India holds second position in the world in Aquaculture production producing about 2 million tones per annum, yet far below from China, which holds number one position with almost 32 million tones production *(Source aquaculture magazine 32nd annual edition)*. India has a large coastal boundary and scope of growth of Aqua farming is tremendous. Various research organizations are continuously working to upgrade aquaculture production techniques so as to enable farmers to get higher yield. Research in allied areas of aquaculture such as breeding, larvae rearing, feed, diseases control, plant management, transportation packaging is being done to optimize aqua farming, for higher profitability.

This article is focused on the role of air blower in Aquaculture.

EVEREST BLOWERS *for* AQUACULTURE

TECHNICAL BULLETIN 2004-2

EVEREST Transmission

All living beings require oxygen for their existence. Creatures of land take this vital element from air whereas water creatures take it from the water source they live in. The natural biological and physical factors constantly maintain balance by replenishing the loss of oxygen, thru natural means.

In a natural water body, the dissolved oxygen values in the water depend upon the interaction of biological and physical factors. The biological factors are the quantum of fish or prawn, the amount of organic load in the form of dissolved and particulate organic material, aerobic bacterial populations and primary producers like phytoplankton and macrophytes. The physical factors are temperature, wind velocity / turbulence, salinity and a balance with other gases like carbon dioxide and ammonia. While freshwater has a higher value of dissolved oxygen, in salt water it is less. As the salinity and temperature increase, the solubility of oxygen in water is affected.

The concentration of dissolved oxygen follows a natural sequence in a 24 hour period. As the sun rises the production of oxygen increases through photosynthesis and as the sun sets, the dissolved oxygen level falls due to respiration by plant and animal life, reaching minimum level towards the early hours of the morning. It is at such time the prawns and fish experience distress condition for inadequate supply of available oxygen.

In aquaculture management, additional inputs in the form of feed and aeration facilitate the aqua culturist to increase the oxygen carrying capacity of the water body, leading to realization of higher yields per unit area. Thus aeration system has assumed very great importance in the context of semi-intensive and intensive systems of aquaculture.

Temp	Oxygen Solubility ppm
0^0 C	14.6
5^0 C	12.8
10^0 C	11.3
15^0 C	10.1
20^0 C	9.1
25^0 C	8.2
30^0 C	7.5
35^0 C	6.9
40^0 C	6.4

The table gives solubility of oxygen in fresh water, at sea level, for different water temperature.

An evident from above table, oxygen solubility drops with increase in temperature. Similarly with salinity also there is drop in oxygen solubility. For 35 ppt sea water the solubility values of the chart above would reduce by about 15%.

Aeration Techniques

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 devises. The one aspect in 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 fish culture system, making them power inefficient.

Surface agitators often look very impressive, however, their influence over the oxygen levels in the aquaculture 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 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 thru 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. Coarse-bubble systems require the lowest air pressure and are very resistant to clogging, but are about one third as efficient as medium bubble systems in transferring oxygen to the water.

The medium bubble diffuser requires only slightly higher air pressure, but it's has superior oxygen transfer. The fine-bubble diffuser's superior oxygen transfer usually does not compensate for its higher-pressure requirement and much more frequency clogging.

Fine bubble diffusers, therefore, are typically chosen for pure oxygen or ozone systems where pressure requirements are usually less important than transfer efficiency. Overall, however, medium-bubble diffusers are the most popular among aqua culturists.

Conventional Diffuser techniques

Diffuser Type	Applications	Specifications
Drilled PVC type (Coarse bubble aeration)	Primarily for agitation, de-icing, prevention of Sludge Settling	Low oxygen transfer rates Flow (m3/hr) = $5nd^2$ *n = no. of holes* *d = dia of holes in cm.* *(Taking average velocity of 17.8m/sec.)*
Medium Pore Diffuser using stones made of glass bounded silica	General aeration in hatchery	Medium Diffuser transfer rates. Approx. bubble size 1-3 mm. Flow rate 01 0.15m^3/hr of 25mm length.
Fine bubble Diffusers Rubber membrane type	Pure gas applications. For high stocking density areas like in storage/ transport tanks, emergency aeration	High Oxygen transfer efficiency. Approx. Bubble size 0.5 mm Flow rate = 0.2 0.4 m^3/hr per cm^2 of membrane area

