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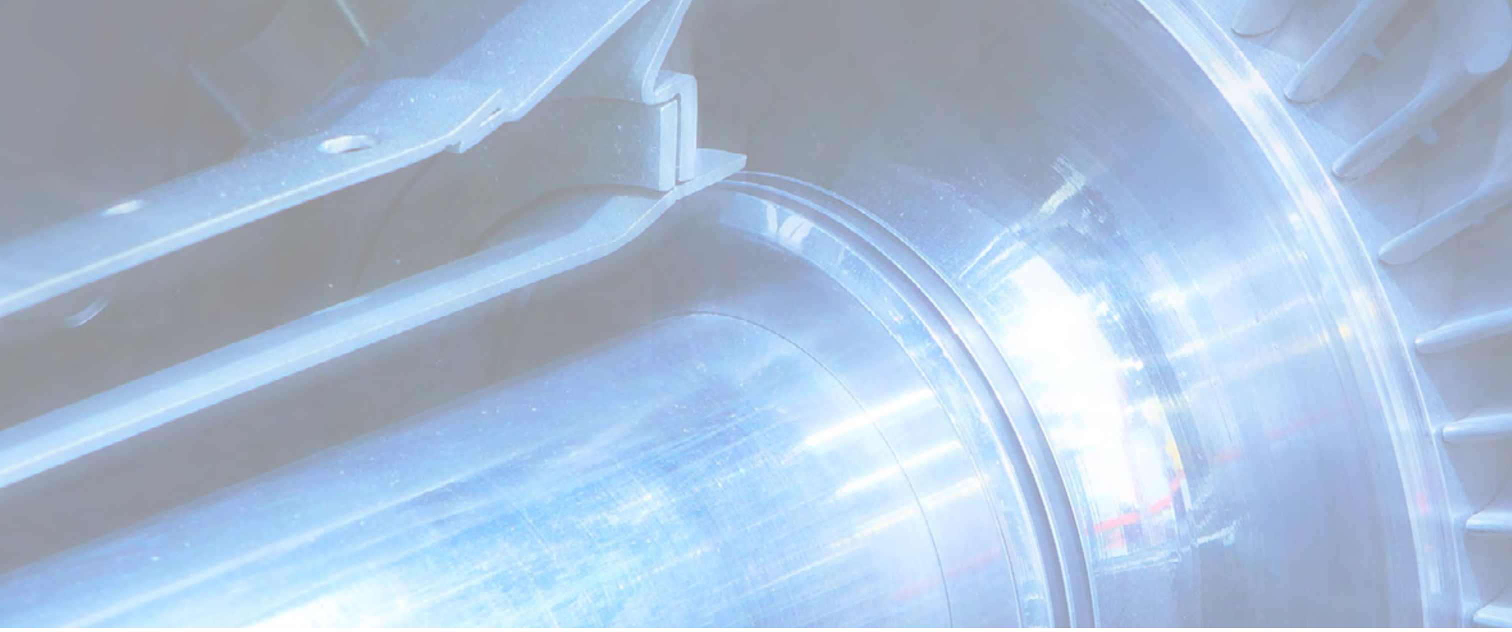

