



Reverse engineering

The plant has been running smoothly for several years now and all production goals and objectives have been met. Recently, you had a celebration of record production and a scheduled shutdown is on the horizon. It has amazed you and your staff how well C-277 (a major compressor turbine train) has run over the years. All of the indications suggest to the maintenance team the next major shutdown will come just in time. Vibration level is up and there is an accelerated amount of metal particles in the oil. But with all that said, you are running normal and the oil is within acceptable limits.

Based on all of the maintenance reports, it looks like the impellers will have to be replaced at the next shutdown. It is shrouded design with scallops in the disk. It had a long history of failure in the past but it was all resolved with the latest modifications more than 10 years ago. The impeller was an upgrade supplied by a third party on behalf of the compressor vendor. Yes, the process team has done some debottlenecking of the process and the compressor is expected to run at another 250 revolu-

tions per minute (rpm) to 8,500 rpm. You dust off the old business cards and call the vendor but the number does not work. No problem, just ask Google™ where they are at. To your surprise, Google cannot locate them. After a few inquiries, you find out they are out of business.

In the next meeting this was reported to the plant manager and an action plan is put in to place to obtain parts for the shutdown. There is no choice but to reverse engineer the design as there appears to be no help. There are no calculations and no geometry data. There are some spare parts that consist of a diffuser, volute and used impeller. The question in your mind is how to satisfy upgrade requirements from a performance standpoint, and have quality and reliable spare parts.

This is a familiar story and happens often on both static and rotating equipment. The following steps can be considered to reverse engineer and satisfy the upgrade:

- Conduct a meeting to establish goals and objectives for the effort. This needs to include process, mechanical, electrical/controls and materials engineers. This

effort may also involve a hazard and operability study as part of risk management. The history of operation and historical performance should be discussed as a baseline. Qualified third-party vendors could also be discussed.

- Create a process specification sheet for the machine. This would include turn-down and recycle cases for the design. In particular, changes in molecular weight and temperatures should be considered.

- Develop a detailed mechanical specification for the compressor.

- The fact you have no geometry is an issue and must be resolved quickly. You only have the spare parts because the machine is running and production is not about to shut down. Use a digital laser scanner to recreate the geometry of the internals and impeller.

- Verify the material of the impeller and performed limited materials analysis.

- Develop a performance model based on the geometry collected. This may include CFD (computational fluid dynamics) and FEA (finite element analysis) models including a compressor perfor-

mance model. The goal is to predict the current operation. If that can't be done, forget about the upgrade as this must be a successful step.

- Once all models match up, engineer the upgrade.

There are some considerations when doing upgrades and reverse engineering. Be careful not to violate any patents or legal agreements involving the effort. Many times patents are no longer valid as they have run out. Also, it is generally the case that the parts are not covered by any patents as method and technology have been in the public domain for years. Don't let an overall patent scare you. It could be the patent only pertains to one small part. On major equipment, a good patent attorney can advise you on what can be done with consultation with the engineers.

As always, all analysis work and design efforts should be reviewed by a professional engineer that is competent in reverse engineering work.

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