

# STEAM TURBINE - BUILT UP OR SOLID?

By Sydney Gross



It's a perennial topic that continues to resurface as new people enter the turbomachinery field from various disciplines. Why have two different rotor constructions, built-up and solid?

First, what do we mean by the two types of rotors? A built-up or disc-on-shaft or stacked rotor is an assembly of a shaft and separate bladed discs. The discs are fixed to the shaft by an interference fit and keys at the disc bore. The keys are a back-up. Discs are typically located axially by steps in the shaft, sleeves or rings shrunk in grooves. The rotor is usually assembled vertically by heating the discs and lowering them over the shaft to the correct position or lowering the shaft through the disc. With a solid rotor the shaft and discs are machined from a single forging and the discs are bladed after machining is complete. Combinations of the two exist but are very uncommon.

Comparable built-up rotors can be manufactured in

less time than a solid rotor for several reasons. The lead times for disc and shaft forgings are less than a solid rotor forging and the discs can be bladed while the shaft is being machined. Additionally, errors in machining and assembly are more easily accommodated. So why bother with a solid rotor to begin with?

Built up rotors are speed and thermally limited by the fit of the disc to the shaft. At some speed the disc bore will grow due to centrifugal force to the point where it can no longer transmit the torque produced in the blading. The interference fit is also sensitive to rapid heating of the turbine since the mass and thickness of the disc is small compared to the shaft and is directly exposed to the steam. When the disc fit is lost, the vibration will increase and bad things may result. Why not increase the interference fit? The interference fit is limited to yielding of the bore and shaft when the rotor is assembled and the ability to disassemble the rotor at some future point. Typical interference fits are 0.002" per inch of diameter although some manufacturers favor heavy fits on the order of 0.003" per inch of diameter.

Built up rotors are typically used up to about 7000 rpm. API 612 requires purchaser's approval for a built-up rotor when blade tip speeds exceed 825 feet/second at MCOS or when inlet steam temperature exceeds 825°F. Most turbine manufacturers have their own criteria which are generally more conservative.

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