The “ASAP” method to optimize axial fan performance

By Nick Agius

Using acronyms or rhymes to remember key points has been around for centuries. It is the reason we are still able to (perfectly) recall the names of the planets from the Sun (in order) Mercury to Pluto. This is after more than 50 years of first learning this technique.

This paper will demonstrate how you can effectively and quickly troubleshoot axial-fan performance (or lack thereof) with the most common acronym in use today. **<u>That acronym is “ASAP”.</u>**

“A” stands for amps, “S” stands for speed and “AP” stands for actual pitch.

Once you have collected these three simple datapoints you can quickly determine the issue(s). We can not tell you how many times we have been hired to travel to a plant site to help diagnose issues related to the misunderstanding of the relationship to one another (power, speed, or fan blade pitch). Often one, or all three are out of whack from the original design, which will cause the axial fan to underperform.

Before we explain the “ASAP” in more detail, lets quickly discuss what an axial fan is and what systems they are used in at your facility.

Axial fans are high volume, low pressure fans used to move air in ACHE’s (air cooled heat exchangers), CT (cooling towers) or ACC (air cooled condensers). They are designed as standard fans, Low-Noise fans, and even Ultra-Low-Noise fans. A fan assembly mounts onto the fan shaft with a fan hub and bushing. The fan blades then connect to the hub using special clamps. Fan assemblies can be any number of blades. Usually, they have some form of inner seal disc to stop airflow from re-circulating at the center near the hub.

Now let us dig a bit deeper into how we collect the “ASAP” data.

<u>“A” Amps:</u> An electric motor works best when it is 100% loaded. Also, keep in mind modern motors typically have a 1.15-SF (safety factor). You need to ask your electricians to do a quick amp reading for all the motors involved in your investigation. Ask them to also record the FLA (full load rating) off the motor tag. If the motor is older and does not have a FLA number, simply use this common rule of thumb to guess FLA.

- 1 amp =1HP for 575 volts
- 1.25 amp =1HP for 460 volts

Also, ask them to record the motor speed, frame and if it is a two-speed motor or VFD (variable frequency drive). This will come in handy later in this paper and process.

"S" Speed: There is an old myth amongst plant personnel that you only need to use amp-draw to pitch fan blades correctly. **This method is untrue and dangerous**.

Speed is a big part of this equation. It is extremely easy to lower fan performance using out-dated rules of thumb like this. One needs to have the proper skills to read a fan-curve to set the best maximum target pitch. Think of each separate cooler (at your facility) having its own personality. **One size does not fit all** when it comes to axial fans, motors, and drive systems.

High Efficiency, Timing belt drive and ARD

Inlet Bells add efficiency, lower noise

To check speed, do not waste time with a strobe light or tachometer. Measure the two pulley sizes, which can be done with a tape measure under the belt guard while the fan is running. It is a good idea to double check your findings with a BOM or equipment file.

If you have a gearbox, note the ratio on the gearbox tag or the OEM specification sheet. Once you have the proper drive ratio, divide the motor base-speed by this ratio to get fan speed. If you know the fan OD (outside diameter) multiply the speed by circumference to get fan blade tip-speed. API suggests not going over 12,000 fpm but often for Low-Noise fans we can see fan speeds as low as 8,000 fpm. We have discovered extremely dangerous fans running over 16,000 fpm by this simple speed check. We have also discovered fans running backwards and far too slow. Speed is a major part of any axial fan's performance.

The modern fan designs seem to be running much slower due to everyone trying to keep their plant noise to a minimum. This is creating even more fan related issues. If the OEM tried to use a standard fan but cheated with a lower speed, to meet a stricter noise specification, then they have done you (the end-user) a major disservice.

Ultra-Low noise fan

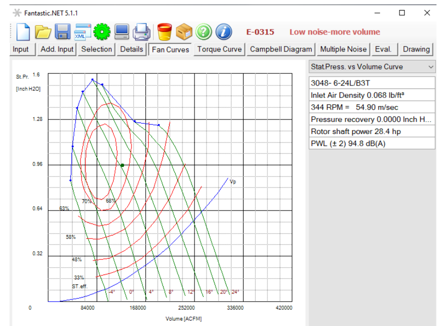
If the noise specification is low, you need to intelligently design Low-Noise or even Ultra Low-Noise fans. These special fan systems have wider fan blades and more blades/assembly, so the fan is statically efficient at lower tip speeds like 8,000 fpm or even lower. We cannot always blame the OEM's for this design issue. End-users need to do a better job writing proper specifications when noise is a concern. The OEM is under great pressure to try and win orders (on lowest cost) yet meet the specification provided by their customer. In the end you get what you paid for.