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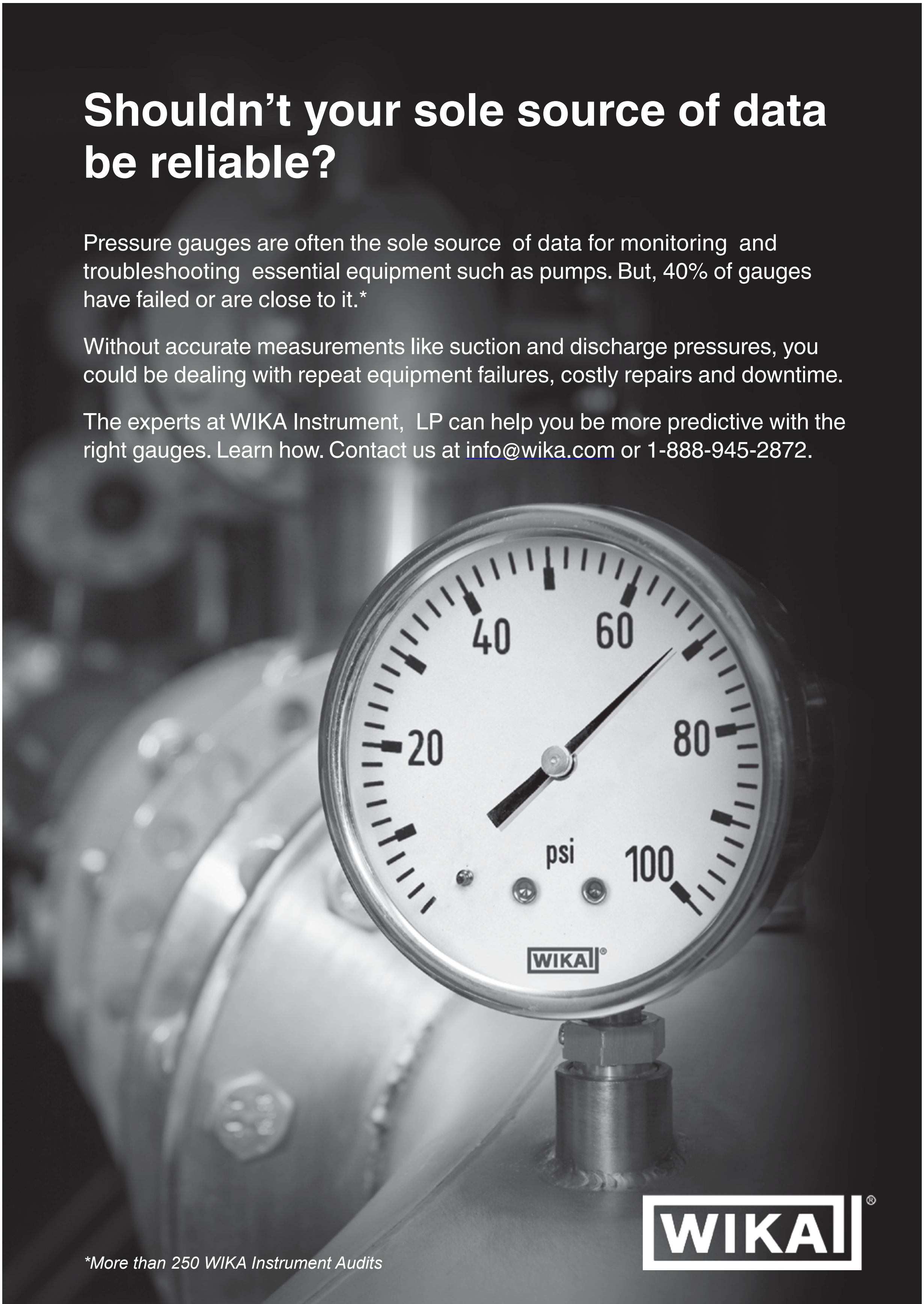
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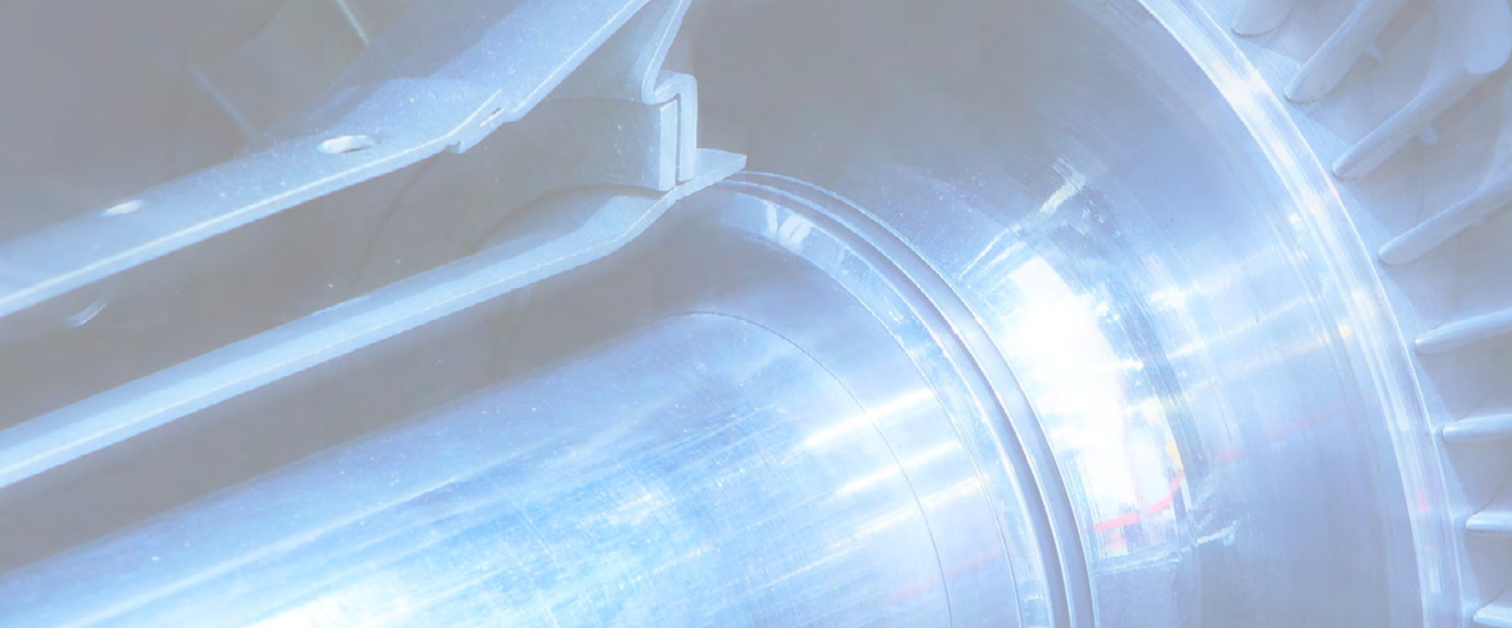


Put the Right Spin on Rotating Equipment Revamps

Take advantage of improved machine internals and better seals

By Amin Almasi, rotating equipment consultant

DESIGNERS OFTEN underestimate the sizing factors for rotating machinery trains (particularly drivers), leading to installation of marginally adequate units. Then, once in service, components suffer the inevitable effects of ageing (fouling, wear and other forms of degradation). Because all elements in a train impact its operation, degradation in any component affects total performance. As a result, plants often must contend with equipment that no longer can provide sufficient capacity and, thus, has become a bottleneck. The output power limitations of compressor drivers in particular are serious issues in many cases.

Washing or cleaning can address some effects of ageing but can't recover a large portion of the lost capacity. So, plants usually must consider revamping, renovating and uprating rotating machines such as pumps, compressors, steam turbines and gas turbines. Revamp and renovation projects generally include uprating drivers, re-wheeling of some compressors, installing larger pump impellers, modifying control valves and making various piping changes.