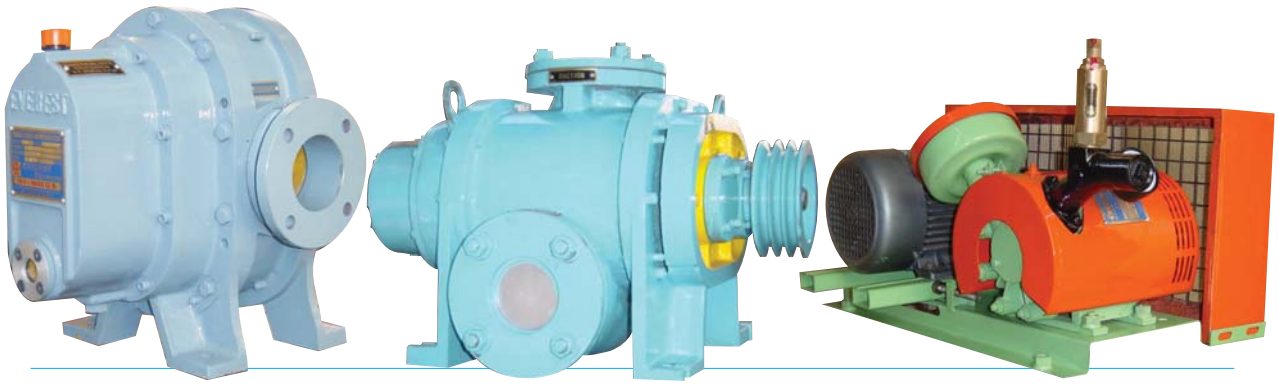
Conventionally, in Hatcheries multiple tanks are to be continuously aerated, the use of centralized air blower with distribution pipe grid is a general practice. Along the distribution grid, flexible rubber pipes are connected having ceramic diffusers/stones at their end, immersed in tank, through which the air is diffused into the tank. This arrangement offers host of advantages such as centralized air supply, low installation cost, low maintenance, high flexibility, efficient oxygen transfer and easy operations. Their role is very critical, therefore, high reliability and performance is of major concern. They are major power load in a hatchery and as they run continuously, energy efficiency is important.

Everest offers a vide range of energy efficient oil free air blowers which meet the desired essential parameters.

Everest Standard Air Cooled Blowers

Everest Aqua-Series Oil Free

Everest Dry Vane Blowers



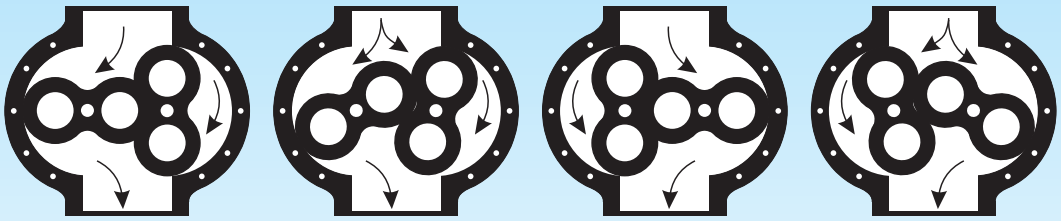
Everest Standard Air Cooled Blowers are most popular for their low cost and reliability. A wide range is available to cover practically any Hatchery requirement. They deliver oil free air as they have lip seals which isolate the lubricating chambers from the main gas chamber.

Everest Aqua Series of Air Blowers specially developed for Aqua applications offer 100% oil free air supply and are rated for continuous duty application. Unlike conventional air blowers, Aqua series have modified end plates, which are physically isolated from the lubrication chambers to ensure 100% oil free air even under worst case of oil seal failure, giving total protection to hatchery.

Everest Dry Rotary Vane Air Blowers developed by Everest are an ideal choice for low capacity low power applications, such as Brood stock aeration, Maturation tanks, aeration, Algae culture and seed transportation. These are small compact oil free blowers which can be run by single phase or 3 phase electric motor or even small engines. They differ in construction from the lobe blowers and have Graphite vanes running in an eccentric rotor assembly. They do not have timing gears and hence require no oil lubrication. They have simple construction making them easy to operate and service.

