THE HST COMPRESSOR

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ABSTRACT

Bearings have been widely used all over the world in many different applications. They are small parts of machinery, yet indispensable in almost all applications. There are so common today that we tend to remain blind to the latest bearing technology breakthroughs and flow-on benefits.

The Conquest of Space brought us a lot more than a picture of a flag on the moon. It provided us with the impetus to develop and test newborn technologies in extreme conditions. As a result computer control technologies have advance rapidly in the past forty years. Now the stage is set for the application of these now mature technologies into novel applications.

The friction bearing of the past has been superseded by high-speed magnetic bearings made possible by advanced control hardware and software.

In the water industry, fine bubble membrane diffuser systems and mechanical aerators rely on a supply of air under pressure. High speed compressors are traditionally used in the municipal and industrial wastewater treatment plants and industrial applications like production of glass wool insulation, production of thin sheet metal, other low pressure applications worldwide.

The HST Turbocompressor makes use of the new bearing technology and incorporates a number of other operational benefits and are now being used to replace the old aeration compressor systems to provide the required air. These units are based around a high-speed motor with integrated turbocompressor, a frequency converter and magnetic bearings. The magnetic bearings used in the units have no wearing parts, require no oil, generate no vibration and thus are highly efficient.

1.0 INTRODUCTION TO THE HST COMPRESSOR

The HST turbo compressor is a successful state of the art application using contact free bearing technology

HST is a single stage radial turbo compressor specifically designed to meet the aeration requirements of wastewater systems and many process applications like pulp and paper industry, air knife (constant galvanizing line) industry etc

HST unit includes a fan impeller directly mounted onto the motor shaft. The mechanical side of the HST compressor is therefore resumed to a single moving part spinning at high speed without any friction

The frequency converter is spinning the shaft up to 16 times the normal frequency thanks to two sets of magnetic bearings
This combination allows speed modularity without any lubrication or vibration. HST is a complete design turbo compressor solution including local control, built in variable speed control and vibration free operation mounted inside a noise enclosure delivered as a standard package.

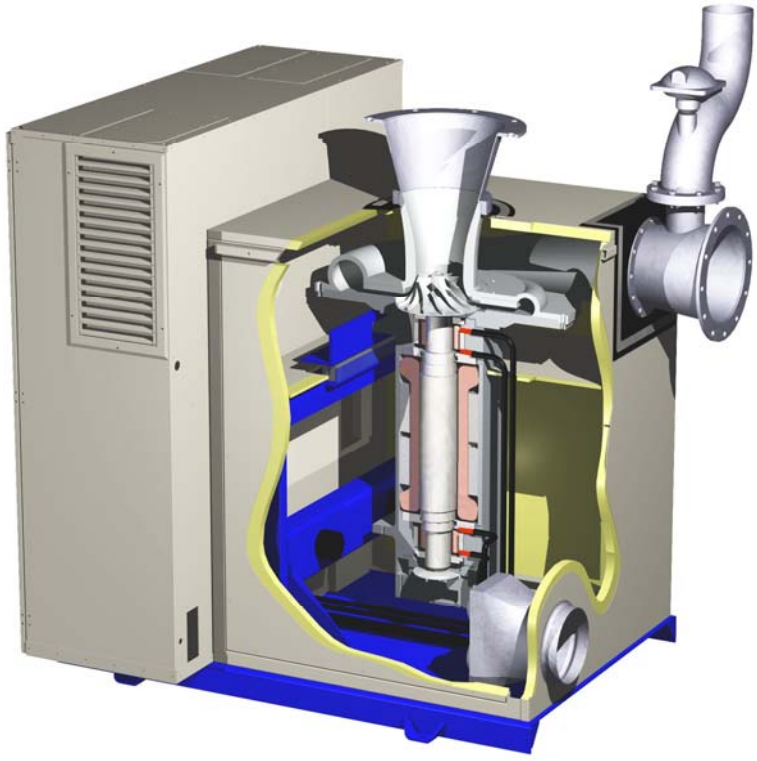

Figure 1: *Cutaway View of a HST Compressor*

2.0 DISCUSSION

2.1 Magnetic Bearing features

All traditional bearings have a predicable lifetime and will need replacement on regular basis. They all generate waste heat and friction and require lubrication at regular intervals. These limitations could now being overcome.

Different concepts have been developed over the years by various researchers. The thrust of most of this research is to reduce friction and achieve greater operating speeds. The point of contact in the all common bearings is the source of friction, the site of lubrication and ultimate limiter of speed. The idea is to remove the contract points. This has led to the development of magnetic bearings.