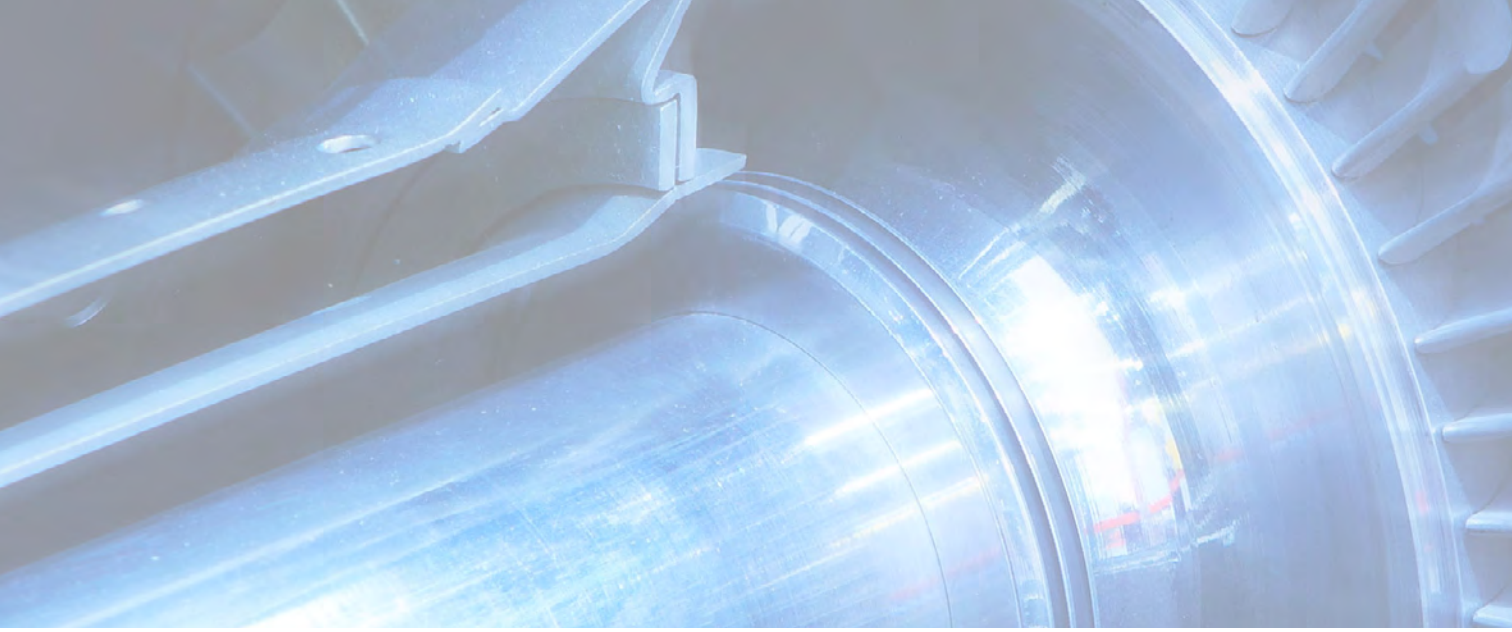
In this article, we'll look at various factors to consider in a revamp and upgrade.

Figure 1. Steam turbine is being prepared for repair and renovation. *Source: Siemens.*

GETTING STARTED

First, conduct a performance test on the particular unit being considered for revamping or upgrading. The results can assist in defining the extent of performance degradation and the scope for upgrading; these machinery performance data also will allow you to assess the improvement provided by the renovation.

Machinery upgrading usually is feasible and, indeed, routinely takes place at many chemical plants. Whenever possible, retain the existing casing and only replace the internals — rotors, impellers,



diffusers and similar. (Sometimes, this is termed "re-rotoring" or "re-wheeling.") A rule of thumb (with some exceptions) calls for changing only the internals if the cost of retrofit parts doesn't exceed 45% of the purchase price of a new machine. The advantages of not replacing the entire machinery system are rather obvious. Only minimum changes must be made to external components such as the piping, foundation and baseplate. Also, less time is needed for getting revamp parts than for delivery of a new machine.

SHAFT REMOVAL

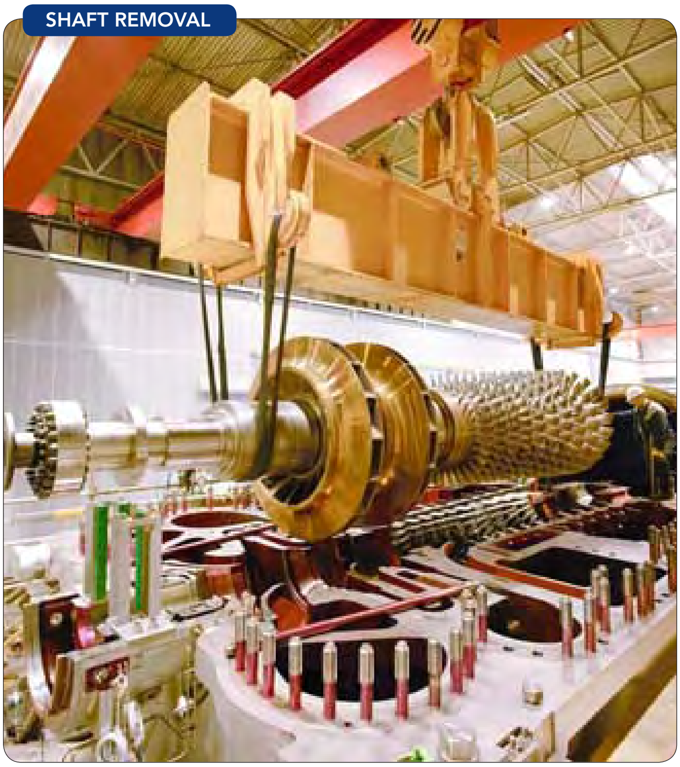


Figure 2. Repair and overhaul of compressor requires taking the main shaft out of the casing. *Source: Siemens.*

