FULL SPEED AHEAD

Achieving High Speeds and Overcoming Rotational Forces on Turbines and Compressors

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ABSTRACT
This poster reviews the mechanical designs incorporated in the redesign of a turboexpander that originally operated at 28,000 RPM and 18% efficiency. To improve this equipment’s efficiency, the operational speed was increased to 60,000 RPM. To overcome the rotational forces at these high speeds, cutting-edge mechanical design techniques were utilized to ensure safe and efficient operation.

OBJECTIVES
To improve liquid production for our customer’s peak shaving LNG plant through improvements in mechanical design and efficiency, requiring an increase in operational speed to 60,000 RPM. This efficiency and speed increase was possible through machining knowledge, design expertise, and analysis of rotating equipment.

INLET GUIDE VANES
Variable area inlet guide vanes improved, with added spacers to eliminate vane sticking. Vane design incorporated into wheel resonance analysis to limit operational no-run zones.

HYDRODYNAMIC BEARINGS
Custom-designed bearings to ensure correct damping, stiffness, preload, etc. Smaller pad faces to reduce horsepower loss and allow for extremely high rotational speeds.

EXPANDER SHROUD
Expander shroud carefully machined to ensure tight fit to reduce side wall leakage for operational efficiency.

COMPRESSOR DIFFUSER
Enhanced vane design to improve fluid dynamics of the gas upon exiting the Compressor.

COMPRESSOR WHEEL
Improved wheel dynamics, including blade curvature design, Titanium backing-hub included for shaft-to-wheel polygon design to overcome material expansion and rotational forces at extreme speeds.

DIFFUSER CONE
Enhanced length of Conical diffuser, designed to improve fluid dynamics of the gas upon exiting the Expander.

EXPANDER WHEEL
Redesigned from original shrouded wheel design. Blade curvature changed to improve efficiency and undercut design to create a cantilever effect during operation at high speed.

SHAFT
Tri-lobe tapered polygon design ensures wheel-to-shaft coupling and centering. A single internal stretch rod applies clamping force that centers the wheels onto the shaft during operation, ensuring the rotor can withstand rotational forces and remain tight after material expansion.

RESULTS
The above detailed mechanical design improvements increased the speed of this unit by 114%, efficiency by 18%, resulting in a 196% increase in power and 130% increase in liquid production. While overall mechanical stress greatly increased due to the new operational speeds of the unit, cutting-edge mechanical design techniques ensured this unit, and three sister units, would operate safely and continuously.

+18% EFFICIENCY  +180% POWER  +130% PRODUCTION

CONCLUSIONS
Through years of R&D work, beginning in the 1990s, this unit improved greatly in terms of power, RPM, and liquid production.

From an original 28,000 RPM design to the current 60,000 RPM operational speed, the forces acting upon the wheels/impellers are significant. To overcome these forces, and to maintain mechanical integrity, every single internal part was specially redesigned to meet the liquid production goals of our customer while ensuring operational efficiency and machine integrity.