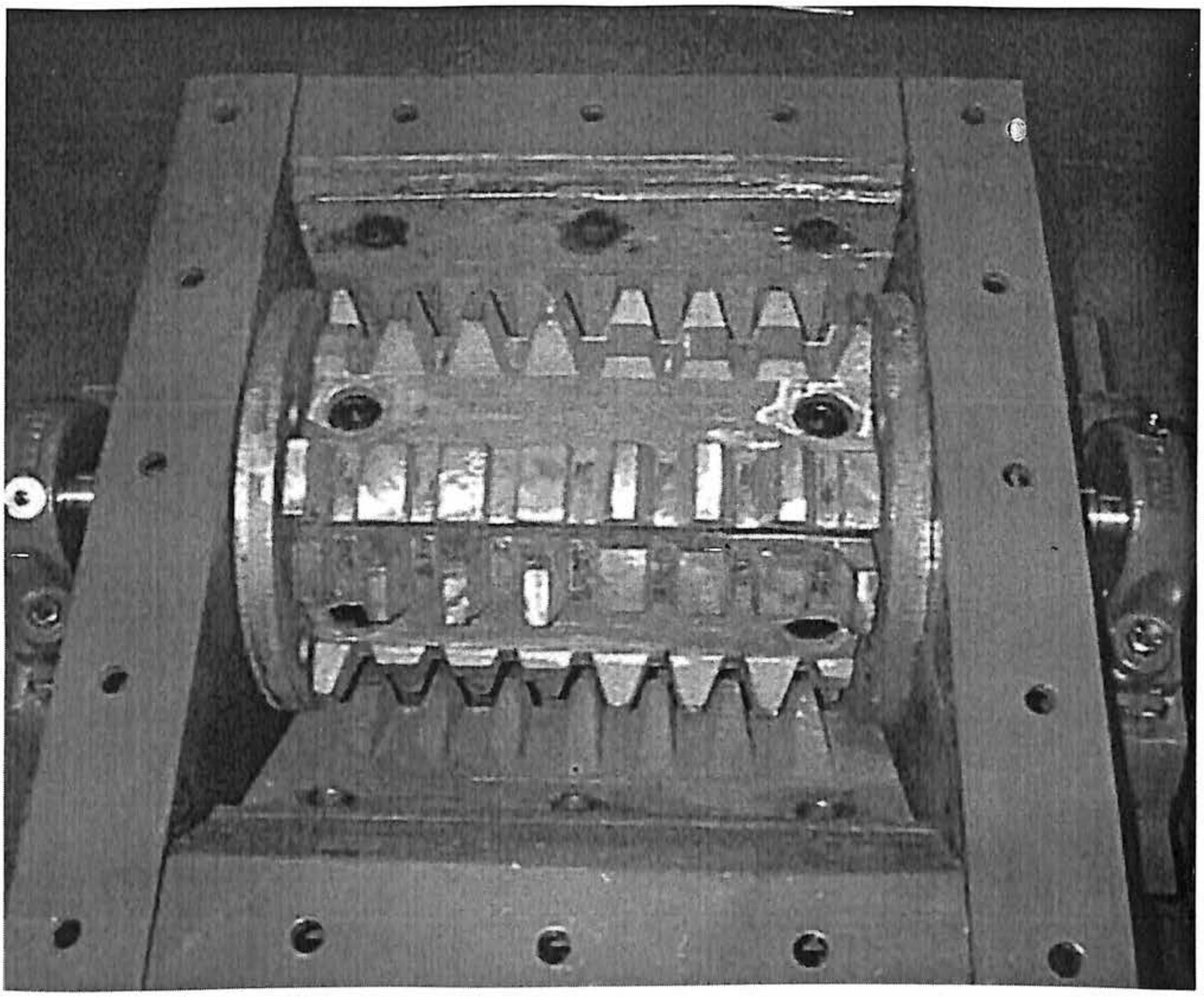
Construction details



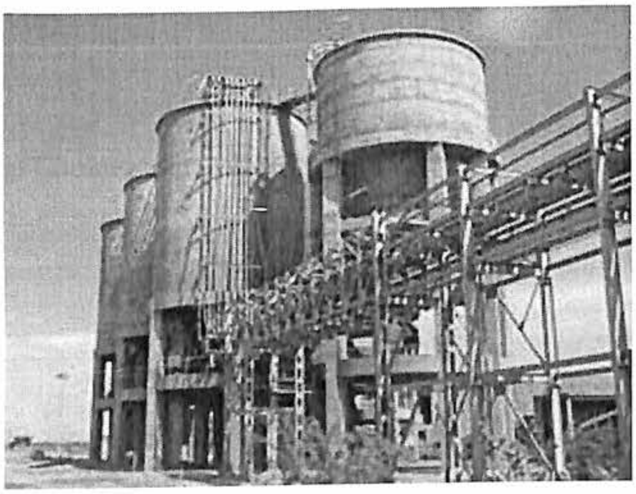


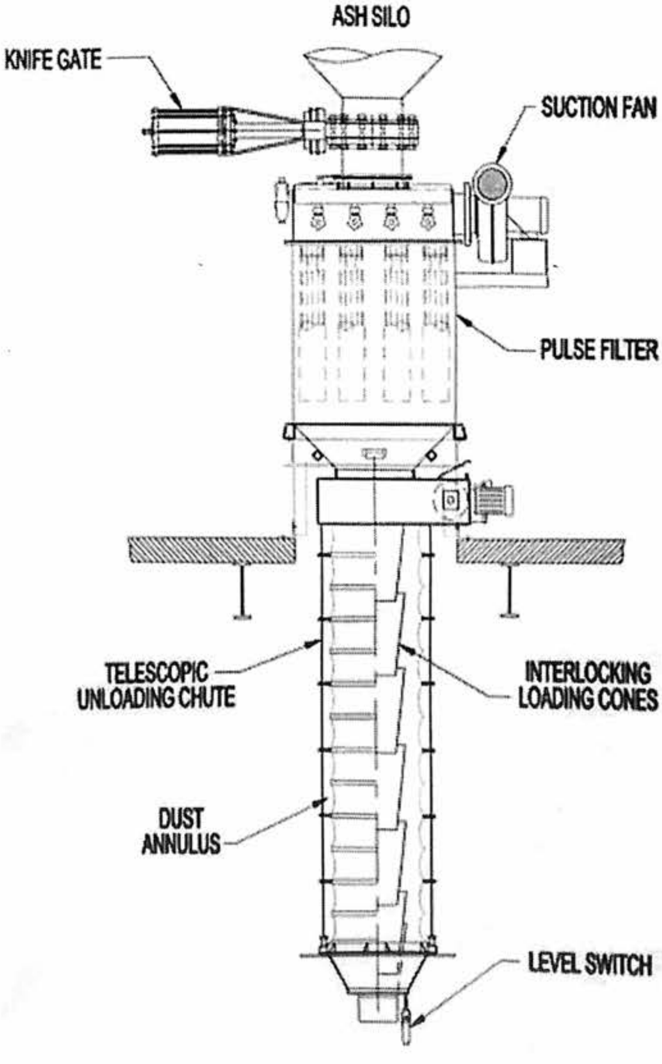

Clinker grinder reduces (crushes) bottom ash material to a size suitable for pneumatic ash conveying. Note offset intake tee for introduction of crushed bottom ash to the pneumatic ash conveying pipeline.

**Clinker Grinder**

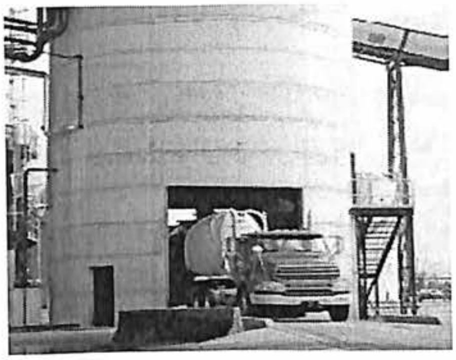


*Ash Storage Silos*






The Ash coming out of the unloading chute is transferred to waiting trucks for various uses.



Advantages of Silo System

i) Commercial utilisation of ash in :

- Cement additives.
- Brick plants.
- Road making, etc.

ii) Saving of water – a precious commodity.

iii) Energy Efficient

iv) High reliability

v) Long Plant Life

vi) Least maintenance

vii) Environment concern:

– In a period, when environmental protection and awareness is a major industrial and social concern.

Dense Phase pneumatic conveying, by totally enclosed handling system,is particularly amenable to the environment.

– All conventional problems of spillage, dust, contamination and storage are efficiently and successfully eradicated.

– Plant housekeeping is greatly improved.

# Conclusion

Ash utilization and ash handling is a major concern in power sector. .This ash is a raw material for the various types of the materials.IPGCL, one of the largest power utility of India, presently meeting more than one fourth of power demand by about one fifth generating capacity is also using coal as a main source fuel for power generation. The fly ash produced by burning Indian coal has tremendously used for different applications. Several areas of ash utilization where in technology demonstration projects have been completed or are underway include ash bricks, blocks, tiles, use in agriculture, embankmants, construction of roads, mine filling, raising dykes etching.

References:-


1. IPGCL manual
2. www.paryawaran.com
3. Environment and its basics by R.M Gordon