AERATION

Water aerated naturally by flowing over sandy or pebbly beds or rocky falls has been acclaimed by writers of all ages and countries. Only a few of these enthusiasts realized that the waters they so highly praised were clear, bright, sparkling, tasteless and odorless when they reached the streams. In the eighteenth century, artificial aeration was directed at making up the oxygen deficiencies of distilled water and of rain water that had been stored up in household cisterns. Towards the end of the eighteenth century and early into the next century, aeration was applied to a few public water supplies carrying decomposed vegetable or animal matter. Not until the last half of the nineteenth century did aeration become a marked feature of municipal supplies. Even then, the number of applications was small and pertained chiefly to stored surface waters subject to tastes and odors from algae growths. In this period aeration was applied here and there, generally to ground waters, for the removal of iron, and then of manganese, and also to eliminate malodorous gases from sulphur bearing ground waters.

Aeration is the process by which air is circulated through, mixed with or dissolved in a liquid or substance. In its broadest sense, aeration is the process by which the area of contact between water and air is increased, either by natural methods or by mechanical devices. Ordinary usage in water works practice has however, been given the term in the more limited sense referring specifically to use of mechanical devices or procedures. In this limited sense aeration clearly defines itself as a method of treatment rather than merely a modification of natural conditions at the source of supply. The terms 'natural aeration' or 'reaeration' are used to represent non-mechanical procedures or slower aeration of large bodies of water under natural conditions. In the progress of water from source to consumer, aeration is one of the most elemental techniques frequently employed in the improvement of the physical and chemical characteristics of water.

As suggested, the basic purpose of aeration is the improvement of the physical and chemical characteristics of waters for public supply. Primarily, this improvement involves the reduction of objectionable tastes and odors, but some additional benefits of aeration, as a preliminary step to other purification processes have also been noted.

In the cool stagnant bottoms of lakes and reservoirs during late summer and late winter, in deep wells and in the dry-weather flow of some sluggish rivers are found natural waters which are so deficient in oxygen that they are objectionable in both taste and odor. Aeration of such waters improves their tastes by supplying the deficient oxygen, rescuing the free carbon dioxide and eliminating much of the hydrogen sulphide and other odorous constituents present. Removal of iron and manganese from such oxygen deficient waters also usually requires aeration as an initial step. This initial step allows for the lower oxides of these minerals that are dissolved in the water and combined with carbon dioxide to be converted to higher insoluble oxides and in turn removed by subsequent sedimentation, contact or filtration.

Methods of Aeration of Liquids: Aeration of liquids (usually water) is achieved by:

- Passing the liquid through air by means of fountains, cascades, paddle-wheels or cones.
- Passing air through the liquid by means of the Venturi tube, aeration turbines or compressed air which can be combined with diffuser(s) air stone(s), as well as fine bubble diffusers, coarse bubble diffusers or linear aeration tubing.

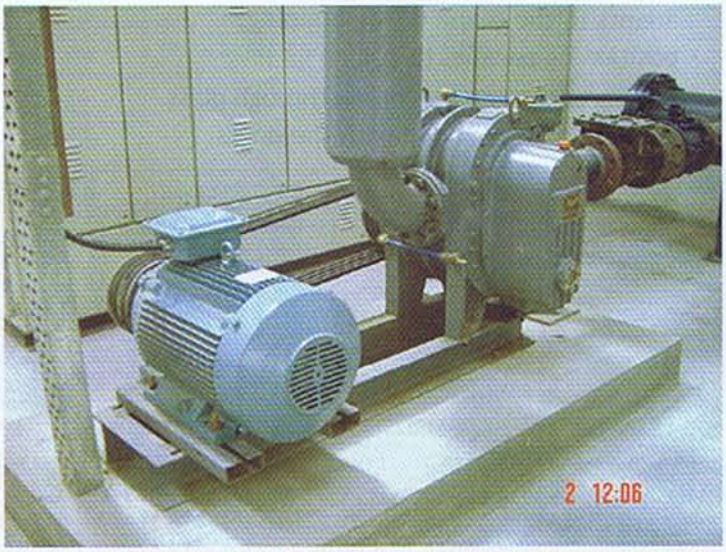

FIG: Typical Aeration Blower
(Photo Courtesy: Everest Blowers, New Delhi, India)

On a given volume of air or liquid, the surface area changes proportionally with drop or bubble size, the very surface area where exchange can occur. Utilizing extremely small bubbles or drops, increases the rate of gas transfer (aeration) due to the higher contact surface area.