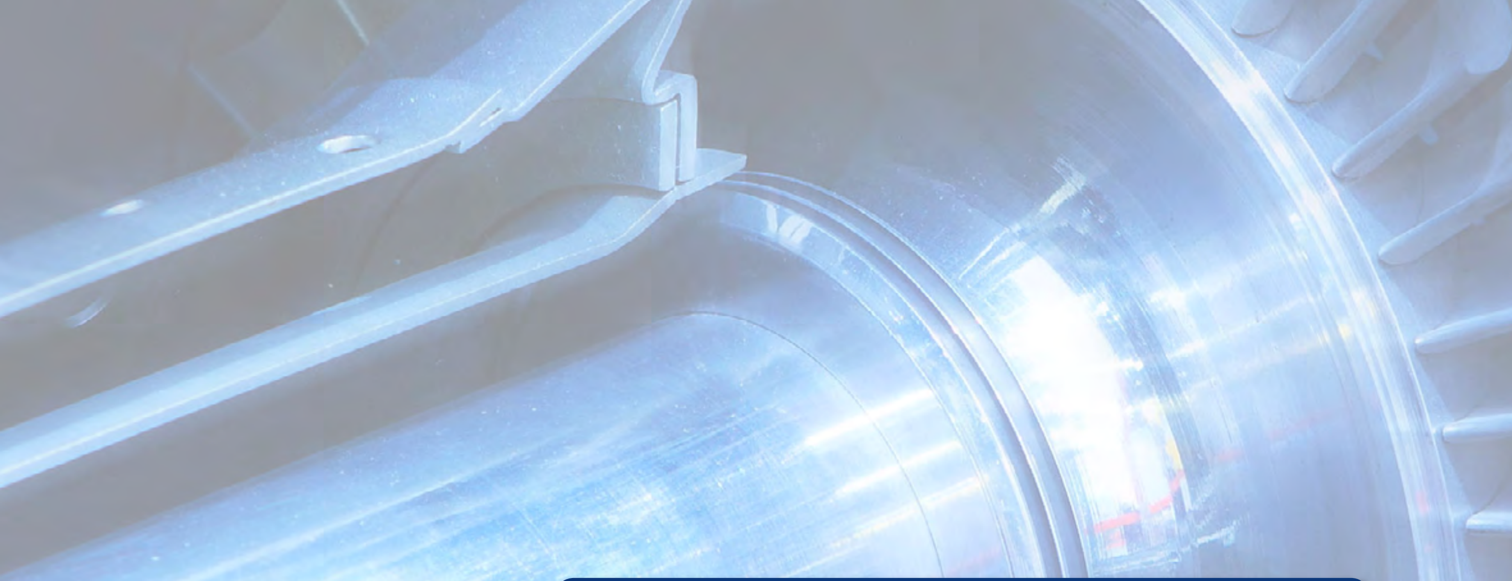
More importantly, a revamp requires a considerably shorter shutdown (and, therefore, provides a huge production benefit). Figure 1 shows the dismantling of a steam turbine for repair/renovation. Figure 2 shows the main shaft of a compressor being removed during a revamp.

A speed change possibly can upgrade both compressor/pump and driver. In some instances, replacement gearing — to give a different ratio and, thus, a speed change — will fit in the existing gearbox (gear unit) casing. Together with selective replacement of some (but not all) compressor or pump components (even selective replacement of stages), this could reduce greatly the investment, revamp project time and upgrading workload.

A plant also may gain efficiencies from internal design improvements made since the current equipment was installed. These include reduced parasitic losses, tighter manufacturing tolerances and use of modern seals. Today, compact and very efficient internal designs that can be fitted into old casings are available. So, ask your vendor to evaluate components that you want to retain (such as the casing) and to provide a suitable guarantee. And always subject new internal/rotor systems to the full range of testing.

SEAL SYSTEM UPGRADING

Nowadays, turbo-compressors most commonly rely on tandem dry gas



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seals. These seals considerably reduce power consumption and increase reliability. So, every turbo-compressor upgrade and renovation program (especially for old compressors using oil seals) should include the latest dry-gas-seal technology. The primary vent of today’s dry gas seals generally will be piped to a flare because venting to the atmosphere normally isn’t permitted. The secondary vent may release a small amount of inert gas (such as nitrogen) to the atmosphere.

Upgrading and renovating dry gas seal systems is a well-known option for many compressors at chemical plants. Two options usually are discussed:

- *Improving the seal-gas filter system.* Usually, original (manufacturer standard) filters are small in capacity and have a large mesh size. In most cases, it makes sense to switch to filters with 4–6 times more capacity and 5–8 times smaller mesh size.

In a case study for a turbo-compressor in a chemical processing unit, the original seal filter mesh was 3–5 microns. The upgraded seal filter has a 1-micron mesh size and dimensions six times bigger than the original filter.

- *Upgrading seal system instruments.* Current instruments may not have been selected properly. Sometimes, the instrument range isn’t sufficient. Often, seal system flow meters have been sized improperly.

GAS TURBINE UPRATING

Unlike previous generations, the latest gas turbines use single crystal blades, better blade-tip clearance control, advanced metallurgy, new thermal barrier coatings, advanced manufacturing techniques, modern three-dimensional flow analysis, accurate heat-transfer studies and gas-flow-improvement programs.