BASIC TWIN LOBE ROTARY AIR BLOWER PRINCIPLE

TWIN Lobe Rotary Air Blowers belong to the category of Positive Displacement Blowers. They consist of a pair of lobes, rotating inside a properly shaped casing, closed at ends by side plates. The drive to be is connected to the driven lobe, through a pair of gears and they always rotate in opposite directions. As the rotors rotate, air is drawn into inlet side of the cylinder and forced out the outlet side



against the system pressure. With each revolution, four such volumes are displaced. The air which is forced out is not allowed to come back due to the small internal clearance within the internals of the machine except a very small amount called 'SLIP'. There is no change in the volume of the air within the machine but it merely displaces the air from the suction end to the discharge end, against the discharge system resistance. Since the lobes run within the casing with finite clearances, no

These blowers deliver, practically, a constant flow rate independent of the discharge pressure conditions. The flow rate is dependent, largely on the operating speed. Due to these constructional features it has the following distinct characteristics:

- The flow is largely dependent on the operating speed
- The input Power is largely dependent on the total pressure across the machine.
- The suction & Discharge pressures are determined by the system conditions only.
- The temperature rise of the discharge air & machine is largely dependent on the working pressure.

Blower Selection: A right selection and installation of air blower can result in substantial energy saving. For proper selection of blower Air volume and Air pressure are the most important parameters on basis of which suitable model can be selected from a wide range of Everest Blowers.

Air Volume: It is the quantity of air required generally measured in m3/hr (or cfm - cubic foot per minute). It is the total air requirement of the plant and depends on the plant capacity or the quantity of water to be aerated. Detailed calculations are needed to establish the required air flow rate, based on initial oxygen levels, final oxygen levels desired, BOD demand, Oxygen transfer efficiency etc. However, as a thumb rule air requirement per 100 tons of water aeration can be taken as about 100m3/hr for medium pore diffusion aeration system (using stones). Accordingly the total air requirement can be calculated based on the total water quantity to be aerated.

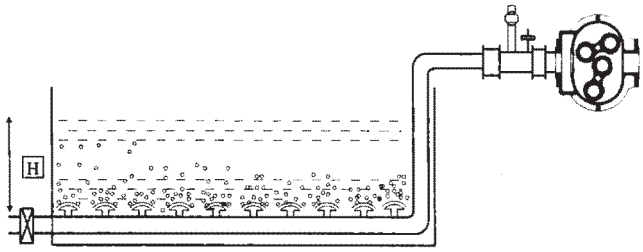
Air Pressure: It is the minimum air pressure required to enable air to bubble through the water, through the immersed stones, after overcoming the total pipe line drop from the blower room to the diffuser tank. Since power consumed by the blower is directly proportional to the air pressure, proper piping installation, sizing and no. of stones should be generously designed to minimize the air pressure demand. For a tank depth of 1.5 meter the optimum pressure requirement should be about 2.5 psi (1700mmWg). A pressure gauge, installed at the discharge of the blower delivery line gives the total back pressure load on the blower. Higher back pressure indication may be due to:

- High line losses due to small diameter distribution grid / piping
- High air flow
- Chocked suction filter
- Insufficient no. of stores / diffusers

A systematic step-by-step check can be made to establish the cause for excessive back pressure and the same should be corrected to optimize power consumption. High discharge air temperature is also an indication of excessive differential pressure across the blower.