Magnetic bearings support load using magnetic levitation. The rotating shaft can levitate and permit relative motion without friction or wear. Compared to conventional machinery, they have the following advantages;

- Light weight
- Compact structure
- Safe operation
- Higher efficiency through a large operational region

The magnetic bearing consists of an electromagnet assembly, in which the magnetic field is produced by the flow of an electric current. The physical arrangement of the magnetic bearing is little more than high school science – by far the most complex part of a magnetic bearing is the control system, the Magnetic Bearing Controller (MBC).

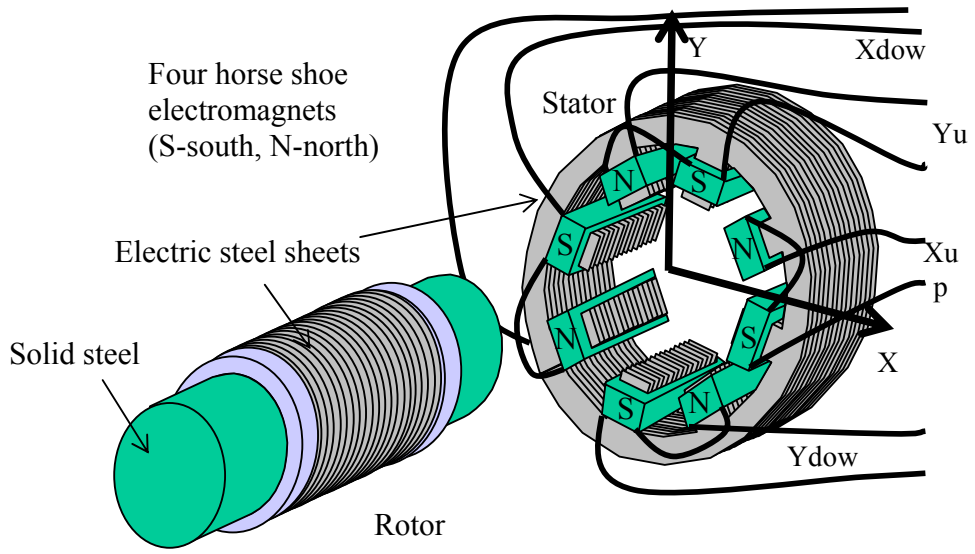

Figure 2: ***Magnetic bearing general arrangement***

2.2 Magnetic Bearing Controller

The magnetic bearing controller includes a signal processor, power supply, controller; amplifiers in order to control radial and axial bearings. A battery backup is also provided as the bearing fails when power is cut. The complete magnetic bearing assembly includes position sensor, rpm sensor and safety bearings (also called touchdown bearings).

As soon as the power is turned ON, the shaft is levitating in between the magnetic bearings.