The general idea behind aeration is to bring the water into intimate contact with the air. Either the water may be discharged into free air or the air may be forced into a body of water. Apparatus used includes: low cascades, multiple jet fountains throwing water to considerable heights, multitudinous spray nozzles discharging not far above the surface of a reservoir, superimposed trays or shelves, submerged perforated pipes, and porous tubes and plates. Motivation has been by gravity head for water, pumping head for water and pumping head for air. Chronologically, working installations consisted, first, of cascades and gravity operated multiple-jet fountains, then forced aeration for a few years of commercial exploitation, followed by low-throwing spray nozzles, and finally, diffusion of air through porous tubes and plates in water.

Uses of Aeration of Liquids:

- Production of aerated water for drinking purposes
- Secondary treatment of sewage or industrial wastewater
- To increase the oxygen content of water used to house animals, such as aquarium fish or fish farm
- To increase oxygen content of wort (unfermented beer) or must (unfermented wine) to allow yeast to propagate and begin fermentation
- To dispel other dissolved gases such as carbon dioxide or chlorine
- In chemistry, to oxidize a compound dissolved or suspended in water
- To induce mixing of a body of otherwise still water

The table below gives solubility of oxygen in fresh water, at sea level, for different water temperature. As evident from the table, oxygen solubility drops with increase in temperature. Similarly with salinity also there is a drop in oxygen solubility. For 35 ppt sea water the solubility values of the chart would reduce by about 15%.

Temperature	Oxygen Solubility (ppm)
0° C	14.6
5° C	12.8
10° C	11.3
15° C	10.1
20° C	9.1
25° C	8.2
30° C	7.5
35° C	6.9
40° C	6.4

FIG: Disc Diffuser Installation
(Photo Courtesy: Environmental Dynamics, Inc., U.S.A.)

Aeration can be accomplished by mechanical aerators or underwater air diffusers. Mechanical aerators agitate water to produce liquid to air contact, while underwater diffusers introduce air bubbles from a depth to achieve oxygen transfer and mixing.

There are a wide variety of surface aerators such as paddle wheels, pumps which spray water into the air, and several other devices. One aspect common with all these systems is that they all expend a great deal of kinetic energy in throwing large quantities of water into the air. Obviously if the systems are expending energy in this task, the energy is not being directly used to aerate or mix the water in the system, making them power inefficient.

Surface agitators often look very impressive, however, their influence over the oxygen levels in the system is rather localized to the area surrounding the equipment. This factor becomes very apparent in ponds with a water depth of more than 1 metre. If oxygen levels are measured at a depth or in the sediment, very low levels may be recorded. The low dissolved oxygen levels may lead to anaerobic sediment conditions and deterioration in water quality.

Bubble type aeration systems are replacing many mechanical aerators because of their low maintenance, high reliability, safety, flexibility and higher oxygen transfer efficiency. They are better at removal of gases such as ammonia and carbon dioxide. In this arrangement atmospheric air is bubbled through water through diffusers, which bubbles and rises to the surface of the water body and in process, the oxygen transfer takes place. Diffusers are designed to deliver either coarse (approximately 4-6 mm), medium (approximately 2-3 mm), or fine (approximately 1 mm) air bubbles.

Aeration is more than supply of oxygen and mixing. Aeration is the cornerstone of biological wastewater treatment. It controls the treatment performance and operational economics of the entire wastewater treatment facility. Analysis of wastewater treatment plant costs repeatedly shows that aeration accounts for 50% to 80% of the overall plant operating budget. Only by selecting the right aeration technology and a properly designed aeration system, can treatment performance and plant operating cost objectives be attained.

"Aeration is more than a capital purchase, it's an investment in total ownership cost".

The design of an aeration system is a complex process, which extends beyond simple selection and sizing of system components. True wastewater treatment plant optimization first requires a full evaluation of project objectives and an aeration system design focused to meet project objectives. Optimization also requires a properly operated and maintained aeration system.

Amongst the aeration techniques available, the most economical and widely used is Diffused Aeration System, where, through fine bubble tubular / Disc diffusers, moderate pressure air is pumped into the water body. For maximum economy and efficiency the tank depth is designed between 5-6 metres, allowing sufficient bubble contact time for oxygen transfer. The air requirement is calculated based on the Oxygen Demand/Need of the water body and the efficiency of the aeration system. The work done for any compressed air system is proportional to product of PV (Pressure and Volume). This clearly indicates that optimum design for minimum pressure and air flow would result in Energy Efficiency. Since the aeration plants are designed for round the clock operations the running Energy cost can be tremendous upsetting the entire project feasibility.

Most plant designers do not take air pressure and volume requirements seriously and allow generous factor of safety which may result in high operating energy costs. The Oxygen demand of any water body is never fixed/constant but varies depending on various factors and operating conditions. The Aeration systems should be designed to be able to deliver variable air flow, saving energy to meet the aeration demand. A close design interaction with blower manufacturers can result in great savings since many flow regulating techniques are available and selecting the most suitable, energy efficient and reliable technique for the system is essential.