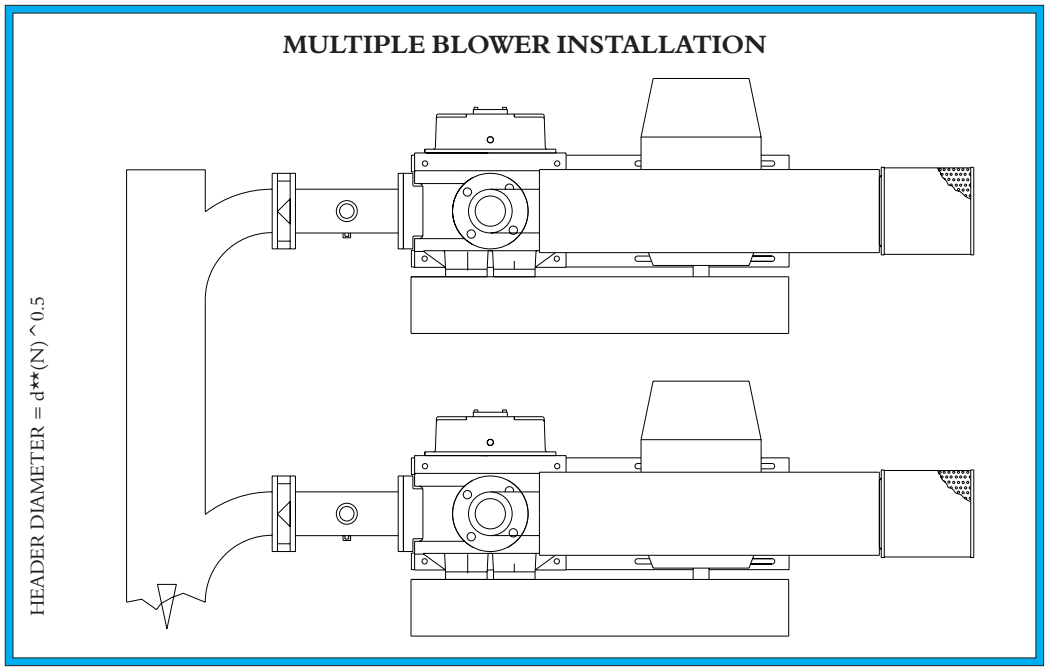
THERE is no compression or change in volume within the machine but the Blower works under system back pressure conditions. To illustrate further, let us consider a case when the discharge of a Blower is connected to the bottom of a tank, having water to a depth of 'H' mm. The air discharged out of the Blower accumulates in the discharge line until sufficient pressure is built (slightly over 'H' mm of WG), when it starts to escape out. The system resistance or the static load on the Blower is thus 'H' mm WG. The power consumed by the Blower depends upon the flow rate and the total pressure head on the Blower. A Blower is capable of resisting high pressures but the mechanical limitations arising due to increased power intake, temperature rise and increase in 'SLIP' restricts the working pressure head. The Blowers are generally selected for the maximum system pressure which they may encounter during operation and the prime mover is selected accordingly. When in operation, the Blower offers a considerable power saving since the power consumed by it depends upon the actual working pressure under which it operates and not the rated pressure. Consider a case when Twin Lobe Rotary Air Blower is selected for an application requiring a capacity of "Q"m^3/hr at "H"mm of WG at which the power is specified as "P" KW. Under the rated conditions it would consume "P" KW, but if the system back pressure falls from the rated/design value, the Blower automatically starts working under lesser head and power requirement falls accordingly. These salient features make Rotary Air Blowers a versatile machine. They are ideal for applications requiring Constant Flow Rate at Varying discharge Pressures.

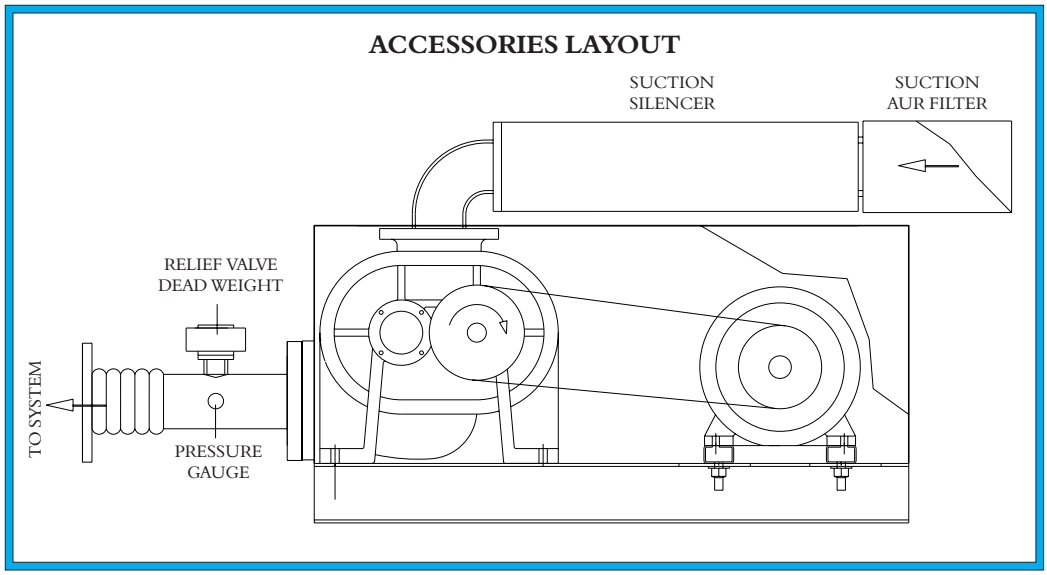
SYSTEM PRESSURES / BACK PRESSURE ON BLOWER



Blower Advantage: Everest Aqua blowers are custom designed for Aqua applications since Everest technical team, having studied the application and installation, incorporated all the essential features. We understand Aqua needs and are fully competent to answer all blower related queries. Total technical support and efficient after sale services contribute an integral part of Everest.