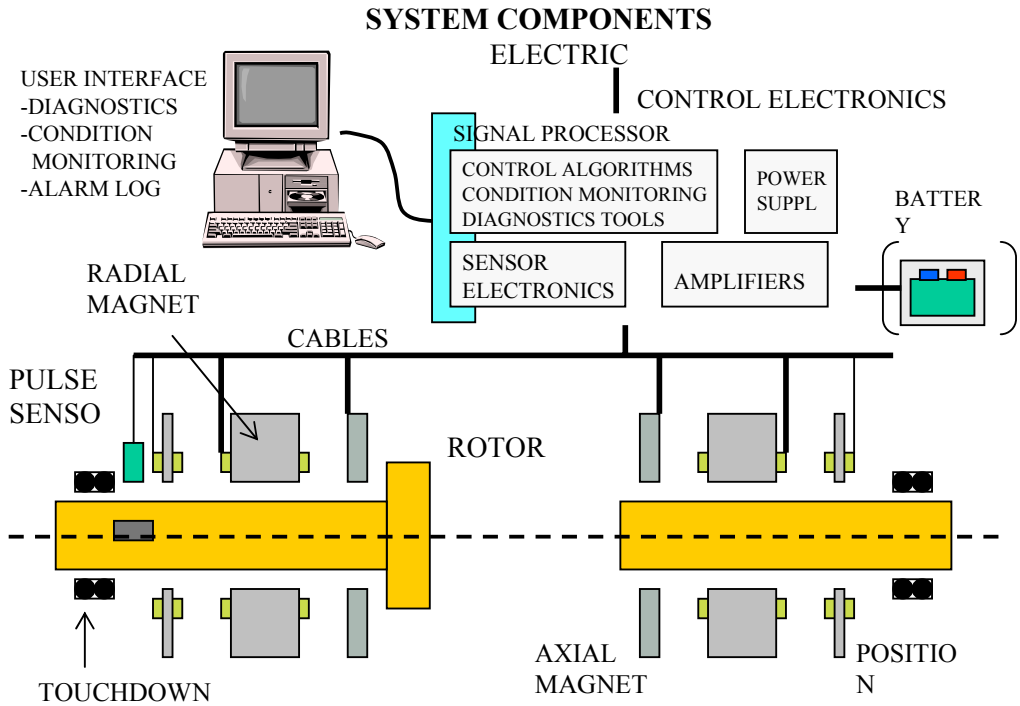

Figure 3: ***Magnetic bearing schematic***

The power amplifiers supply equal bias current to two pairs of electromagnets on opposite sides of the rotor.

In conventional magnetic bearing design only the attractive magnetic force is utilised. This is part of reason why control of magnetic bearings is very complicated

AMB OPERATION PRINCIPLE

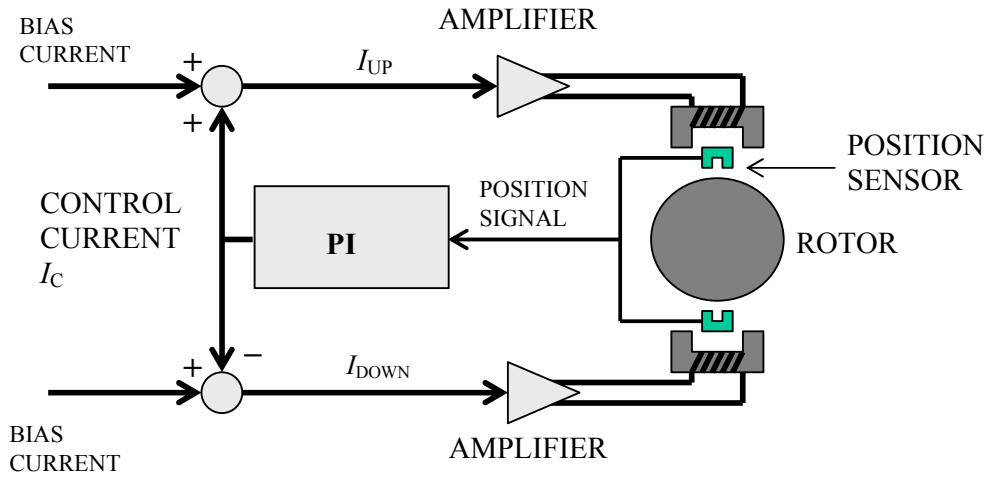

Figure 4: ***Magnetic bearing control schematic***

The position sensors provide a feed back to the PID about the exact location of the shaft. The PID will then adjust the attractive power of each magnet in order to keep the shaft in the predefined optimum position by adding or reducing the amount of current going through the magnet

3.0 HST COMPRESSOR ADVANTAGES

3.1 Construction

The successful HST combination of magnetic bearing and frequency converter provides many attractive advantages and simplify the process in which it's employed
In case of excessive pressure ratio or intake temperature in a waster water treatment plant aeration system, HST integral can automatically adjust the air flow delivery to the new conditions by increasing or decreasing the shaft rotational speed, which guarantee continuous process air delivery.

This is not always possible using traditional compressors as their impeller height, diameter and blade angle are designed for specific operating conditions, this lack of flexibility could lead to expensive shut down and adjustments repairs costs.

A summary of some blowers' type available on the market and theirs characteristics is outlined in Table 1.