"AP" Actual Pitch: This is the only task in the "ASAP" method that requires the fan to be shut down and locked out. Ask your MW's (Millwrights) to log the fan blade pitch (angle) for each fan blade in the fan assembly using a digital level.

The reason we check them all and not just one is this: If the blades are not all within +/-.5 deg of each other (on the same fan assembly) this can be a cause of system vibration, which leads to other major issues.

Be sure to use the fan manufacturers manual so your MW's know where to take this pitch reading on the blade. Often this simple point gets missed, resulting in misinformation, which you cannot afford to have at this stage. Fans are often over-pitched due to the rule of thumb mentioned in the above section, so this is a key data point to help you find quick solutions.

Now that you have gathered your "ASAP" data, what do you do with this information?



The best way to answer this question is by also gathering the OEM fan specification sheet from your equipment files. If you do not have this, contact the OEM of the system, and request this data. If they are no longer in business contact the actual fan manufacturer. If they are no longer in business, you need to contact someone with unique skills and experience to be able to reverse engineer the system based on your "ASAP" data.

What other things should be considered?

The "ASAP" data points above are a good start (for the axial fan) but there is so much more to consider, which is, the whole system around the fan. There is an informative technical paper that was published in Hydrocarbon Processing Magazine that goes into the system in more detail if you have an ACHE.

Here is a URL to this paper [Optimizing-ACHEs-Hydrocarbon-Processing-Agius-2006-English-Rev-2020.pdf (thefanguy.ca)]

Here are a few quick additional factors/questions, that effect cooler performance for ACHE's

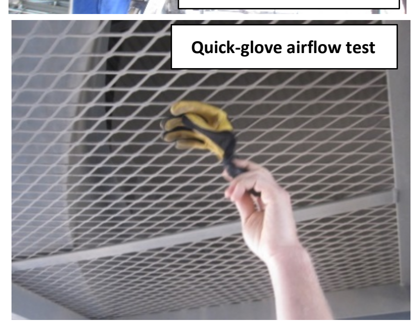

Very dirty fin tubes

- Clean fin tubes (they need to be cleaned yearly at a minimum)
- Fouled fin tubes (external or internal)
- What style of fin tube do you have now *
- Holes and gaps in fan box (which reduce static efficiency of the cooler)
- V-belts are <93% Eff, they slip and reduce speed/airflow/cooling
- Timing belts are 98%, no slip
- Are there any Inlet Bells
- Poor tip clearance (API has specification for this)
- HAR (hot air recirculation) issues, easy to solve harder to detect (See TheFanGuy web site videos)
- Fan shaft bearings (are they heavy enough to meet API Minimum for L10 life)
- Did the OEM design everything correctly? It is also quite common that the OEM did a poor job designing the mechanical parts in the first place. You cannot imagine how many times we have caught errors made by the cooler OEM's. For example, on belt drives where they design the motor pulleys smaller then NEMA recommends. This negatively effects the motor bearing loads and overall belt life cycle


Proper airflow testing

Airflow testing axial fans: If you feel your fan is not moving the air as designed by the OEM you can hire a skilled contractor to test airflow and system performance. Here is a good YouTube video showing the proper way to test axial fans.

Airflow test http://youtu.be/bajuRQQzvVI


Quick-glove airflow test

If you want to perform your own "quick test" using your work-glove, here is a great video link to see how to achieve this simple task. This is not meant to replace a full airflow test, but it is remarkably effective in finding an underperforming fan without any extra cost or permits needed. If the fan does not hold your work glove on the bottom screen (at full speed), then you perhaps have an "ASAP" issue.

Using work glove to test axial fans https://www.youtube.com/watch?v=WABjlaj-Xu8&feature=youtu.be

(*) to better understand all the different types of fin tubes available, read this paper
HP-9 Specify the right fin... (chartindustries.com)

Winter air and your axial fan: We would like to make this one last point as it is extremely critical but gets overlooked all too often. Winter air is heavier, so it requires more HP to push your axial fan versus summer ambient air. In the winter, you need less cooling (typically) as the ambient is much cooler. Conversely, in summer we need maximum cooling due to a higher ambient air temperature. The OEM uses the hottest summer ambient to build the cooling system (see their specification sheet). So, the OEM must install a larger motor then is needed at that summer ambient (for winter air). This is also dedicated to the OEM by an outdated API requirement. In a perfect world API would specify VFD's on all fan motors, so this larger motor would not be required. But we can now take advantage of this fact on older coolers with extra HP to use up. Install VFD's and push that larger HP in summer when you need the extra cooling.