BLOWER INSTALLATION AND OPERATION





Blowers fail for a reason: The most common causes of failure include operating beyond the unit's limits of speed, pressure, compression ratios, temperature and horsepower. Additional failure causes are from installation mistakes, and the break-down of lubrication, improper oils, and high operating temperatures. Process conditions that either deposit material inside the blower or corrode or erode the internal parts, mechanical damage due to foreign objects (weld slag, nuts, or bolts) or non-compressibles going through the blower (sludge or a slug of water), are not uncommon causes of failure.

When a unit fails, the cause of failure can normally be determined by inspection of the parts. The following are some things you can look for to help solve problems in the field.

Overpressure

There will be metal-to-metal contact between the non-drive end of the rotors and the endplate and/or between the rotor tips and the inlet side of the housing. The extent of contact is relative to the amount of overpressure. Extreme overpressure, a dead head (blocked discharge) or continued operation with contact occurring will cause the rotors to make contact with the gear end plate. Overpressure causes the discharge temperature to exceed operating limits. The heat expansion of the rotors is at a faster rate than the housing. This causes the rapid expansion of the rotors to use up the free-end clearances. The process is the same for the rotor tips. The cool inlet side of the housing does not expand as quickly as the rotors causing loss of clearances and ultimately Blower seizing.

Causes

Everest Blowers being Positive Displacement Type Machines do not develop pressures on their own but work on System back-pressures. Overpressure is caused by some kind of restriction on the discharge side of the blower. This is usually the result of a valve closure or line blockage caused by product build up. Likewise, discharge piping that is too small can also create an overpressure condition. The Table gives the recommended line size based on flow and velocity. Column 1 indicates the expected pressure loss, in psi, for 100 ft. of line length.

Line Size Inches	Recommended Air Flow (m3/hr)
1.0 (25 mm)	17 (10 cfm)
1.5 (40 mm)	51 (30 cfm)
2.0 (50 mm)	93 (55 cfm)
2.5 (65 mm)	153 (90 cfm)
3.0 (80 mm)	305 (180 cfm)
4.0 (100 mm)	593 (350 cfm)
5.0 (125 mm)	932 (550 cfm)
6.0 (150 mm)	1440 (850 cfm)
8.0 (200 mm)	2966 (1750 cfm)

For Bends, valves etc equivalent pipe length can be determined for loss estimations. However, care must be taken to include bare minimum restrictions, valves, bends, and change in cross-section in the discharge line since all add to the line losses effecting Load on Blower & the power consumed.

All types of over pressures would result in Overheating & Overloading of the Blower. Frequent Motor Tripping / Burnouts can result .Continued Overpressure can cause premature failure of Blower Internals.

Starved Inlet

The outstanding characteristic of this failure is that the rotors, face of the end plates and the inside of the housing will take on a gold discoloration. The non-drive end of the rotors usually makes contact with the end plate. The rotor tips do not normally rub but can in some cases. Damage from this condition usually isn't as extensive as overpressure because the condition uses up available horsepower and kicks out the motor.

Causes

A large part of the blower cooling comes from the air it draws in. When the inlet flow is restricted due to choked filter, as line blockage by a valve closure or material buildup, over heating /over loading damage occurs. Clean / Replace filters periodically. A second cause is a reduction in blower speed. This could be a bad motor, loss of power, or possible single phasing of the motor. Mistakenly reversing sheaves when installing can result in this type of failure.

INSTALLATION

Areas of concern at installation are soft foot conditions, alignment of pipe loads, and drive alignment.

Soft Foot

These conditions result when the unit is anchored down and the surface is not flat. This condition caused a stress load at some point in the unit. When anchoring the unit down any contact point between the feet and the mounting must be shimmed to be sure the blower feet are square with the base. Do not tighten bolts to solve a soft foot condition without shimming.

