Efficiency Beyond the Blower

Author:

Chris Livingston

Western United States Sales Municipal Sales

HSI, Inc.

clivingston@hsiblowers.com

KEYWORDS: Process Control, Blowers, MOV, Pressure Control, Energy Usage

The Problem:

Blower technologies have increasingly advanced over the last decade but are hamstrung by the inefficient or absence of process control systems.

Goals and Objectives:

- Provide brief scope of blower technologies and advancements in efficiency
- Demonstrate how control of blower and system equals the turnkey solution plants require
- Illustrate the key benefits of a Flow Control system utilizing Mostly Open Valve versus traditional control systems

Introduction to Blower Technologies:

Air blowers represent a significant percentage of a waste water treatment plant's (WWTP) power consumption. This can add up to millions of dollars over several decades in electrical costs alone. While selecting a more efficient blower will help alleviate much of this cost, there are factors beyond the blower which discourage peak efficiency of system operation. More so, what is advantageous about of spending additional capital on an efficient blower if they are not controlled efficiently?

First, however, one needs to consider the four major blower technologies within the water and wastewater markets:

- internally geared single stage
- positive displacement

- multistage centrifugal
- gearless single stage, or “turbo”

Each of technology is able to provide a form of solution to water and wastewater applications through their standard “ON/OFF” function. Further, each embrace performance strengths unique to the technology positively affecting efficiency, turndown, flow capability, etc. However, these strengths are often limited by their absence of smart blower and process control.

Local and Process Control

Many of the factors within a WWTP which hinder a blower system’s efficiency do so with the absence of control. Control is the solution to optimizing a plant’s aeration process. There are two forms of control to consider; local blower control, and process control.

Locally, all technologies listed above come with the most basic control to provide protection only. This is achieved in a variety of manners depending on the technology but all aim for the same purpose of protecting the blower. For this reason, blowers with this most basic form of control only provide two benefits to plant operators; a pre-set airflow and protection.

Process control refers to the entire aeration process, from blower motor to actuated valve before basin, all of which is controlled via a Master Control Panel (MCP). Plants utilizing process control gain real time trending and response to varying site conditions and requirements, operating more efficiently and saving energy.

Factors Affecting Efficiency

The vast majority of blowers in the water and wastewater markets have little to no process control and very basic local control.

For example, most of the multistage centrifugal blowers in operation are manually controlled via an inlet butterfly valve. Since the motor is operating at constant speed, the valve must be closed a certain percentage in order to hit the application’s design point. This is known as inlet throttling, or choking a blower. A strong analogy for this type of control would be to operate a vehicle with one foot fully pressing the gas pedal and using the brake to vary the speed of the car. Throttling a blower greatly lowers the efficiency of the system as the blower is throttled to achieve its desired flow and pressure.

A simple and cost effective solution is to outfit the multistage blower with a variable frequency drive (VFD) and upgraded control panel. The control panel dictates a higher or lower air volume requirement and calculates the necessary speed which is then send to the VFD. The VFD then sends a hertz signal to the motor either increasing or decreasing the RPM. Instead of throttling the inlet the blower is now controlled by speed, operating at less horsepower to achieve the same design point. Figure 1 below illustrates the power draw difference between a throttled multistage and VFD driven multistage:

Figure 1: Comparison of VFD & Throttled Multistage Blowers Across Summer, Average, and Winter Conditions

MULTISTAGE CENTRIFUGAL BLOWERS

	3500 SCFM 100F, 85% RH 2700 SCFM @ 8 PSI		3500 SCFM 68F, 36% RH 2700 SCFM @ 8 PSI		3500 SCFM 20F. 10% RH 2700 SCFM @ 8 PSI		Totals	
	Inlet Valve	VFD	Inlet Valve	VFD	Inlet Valve	VFD	Inlet Valve	VFD
Speed	3,550	3,234	3,550	3,060	3,550	2,871		
BHP	145	116	146	105	149	94		
VFD Drive Loss		4.5%		4.5%		4.5%		
kW	108.1	90.6	109.1	81.7	111.3	73.3		
Hours per Year	2,190	2,190	4,380	4,380	2,190	2,190	8,760	8,760
kWh	236,715	198,355	477,742	357,663	243,770	160,605	958,228	716,624
$ per kWh	$0.10	$0.10	$0.10	$0.10	$0.10	$0.10	$0.10	$0.10
$ per Year	$23,671.53	$19,835.48	$47,774.20	$35,766.33	$24,377.03	$16,060.54	$95,822.77	$71,662.35

(1) Assumes Comparison Between Cost of VFD Drive and Added Control System vs Actuated Inlet Valve and Control System

Power Cost Saving with VFD	$24,160.41
Incremental Capital Costs (1)	$15,000.00
Simple Pay Back (Years)	0.6

Likewise, high speed turbo blowers are built on the principle of speed control and thus include VFD's within their package. Control over turbo blowers, or other VFD controlled blower, is easily accomplished through the unit's Human Machine Interface (HMI). Plant personnel have complete control over the turbo and are able to adjust the discharge flow of the blower to suit their processes' air requirements. A multistage centrifugal with VFD is operated in the same manner. As a result, a plant with VFD controlled blowers has taken the necessary first step towards optimal aeration system efficiency.