VFD drive controls fan speed

If we set the fan blade pitch in the summer to load the motor 100%, we would get the absolute best cooling for that summer, but what happens in the fall when the air gets colder? We would need to either change speed or pitch or have a larger motor for the heavier air.

This requires some extra thought.

Speed change: Three ways to change speed are VFD's (variable frequency drives), two-speed motors or change the small motor pulley twice a year.

Any one of these ways allows us to have a more aggressive year-round blade pitch to maximize summer cooling yet dealing with the heavier winter air a few months of the year.

Modern VFD's are the way to go for lower noise and power savings. It is best to specify for 100% VFD's so all fans are adjustable. This way you can max-out your motor FLA in summer which can positively impact your airflow by ~5% and simply turn the speed down in winter when the cooling is not (typically) needed, but the air is heavier.

OEM's must follow an outdated thought-pattern that suggests you need to design with a higher HP (then needed in summer), so you have enough power in reserve for the few winter months, with one year-round pitch. This concept will never use up 100% FLA in summer (when you need the most cooling). This is more of an issue for our colder Canadian winters then if you were closer to the equator.

If you install VFD's this issue goes away, as you can just pull back the speed in winter and at night when the air is cooler, reducing noise and save on power costs.

Pitch change: One way to change pitch while the fan is running is by using a special AV (auto-variable) fan hub. This is older technology developed many decades ago. If you have AV hubs in your system now, then check to see if they are working. They are expensive to repair or replace. If they are not working, then it is best to convert to a standard fan and VFD. AV hubs are still available from most fan vendors, but the higher costs are not worth it. They also double the weight of the fan assembly.

AV hub in repair shop

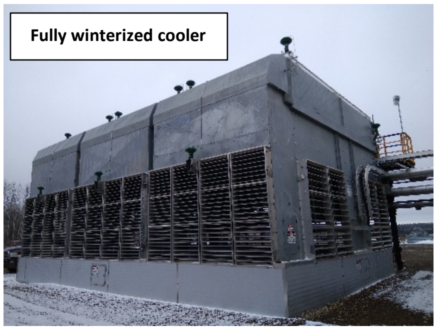
The last option, which is much less desirable due to the time it takes, is to mechanically change fan blade pitches twice a year (spring and fall). This practise was more common decades ago, but now with safety protocol and permits required to do any work, this is just not cost effective. If you have one lone fan on a system that is easy to get to like an engine-fan, then this method is still a good option. Engine-fans tend to freeze-off in winter with too much cooling, so adjusting fan blade pitch also saves energy from the engine when the cooling is not needed.

All these above points are also well documented on TheFanGuy web site under FAQ. www.thefanguy.ca/faqs/

Caveats: As always, there are exceptions, so we need to state them.

The above applies to FD (forced draft) systems in non-winterized coolers with no form of VFD or AV or two-speed motor.

If you have an ID (induced draft) system, the fan is not seeing outside winter air. It is moving the warmer air exiting the fin tubes, which is much warmer (less dense). A wet CT is typically an ID system, so again, the ambient is not always the outside ambient air.



The same goes for a properly winterized system (when it comes to ACHE's) with properly functional louvers (top, side, and internal). Often in winter these systems get very warm inside. Most of these winterized units have extra heaters inside the cooler. So, the fans will not be moving colder winter air.

Conclusion

In conclusion, the next time you need to troubleshoot any axial fan performance issue(s) at your gas plant, refinery, or chemical facility, **use the "ASAP" method** before you spend money hiring consultants or EPC's.

All axial fans are not created equal. Some are more efficient than others with less moving parts and less maintenance. OEM's place the lowest cost parts into your system, so develop your own general specification so you only spend money once. This way you do not waste resources and time trouble shooting a poorly built system.

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[BIO]

Nick Agius has been working with axial fans since 1978. He is recently retired from his role as a National Rotating Equipment Specialist for Motion Industries (Canada and Alaska). His Anti-Rotation Device (ARD) solution for belt driven air coolers was first patented in 1996 with two other follow up patents since. Nick.agius@shaw.ca. Visit his web sites at www.thefanguy.ca or www.thefanguy.com