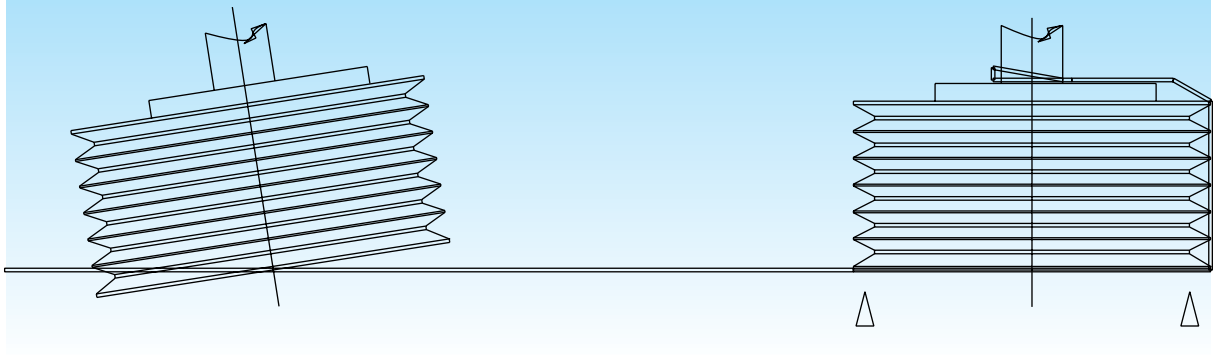
Alignment of Piping

This is as critical as anchoring alignment. This is true even when a flexible connector is being used. Flanges must be aligned to avoid stress loads by trying to draw the flanges together or by forcing alignment by use of bolt or pry bar. Both the soft foots and improper piping alignment can result in premature failure of a blower. Damage from these conditions can happen at startup, or later during operation upon the severity of misalignment. Damage resulting from a soft foot or piping misalignment could be a bearing failure with no damage to other bearing or gears. Intermittent or random contact of rotor to endplates and/or rotor tips to housing may occur.

Drive Alignment and Tensioning

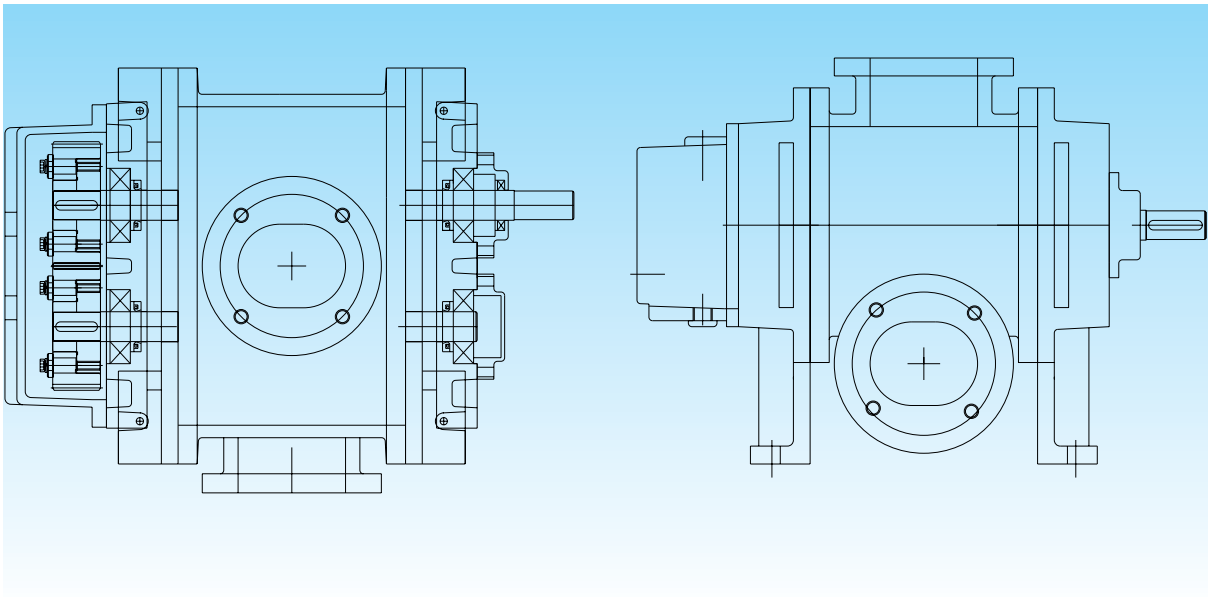
This can result in premature failure. Either belt drives or direct drives when not properly installed can result in excessive vibration and premature bearing failure. Drive alignment damage is usually failure of the drive shaft bearing and secondary dam-age to the drive shaft, gears and rotors. Sheaves that are not in line with one another will overload the bearing causing it to fail. If caught early, secondary damage may not be significant. An overhung load will cause the same damage. Excessive belt tension will also result in damage to the drive shaft bearing and in many cases causes fretting corrosion along the drive line. This can occur between the drive shaft and sheave bushing, but also look for fretting corrosion between the gear and rotor shaft, between the gear hub and the inner race of the bearing or between the bearing and the rotor shaft. Damage from a direct drive misalignment usually results in a drive shaft bearing failure without secondary damage. Bearing, gear and rotor damage can happen depending on how long the unit operates with the coupling in an axial loaded condition.