Performance improvement (uprating) packages take advantage of these advances to enhance both heavy industrial gas turbines (sometimes known as “frame” units) and aero-derivative gas turbines. For example, the uprating of a frame gas turbine at one plant increased production capacity to around 112% of normal. In this case, the main parts of the uprating package included the first stage nozzles, the thermal-barrier coated combustion chamber liners, the splash-plate crossfire tubes, the high-pressure wheel buckets and new sets of thrust bearings as well as a new control system and modern condition monitoring. Installation of such a package can allow an increase in the turbine firing temperature. For aero-derivative gas turbines, an uprating package can result in higher power output (up to 13% more for some turbine models), greater energy efficiency and lower NO_x emissions (if suitable new technologies are part of the package).

Use proven-in-service technologies in a gas turbine renovation/uprating project. Sometimes, the turbine components may get overheated as result of a high firing temperature (a usual option in an uprating project) and this could result in a costly field modification.

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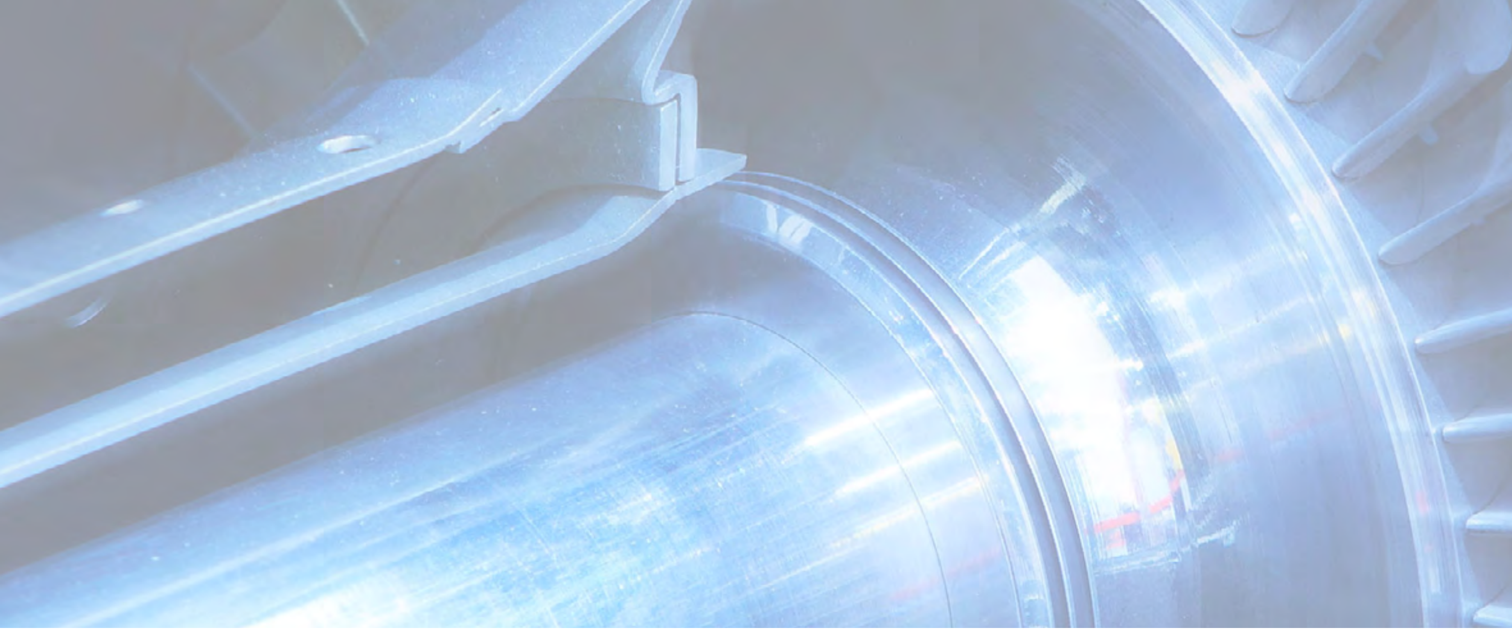


Don’t Slight Strainers

These simple but often essential devices deserve adequate attention

By Andrew Sloley, contributing editor

STRAINERS REMOVE relatively large diameter particulates — typically 325 µ (0.00128-in.) or larger — from process streams by screening the solids out with either a plate element or wire mesh. Getting rid of smaller particles normally requires a filter.

Strainers may have temporary or permanent installations. Temporary strainers remove maintenance or construction debris on startup. Typically they stay in service for a week after startup. Permanent strainers remain in the process to cope with ongoing issues with solids or extreme sensitivity of equipment. Examples of services using permanent strainers include water suction from open-air sources, catalyst fines’ removal from process streams and protection of downstream operations from piping system corrosion products. In a piping system, it’s often logical to install the strainer where pipe materials change.