Everest, manufacturers of Positive displacement blowers have a highly qualified and experienced team and offer complete technical solutions to all the OEM. It is economical to install energy efficient blowers as they are cheaper on "COST OF OWNERSHIP" calculations.

FIG: Typical Aeration Package Blower Assembly (Photo Courtesy: Everest Blowers, New Delhi, India)

A 4-Step Guide for choosing an Aeration System (Courtesy: Environmental Dynamics, Inc. – U.S.A.)

STEP 1: COST

The costs associated with owning and operating an aeration system are significant. Maximize return on investment with a present-worth analysis considering initial and long-term operating costs.

TIPS:

CAPITAL COST – Varies widely.

A fine bubble ceramic diffuser system (with gas injection components for cleaning and patent royalties) is twice the cost of a fine bubble membrane diffuser system.

INSTALLATION COST – Product specific.

Labor requirements for an EDI tube

diffuser system is 1/3 the cost of a disc system.

ENERGY COST – Single largest expense.

The 20-yr operating cost for a coarse bubble diffuser system can be 30X the capital cost for the equipment and up to 15X higher for a fine bubble system.

MAINTENANCE SYSTEM – Technology specific.

Repair frequency, labor, chemicals and replacement parts vary based on the selected technology. As a percent of initial cost, annual maintenance varies from less than 5% for a coarse bubble diffuser system, to 10% for a fine bubble diffuser system, and 20% for a mechanical aerator.

FIG: Tubular Diffuser Installation
(Photo Courtesy: Environmental Dynamics, Inc., U.S.A.)

STEP 2: SERVICE CONDITIONS

Consider the operating environment to ensure long term performance. Exposure to chemicals, moisture, and heat from process water and air feed stream must be considered when selecting the material of construction.

STEP 3: VERSATILITY

Not all biological reactors are created equal. Selection of aeration technology should consider reactor depth, basin construction, redundancy/reliability requirements, and accessibility for installation and maintenance.

TIPS:

REACTOR DEPTH? Use a diffused air system in deep applications as surface aeration devices do not effectively mix at deep depths.

EARTHERN BASIN? Use mechanical or diffused air system that do not contact the basin floor. Consider proper energy dispersion to avoid basin erosion.

REEDUNDANCY/RELIABILITY?

Installed spares, such as spare blowers and duplicate surface aerators, assure continuous, uninterrupted service capabilities.

SINGLE REACTOR?

Consider retrievable systems can be installed and maintained without draining the reactor.

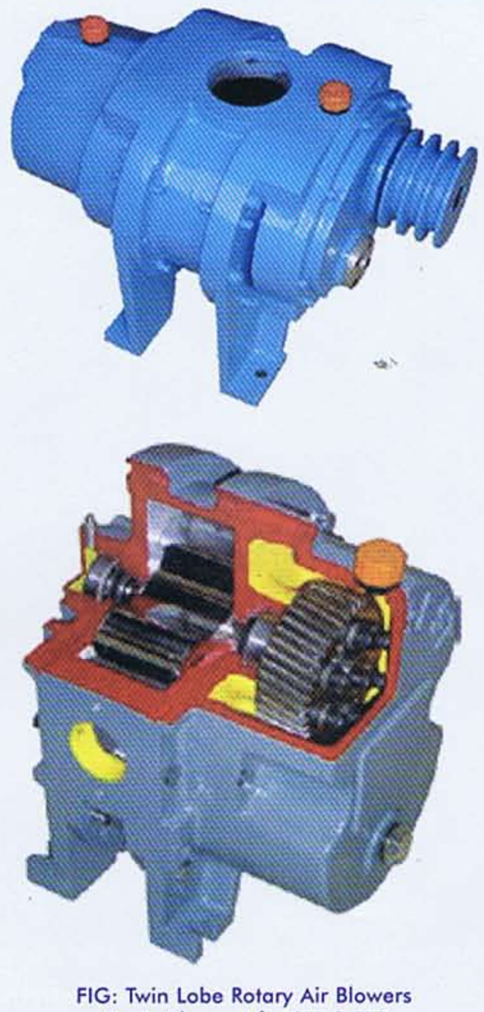

FIG: Twin Lobe Rotary Air Blowers (Roots Blowers) for STP & ETP (Photo Courtesy: Everest Blowers, New Delhi, India)

STEP 4: MECHANICAL DESIGN

Equipment is subject to rigorous, dynamic loads. For long-term mechanical performance, a rugged mechanical design is mandatory. Evaluate the mechanical design of all direct and associated components for compatibility.

Article compiled by technical team of
EVEREST TRANSMISSION
B-44, Mayapuri Industrial Area,
Phase-1, New Delhi-110064, India.
Telefax: 91-11-28114944, 28114955, 28116307, 28117469
Email: info@everestblowers.com ;
Web: www.everestblowers.com