AN EASY WAY TO CHECK SHEAVE ALIGNMENT IS WITH A STRING



Lubrication

Lubrication failure is probably the most common. Most oils have lubrication additives that protect gears and bearing. Heat and contamination break down the oil, and it accelerates at higher temperatures. Breakdown of lubricants generally vary with type of oil being used and the type of severity of service. Recommended oil change varies from 250-1000 hours. The best way to determine when to change oil is to analyze oil at set periods and go for full oil change. Daily check up should be made for oil level and should be topped if required.



The breakdown of the oil will reveal a blower with all the bearing and the gears showing some stage of deterioration. Bearings will have loose inner races and wear marks. Pitting can also occur on the balls, rollers, and races. Gear teeth will have started pitting and may be creased. Gear creasing is an advanced stage of pitting. These will be a visible wear line across the tooth down in the root. These parts may be discolored with a brown varnished color. Lip seals in many cases will be brittle or worn. Bearings can be, but are not usually burnt or melted. Bad oil can look dirty, be thick like tar, have a strong odor, feel very gritty, or appear to be very thin in consistency.

Lack of oil results in catastrophic failure of bearing and gears. Gears can burn up and melt while bearings will appear to be OK. The gears can be at some stage of burning while one or more of the bearings will also burn. Usually one end of the unit will be alright while the other end is damaged. The key to determine this type of failure is the gears. If the teeth are melted and have turned blue there was NO oil in the chamber. If the teeth are melted and the gears show shades of brown and tan, there may have been some oil but not enough to properly lubricate.

(CAUTION) Once a unit has been operated without oil, the damage is done, and deterioration will continue at a rapid rate. DO NOT be fooled when you see the melted gears and/or bearing and the cover is full of oil. Regardless of the amount of and condition of the oil in the cover, it was run without oil and oil was added after the damage occurred.

Noise

Mechanical noise which is caused by the blower can be from rotor to rotor contact which can be seen by inspecting the rotors. A bearing or gear failing or any other metal-to-metal contact will require disassembly and inspection. External sounds may appear to be coming from the blower. Loose parts or bolts on the piping as well as loose or rattling valves will make noises that appear to be coming from the blower. A blower does not change the way it sounds while running. If the sound changes during a run it is caused by some change in the operating system or its speed.

For a normal Blower the Mechanical noise is Low in comparison to the Air Borne noise. Due to the suction of air from atmosphere and its discharge to the discharge line causes noise generation. Proper silencers at inlet and discharge reduce this noise considerably. However, for further reduction Acoustic Hoods are recommended

Blowers are made to move air and gases. The clearances in all units are not large enough to allow solids, slugs of liquids, or paste like materials to pass through them.

Solids

Solids leave unmistakable damage. Nuts, bolts, weld slag, etc., may pass through the unit but will leave marks on the rotors and sometimes on the housing. Damage can be broken teeth on gears, rotor shafts broken, and sometimes cracked bearing bores. Regardless of obvious damage if the rotor shafts are not broken and/or keyways spread, the rotor shafts MUST be checked for run out. Odds are, they are bent. Other solids such as shop rags, cigarette filters, wrappers, will not leave a mark on the rotors but the damage can be the same. Powder, paste, or flake materials may leave no visible marks, but some of the material will usually remain in the blower.

Liquids

Liquids in lesser quantities can pass through a blower without damage. Slugs of liquid will cause damage that will appear as a cracked or broken housing, cracked or broken bearing bores in the endplates, broken bearing races, and possible broken rotor shafts. All or some of this damage will be present.

Seal Leaks

The causes of seal leaks are best left to factory personnel or qualified repair centers. The signs of interior seal leakage are easy to diagnose. If oil is appearing in the process stream, or anywhere in the rotor housing the seals are leaking. On lip seal machines the endplates have open vent holes. If there is any oil coming from these vent holes the interior seals are leaking.