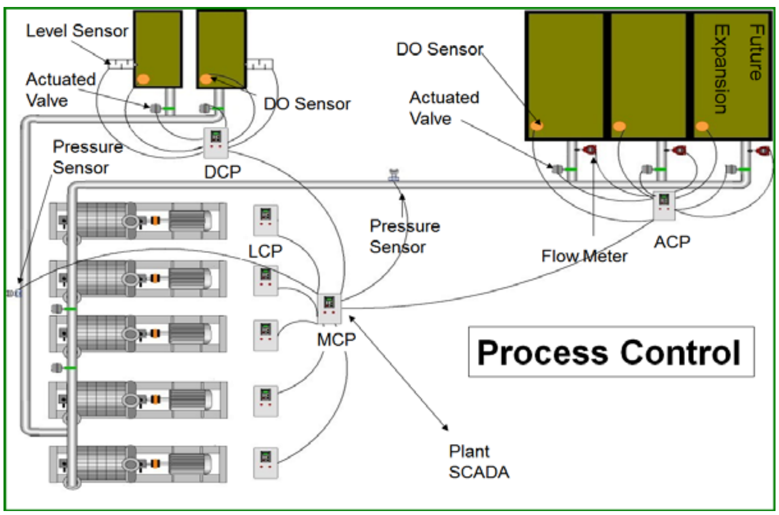
However, both a VFD controlled multistage and a high speed turbo are not utilized to their potential if they are manually controlled by plant operators/personnel. Unless Dissolved Oxygen (DO) and/or other process variables are constantly assessed in real time, the blower will most likely be providing an incorrect amount of air – either too much or too little. With ambient temperature and pressure constantly in flux throughout the day, the DO requirements, for example, change as well.

Maintaining a high DO level not only wastes energy but disrupts the biological equilibrium within the sludge and aeration tanks as well. Conversely, too low a DO level does save energy, however, biological problems will also arise and the system will have to play catch up. The solution to these problems is an automated approach based off key measurements such as DO, flow, and pressure throughout the system. This is an automated process known as "process control".

Solution: Process Control

Process Control refers to the most effective approach used in managing aeration systems within wastewater treatment plants. It is an automated system in which each blower communicates directly to one Master Control Panel (MCP). The MCP receives signals from several process control variables within the system and sequences the blowers to most efficiently achieve the design point which it has been programmed for. These process variables may include DO or Oxygen Reduction Potential (ORP) within the basins that are communicated to each process's respective control panel. The MCP also receives feedback from temperature sensors, pressure sensors, and flow meters. Based on the feedback the MCP receives, the MCP will direct both the blowers and actuated valves to provide the specific volume of air required to maintain the process. Figure 2 below illustrates an example of what this system may look like:

Figure 2: Process Control with Master Control Panel



Furthermore, utilizing a MCP allows for the most efficient sequencing of the blowers. For example, if the process dictates a substantial decrease in air volume, the MCP is able to sequence the blowers to operate at their most efficient point. For a three blower system, this could be two lead blowers operating at peak efficiency and the third blower acting as the trim. The alternative would have all three blowers operating at equal flows but less efficient points.

Types of Process Control

There are two methods of process control that can be achieved within a similar system to Figure 2; Flow Control utilizing Mostly Open Valve (MOV) and Pressure Control. The pressure control method dictates that the blowers' responsibility is to maintain a certain pressure within the system. However, doing so artificially increases system pressure which equates to higher energy usage. In other words, this method's wisdom will allow for a blower to speed up to satisfy a pressure set point regardless if DO is satisfied. In addition, the blowers operate off a closed control loop separate from the DO, which has its own control loop with a modulated valve. Controlling blowers via a pressure set point is both unnecessary and inefficient.

Flow Control with MOV utilizes a single control loop where the blowers are dedicated directly to satisfy DO. Blowers and basins alike are operated on mass flow measured by mass flow meters and/or a mass flow calculation. Basin valve control operates off the MOV principle, meaning that the basin with the highest pressure loss or greatest demand for air will have their modulated flow control valve completely open. Any subsequent control valve modulates as needed to achieve the required mass flow within each basin.

The use of Flow Control allows the system to ignore pressure, thereby equating to a lower system pressure which results in energy savings with a drop of up to .5 to 1 psig less head pressure while stabilizing the DO system faster than pressure control. Finally, it would appear the best argument for flow control is that it allows the process control variable, not a pre-calculated pressure set point, to direct the flow output of the blower itself, matching the delta DO with a specific flow demand. In sum, flow control requires you to meet the demand of the process where Pressure Control requires you to meet an arbitrary set point most often exceeding what the system requires.

Case Studies

Lompoc, CA – Process Control with High Speed Turbos

Fountain Hills, AZ – Multistage Centrifugals with VFDs

Conclusion

Process control is essential to any end user seeking the most efficient operation out of their aeration blower system. Without process control, plant operators run the risk of expending too much energy in over-aeration, or providing too little oxygen to the biological processes taking place. Without the MCP, guesswork takes place and human error sets in. Process control not only simplifies the aeration operation of plants, but can potentially save municipalities thousands of dollars in unnecessary energy usage. The best method for process control is a Flow Control system which utilizes the mostly open valve theory. Flow control with MOV has shown to decrease system pressure and therefore required energy consumption. Thus, it proves valuable to focus on the overall efficiency of the aeration system when designing such a project. While a plant's new High Speed Turbo Blower may operate efficiently, the efficiency potential of the system is thwarted by the lack of smart process control within the aeration system. Indeed, efficiency does matter beyond the blower.