Table 1: *Summary of the type of blowers available and their characteristics*

	1 st. Turbo Compressor	1 st. Turbo Compressor	Screw Compressor	PD (Roots) Blower	Multistage Compressor
Design / remark	**HST**	conventional	oilfree	2 / 3 Lobe	EU: seldom
Design pressure ratio	1,35 .. 2,60	1,35 .. 3,20	1,60 .. 3,50	1,20 .. 2,00	1,20 .. 1,80
Design flow range	1800..10000	2500..100000	800..18000	30..12000	500..50000
Positive displacement	no	no	yes	yes	no
Flow control range	40%..120%	45%..100%		50%..100%	60%..100%
Multiple units flow control	parallel	cascade	cascade	cascade	parallel
Average efficiency at flow control range	excellent / good	excellent / good	excellent / good	good / poor	medium / poor
pressure ratio > design point	yes	no	yes	yes	no
Flow control by	speed	ODV (IGV)	speed	speed	Inlet throttle
Performance optimizing	speed	IGV / none	(speed)	(speed)	none
Impeller(s) manufactoring	serie	case to case	serie	serie	serie
Bearing design	magnetic	slide / ball	slide / ball	ball	ball
Bearing locations + E-motor	2 radial, 1 axial	2+2 radial, 1+1 axial	4+2 radial, 2+1 axial	4+2 radial, 2+1 axial	2 radial, 1 axial
Power transmission	none	coupling	coupling	V-belt	coupling
Gear box	none	yes	yes	yes	no 1)
Oil lubrication	no	yes	yes	yes	no 1)
Noise level, std. delivery	low	medium	high	high	low
Maintanance & service	10%	100%	80%	50%	25%
Spare rotor availability	good	poor	medium	good	good
Compactness	excellent	good	poor	poor	poor
Weight	40%	80%	100%	100%	80%
Competition to HST	-	high	high / medium	medium	medium
Number of moving mech. parts	1	extremely high	medium	high	low

3.2 Installation

HST benefits from a light weighed compact design with small footprint, vibration free which delete heavy foundation and base plate requirements from the civil cost.

Figure 5: *Size of HST compressor and space saved*

We can easily observe on the picture above the difference between traditional blower space requirement and HST foot print delivering the same amount of air. A lot of capital cost could be spared using HST turbo compressors as we can usually double up the air production capacity within existing blower building.

All HST units could be located on site using a forklift and they are delivered completely assembled and tested which save installation and commissioning man hours.

3.3 Maintenance and Operation

Aeration energy consumption represents 50 to 60 % of the total energy demand of a waste water treatment plant and up to 30 % of the operating costs in activated sludge plants. Great savings could be achieved by using automatic DO control and constant air feed regulation. Up to 8 HSTs in parallel can be controlled and monitored via single Master Control Unit (MCU) using feed back signals from the plant automation system or SCADA. The MCU is programmed to operate the HST so as to achieve maximum electrical consumption/air demand overall efficiency. Optimization of operation at all times could cut from 25 to 40% in plant energy costs

HST overall efficiency remains relatively high and constant across the entire operating flow range. This not the case with traditional compressors, they are designed to meet a specific operating point therefore their overall efficiency drop drastically while moving away from that best efficient point and the power consumption increases.

HST maintenance only require the replacement of air suction filters twice a year, this is another major advantage of using HST in waste water treatment plant as it cut down traditional compressor maintenance costs by 10.

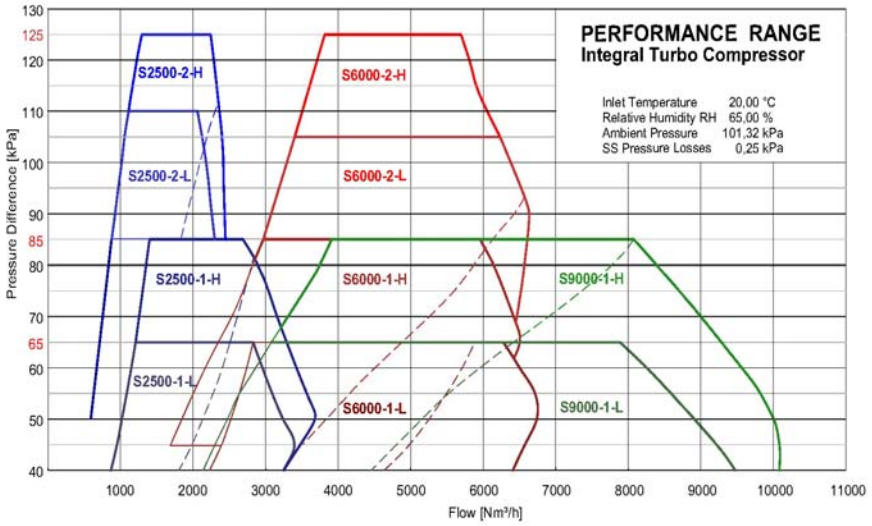

Figure 6: ***Performance range of turbo compressor***

4.0 CONCLUSIONS

The smallest investment cost is not always the most economical choice as it only represents the top part of the iceberg, which is less than 10 % of the entire life cycle cost. Using HST superior contact free bearing system combined with a frequency converter, you can seriously cut down on operation and maintenance cost and easily get your investments cost back within two years.

The key lies with the customer ability to project itself 5 to 10 years in the future demand of his treatment plants and his ability to understand the wide panel of costs involved between the use of traditional multi components compressor and a single stage contact free moving part turbo compressor.