There are many reasons for seals to leak. Listed here are the more common failures and causes:

- Brittle or cracked sealing lip. Failure is usually caused by heat.
- Worn sealing lip. This is usually caused by a build up of dust behind the seal, which will work its way under the lip. This is usually the result of excessive material going through the blower.
- Pitting, scratches, or rust on the rotor shoulder will cause a lip seal to leak. The seal journal of the rotor must be polished.

FINAL CHECKLIST / TIPS

Selection Guide

1. Air should be conveyed as directly as possible at velocity not exceeding 15-20m/sec, so calculate piping accordingly.

2. Changes in the flow direction should be minimized. When bends are required, a turning radius to duct diameter ratio should not be less than 1.5.

3. Duct surface should be as smooth as possible.

4. Abrupt increase in area should be avoided because it tends to cause flow separation and turbulence. When necessary, expending transition piece should be used with half included angle of about 7 - 10 Deg.

5. Avoid abrupt decrease in area, whenever necessary use contracting transition piece having half included angle of about 30 Deg.

6. Keep Suction Filter and Silencer clean. Inspect and clean them frequently as dirty filter would cause pressure drop across it causing overloading on the Blower.

7. Avoid using valves in the suction/discharge line as they cause restrictions to the free flow. Use adequate sized valves, if unavoidable.

8. The total load on the Blower is the system back pressure + line losses. The pressure gauge, therefore, be connected close to the discharge of the blower to estimate total load. This should never exceed the specified limits.

9. Temperature rise of the discharge air is dependent on the differential pressure across the Blower. Air Cooled blowers are designed to withstand temperatures to 90 - 100 °C and for temperature range beyond this WATER COOLED BLOWERS recommended.

FINAL CHECKLIST / TIPS

Operational Precautions

1. The Blower should never be switched on LOAD as it would cause excessive back pressure, resulting in damage to the motor or the Blower. Off-loading valves must be kept open while starting the Blower.

2. Blower motors should be connected through overload relays, set to the motor ratings. This relay setting would safeguard both the Blower and the Motor in case of overloading. Frequent tripping of the relay indicates overloading and must be investigated.

3. Frequent overloading of the Blower may result in TIMING OUT condition and heavy knocking sound would come from the Bower. Switch off the blower in such cases and reset timing or ask for specialized help. Do not operate blower in such condition as it may cause major breakdown.

4. Check lubrication periodically, at least once a week. Poor lubrication would result in premature failure of the Blower internals.

5. While switching off the Blower, open the bypass valve. During switching off, a partial vacuum is created in the discharge line which may result in SUCKBACK of water into the discharge lines/Blower.

6. When two more Blowers are used in parallel to supply air to a common header, utmost care for pipe design should be taken to avoid flow separation and turbulence. A simple test to establish the above can be made at site by observing the change in the input current. Start any one blower and observe its input current. Switch on the second blower. On doing so the input current of the first should not increase by more than 10%. Keep on switching all the blowers observing the input current rise. A properly designed system would not result in the rise of input current when other blowers are switched on. Increase in current by blowers, when more blowers are switched on , indicates overloading which may be due to:

    i. Inadequate size main Header.
    ii. Improper line connection causing heavy flow separation and turbulence.
    iii. Final air outlets not sufficient to handle total discharge.

7. Always ensure that the blowers run against the pressure within their rated parameters. Excessive back pressure results in overloading and excessive temperature rise and may cause severe damage to the machine.

8. The total number of diffusers/stones must be sufficiently large to allow easy flow of air through them. Sufficient margins to compensate for diffuser blockage / choking should be kept while establishing the diffuser type and number.

TO GET THE MOST FROM YOUR EVEREST BLOWER

MAKE SURE proper oil levels are maintained in the gear end and grease in the bearing end.

CHECK OIL level and grease every 40 hours of operation. Loss of oil or grease should be replenished.

FIRST OIL change should be done within the first 100 operating hours and thereafter every 1000 hours or more often, if oil gets dirty.

CHECK BELT tension every fortnight. Too tight belts would cause premature bearing failure while too loose belts would cause overheating of belts and pulleys.

CHECK REGULARLY for any knocking or abnormal sound. high frequency sound indicates bearing trouble. Knocking sound indicates rotor timing upset. Contact "Everest" for necessary adjustments.

CLEAN AIR filter every fortnight by reverse airflow. Choked filter would result in excessive power consumption and overheating of blower. Replace filter every three months or earlier.

CHECK AND clean air silencer every month.

EVEREST Transmission

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