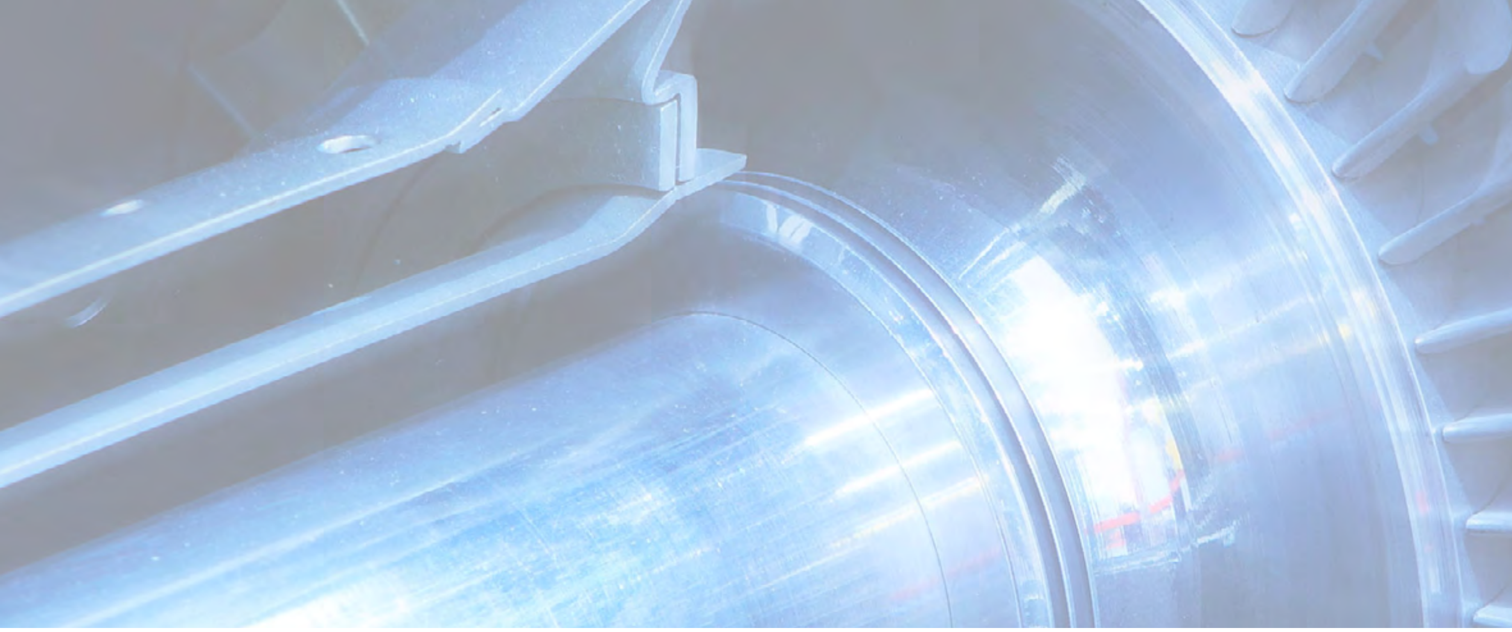
Plate strainers use a simple element inserted between pipe flanges. The flat plate either has drilled or punched holes or a wire screen. In recent years, some manufacturers have switched to laser cutting. The laser cutter can produce any diameter hole or slot; it’s not limited to standard drill or punch sizes and shapes. Plate strainers mostly are for startup to remove occasional chunks of debris. They have relatively low open areas and are restricted to the pipe cross-sectional area, which limits their removal capability. Adding a wire mesh screen reduces the open area even more. Moreover, it generally has a relatively high pressure drop and low capacity to hold bulk material. (For information on wire mesh, see “Tailor Your Wire Cloth,” http://goo.gl/cR1N3d.)

Specifications for plate strainer elements normally set a hole size, hole open area (or percent) and required mechanical strength.

Increasing the strainer capacity requires shifting to a Y-strainer or basket strainer. The common Y-strainer allows for compact installation. Y-strainers typically are set by the line size. The simplex basket strainer comes in nearly endless varieties.

Figure 1 shows two basket strainers installed in a process plant. Some particular points merit attention:

- The strainers are installed in parallel; one should be in service at all times.
- Single isolation valves enable removing the strainers from service.
- No integral davits are included to hold the strainer lids.
- The strainers are angled to ease access and reduce piping-layout clearances.
- Hard-piped connections allow for draining on the true body low-point.
- Instrumentation monitors pressure drop across the strainers.



When a strainer plugs, how to clean it depends upon plant configuration. If there's no bypass, the unit must be shut down. With one strainer and a bypass, the plant can continue to run while the strainer is cleaned. In critical applications, a second strainer in parallel provides for keeping a strainer in service at all times. The choice depends upon the type of unit that's being strained. If the plant shuts down weekly for product changes but the strainer only needs monthly cleaning, extra strainers and piping may not be necessary. If passing particulates for short periods is only a minor problem, a bypass alone may suffice. For critical services, the second strainer is necessary.

Cleaning requires opening the process. As noted, the strainers in Figure 1 use single isolation valves. Isolation requirements depend upon the fluids and operating conditions, and must consider safety.

BASKET STRAINERS

Figure 1. Permanent strainers often are installed in pairs so one always is in service.

Lift-off flange heads may suffice for small strainers such as those pictured. However, strongly consider an integral davit to hold the head of a larger strainer — it will speed basket changes and make the job simpler and, thus, foster better maintenance practices.

Angling the strainer reduces the vertical height required for installation and for removing and replacing the basket. (This may not be crucial in initial plant construction but may come in handy when adding strainers later.) A modest angle is acceptable.

Note that the drain connection on each of the strainers shown is on the true low-point of the strainer body; this prevents accumulation of a small pocket of liquid. Hard-piped connections are useful because they make draining easier and reduce the chance of spills.

The typical strainer should be cleaned at 1–2-psi pressure drop. Basket strength usually will suffice for a 10-psi pressure drop. However, I routinely specify a 15-psi mechanical requirement. The installation shown in Figure 1 has differential pressure connections, although they are hard to see, so the control room can monitor the pressure drop across the strainers. If the operators don't know the pressure drop, the strainers often won't get changed. A broken strainer carrying both the solids and basket fragments downstream helps nobody. At a minimum, all strainer installations should include connections for pressure drop measurement — frequently they deserve full pressure-drop instrumentation.

Strainers, although often overlooked, provide many processes with critical stream cleanup to meet process requirements and protect equipment. Installation that makes strainers easier to track, and simpler and safer to change can optimize their performance.

