KNIGHTHAWK TECH NOTES

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"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 for record production and now a scheduled shutdown is on the horizon. It has amazed you and your staff how well the C-277 (A Major Compressor Turbine Train) has run over the last years. All the indications suggest to the maintenance team that the next major shutdown will come just in time. Vibration levels are 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 the maintenance reports, it looks like the impellers will have to be replaced at the next shutdown. It is a shrouded design with scallops on the disk. It had a long history of failure in the past, but it was all resolved with the latest modifications (now over ten years ago.) The impeller was an upgrade supplied by a third party on behalf of the compressor vendor. Oh yes, the process team has done some debottlenecking of the process; and the compressor is expected to run at another 250 rpm to 8500 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 and after a few inquires, you find out they are out of business.

At the next meeting this was reported to the plant manager and an action plan is put in place to obtain parts for the shutdown. There is no choice but to reverse engineer the design. 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 yet 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 be used to reverse engineer and satisfy the upgrade.

1. Conduct a meeting to establish goals and objectives for the effort. This needs to include process, mechanical, electrical/controls, and materials engineers.
2. Create a process specification sheet for the machine.
3. Develop a detailed mechanical specification for the compressor.
4. The fact that 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.

5. Verify the material of the impeller and perform a limited materials analysis.
6. Develop a performance model based on the geometry collected. This may include CFD and FEA models including a compressor performance model. The goal is to predict the current operation. If this can't be done, forget about the upgrade as this must be a successful step.
7. 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 has been in the public domain for years. Don't let an overall patent scare you. It could be, the patent only pertains to a small part. On major equipment, a good patent attorney can advise 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.

Cliff's Notes:

I hope each on of you had a wonderful Thanksgiving. At KnightHawk, God has blessed us with prospects of a good future and opportunity that is better than ever. We are known most everywhere around the world and continue to receive world class problems. Over the past year, we have executed an RCA involving a failure that hit nearly a billion dollars of loss.

For early January 2008, I am proud to announce the opening of KnightHawk's Hobbs Road Laboratory. It is a comprehensive metallurgical and materials lab which includes metrology equipment. We believe we will have one of the finest Scanning Electron Microscopes in Houston (SES). We will also be able to perform equipment testing and evaluation in this lab. Our field service group, which will be housed at this same location, will be able to provide digital laser scanning using a state of the art portable laser coordinate measuring machine. This can be done both in house and in the field. KnightHawk has taken the business to the next level. Also, we are having a new exciting Web Site crank up in early January as well.

KnightHawk can provide "The Complete Solution" when it comes to static and rotating equipment. Come by and see us or give us a call and we can show you how we can help you. We have been trusted from the large industrial giants around the world, to the small entrepreneurs with a great idea, and you can trust us too.

Finally I want to wish everyone a Merry Christmas and Happy New Year. May God bless you and your family.

Cliff Knight

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KnightHawk Project Update

- Titanium Tower FFS - 1 / API 579 Analysis - Petrochemical
- Flange Leak Finite Element - Offshore
- Main Lube Oil Pump Failure - Petrochemical
- Structural Dynamics - Off Shore
- Compressor Skid Structural Analysis - Off Shore
- Fitness for Service Waste Heat Boiler – Petrochemical
- Thermosyphon Analysis - Petrochemical
- Pump Metallurgical Assessment – Off shore - Africa
- Waste Water Treatment System Design Audit – Offshore
- Waste Heat Boiler Fit-For-Service – Petrochemical – Middle East
- Bio Fuels Plant Design Assessment - Petrochemical
- Stirred Tube Reactor Failure Analysis - Petrochemical
- Boiler Feed Water System Assessment - Petrochemical
- Skid Structural Design
- 15 MW Compressor Audit – Petrochemical - Asia
- Material Handling Audit – Offshore
- Polymer Gear Pump Analysis - Petrochemical
- Gasifier Failure Analysis – Petrochemical
- Waste Heat Boiler Failure Analysis - Petrochemical
- TLE Retrofit Design - Petrochemical
- CFD of Pumps - Petrochemical
- Deck Drain System Design Assessment - Offshore
- 3-D CFD model of Polymer Pump – Petrochemical
- Pump Skid Design – Off Shore
- Rotordynamics – Off Shore
- Integral Gear Compressor Failure Analysis - Petrochemical