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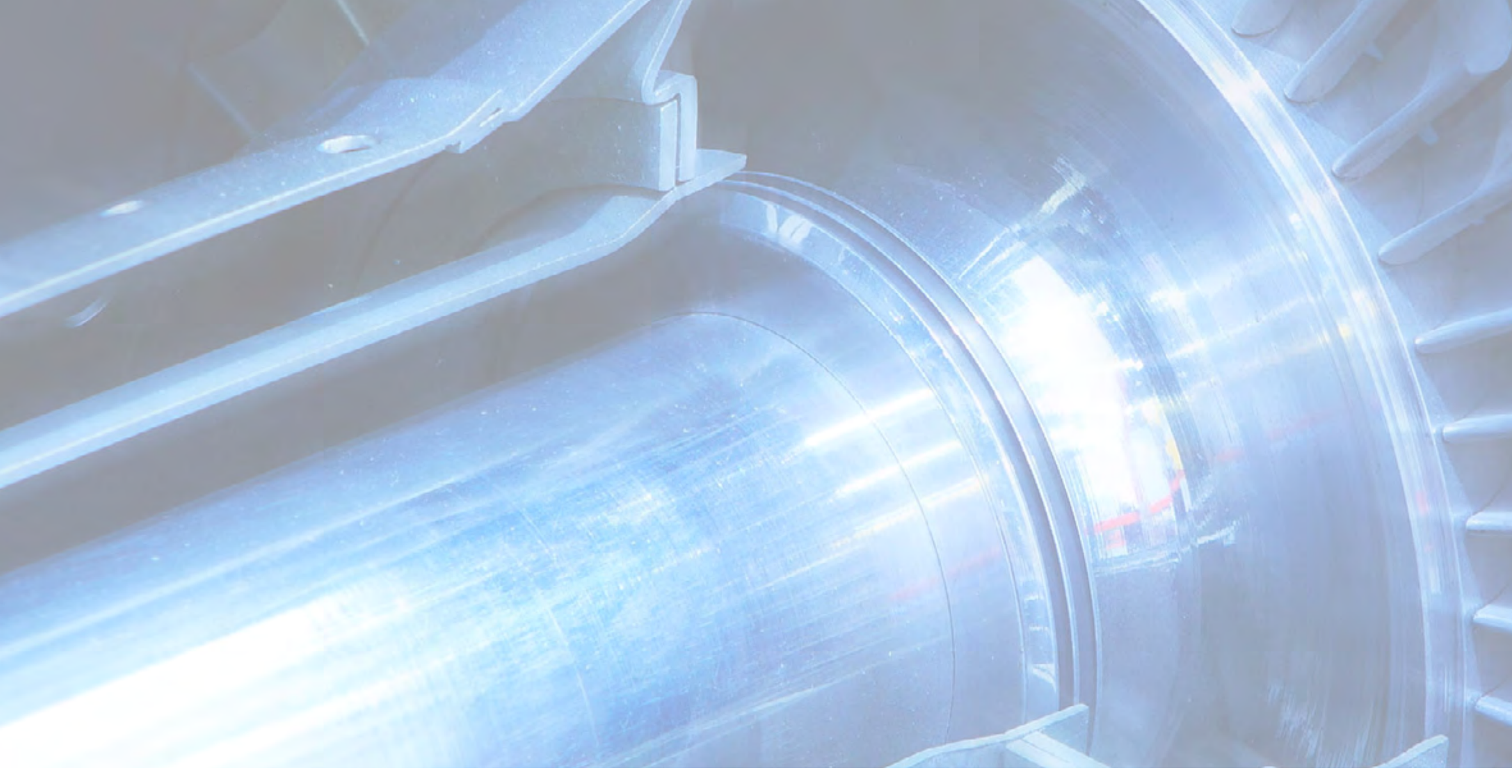

Gun For Better Troubleshooting

Surface temperature measurements often can provide valuable insights

By Dirk Willard, contributing editor

AN INFRARED (IR) scan of the motor buckets revealed overheated contacts. Nevertheless, the maintenance group at Ralston Purina's plant in Lancaster, Ohio, didn't plan any immediate action. A few days later, on a hot day in June, the boiler house motor control center (MCC) exploded.

That's how crucial IR thermography is to maintenance. Even if you don't yet use the technology, you should appreciate its value. Applications include: checking the condition of gearboxes, motor bearings and coils, seals, steam traps, belt bearings, conveyors, electrical components (e.g., buses, fuses, disconnects, and hardware in a distributed control system, MCC controller or variable frequency drive) and rotating equipment, as well as detecting thermal and fluid leaks, material flaws and even liquid level.

IR guns and cameras are valuable because they're non-contact and don't demand prior knowledge of the range of temperatures expected. In contrast, a contact thermometer requires a range and may be inaccurate because of poor insulation or contact. IR measurement actually improves at high — I mean furnace high — temperatures.

A simple IR gun can be very useful and cost effective but only offers single-point measurement. A thermography camera provides a broader picture but is more expensive, which may rule it out for everyday measurement. For more on thermography, see: "Use Thermal Imagery for Process Problems," www.ChemicalProcessing.com/articles/2009/202/.

IR isn't perfect. Its performance depends upon three critical factors: heat capacity, the inertia of the body to resist change, which is a common problem with any temperature measurement technique; proper orientation for radiation absorption — a poorly positioned thermocouple in a furnace can be off by 100°F; and, lastly, minimal variation in emissivity. As with any measurement, taking more readings will improve precision and reveal flaws in methods but probably also will widen the bell curve. Never take fewer than two or three shots with a gun.

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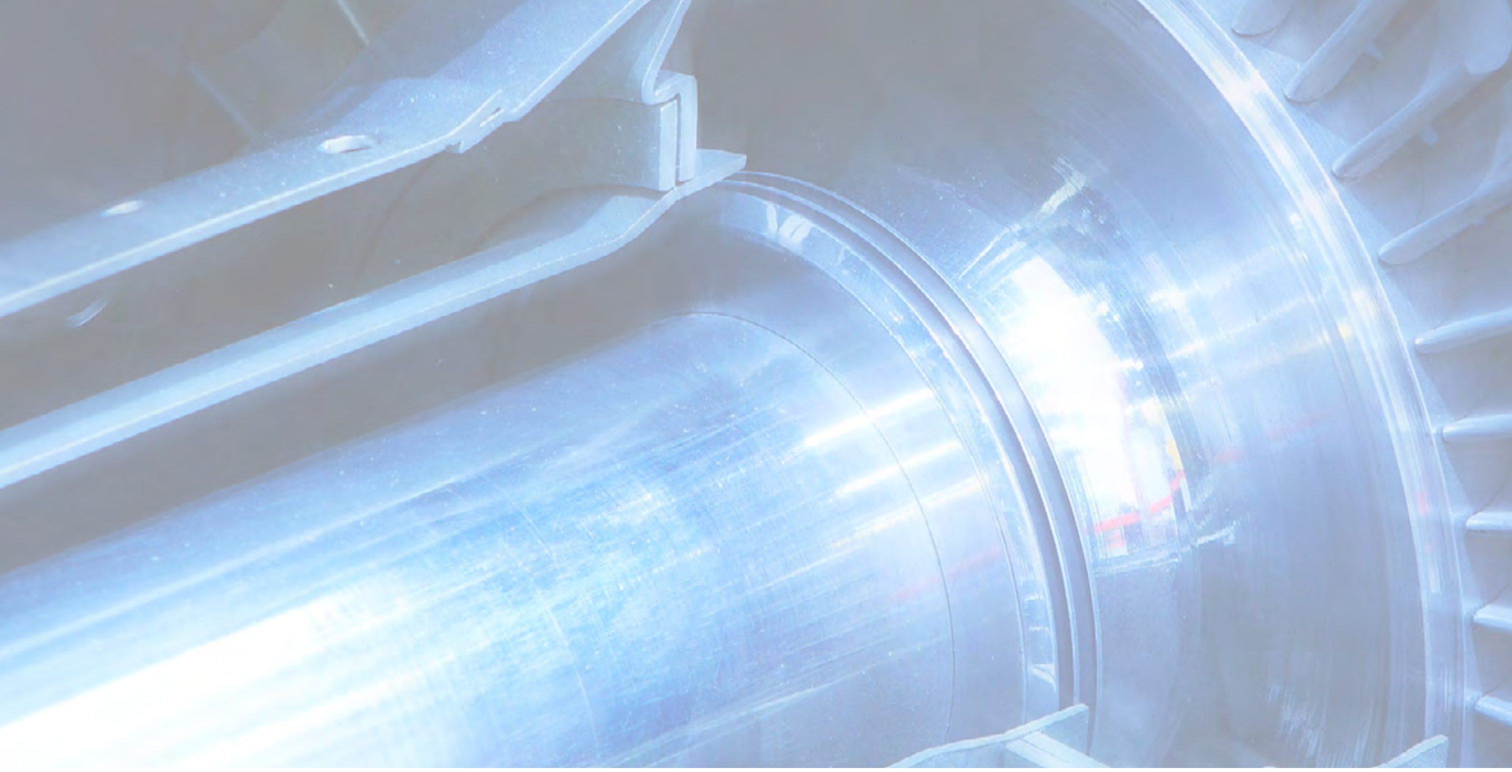

A few tricks can help you get good measurements with a simple IR gun. For instance, find a well-insulated or relatively small hole (ideally, >3 in. deep) on the equipment you want to measure. Then, shoot that spot. Its emissivity will be about 1.00 and, because the IR radiation has nowhere else to go, you should get a good measurement. With insulated pipework and equipment, cut a replaceable flap around a nozzle or flange and shoot that spot. A useful trick is to put a piece of black tape on the surface you want to measure; the emissivity of black tape averages about 0.95. Use tape with a matte, not shiny, finish. Put the tape on at least a few minutes before taking a shot. Another useful target for IR is a red rust spot; emissivity is ~0.7 at 77°F. Always avoid shooting a reflective surface because its emissivity — and the reading — will be low; an emissivity below 0.2 makes measurement difficult. Here's one last trick: use a black surface of a known temperature to tune your gun.

Now, let's consider one of the most difficult applications — detection of steam trap failure. While most experts advise using an ultrasonic tester, IR can be useful with some types of steam traps — but not with inverted bucket traps because they generally fail open. IR can identify a plugged trap by detecting a difference between downstream and upstream pipes and the trap-feed and equipment-supply lines; in the latter case, if the difference is 20°F or more the trap has plugged. IR may be the only option for a trap that's in a hard-to-reach location because an ultrasonic tester must contact the trap.

For bearings in rotating equipment, perform a scan when the bearings are new, but not within a day of initial lubrication, to create a baseline profile. Then regularly monitor them. Treat a bearing running 100°F hotter than normal as failing.

As far as the situation at Ralston, the plant engineer probably was pondering how to deal with it when the fire occurred. The solution requires some finesse. (Don't send in a deck ape!) Copper contacts must be gently removed, cleaned and tightened, preferably with a torque screwdriver or wrench, although some electricians say finger tight works fine below 100 amps, i.e., 75 hp or below on 460 VAC. Afterward, it's good practice — as with all specialty torque items — to keep a log and mark the bolt head with permanent ink.

IR guns offer an inexpensive qualitative means of involving your operators in day-to-day equipment troubleshooting. ●

DIRK WILLARD is an award-winning *Chemical Processing* contributing editor. He has won recognition for his Field Notes column from the ASBPE. You can e-mail him at dwillard@putman.net