DISCUSSION

R. J. Ortolano[1]

The authors are complimented on their paper, which depicts a number of significant design improvements that are expected to produce both efficiency and reliability benefits. It is noted that the use of countersunk riveted blading to accommodate multiple radial seals on the spring-backed rings also avoids rivet erosion from abrasion.

The reversal of the nozzle chamber is intended to improve the HP turbine efficiency. Hopefully, this is achieved without creating an excessively high partial arc stimulus on the downstream reaction blading due to the shorter steam path.

The 180 deg ring-type nozzle chambers with removable nozzle blocks should be a distinct structural advantage while retaining access and ease of repair for the blocks.

Monoblock constructed blading is another significant feature, which should reduce assembly distortion and associated stress. Care should be given to stresses at the axial pin holes in the blades and disk, particularly at the corners and with respect to an interference fit pin. Of course, since the blading is manufactured as a set, it requires diffusion alloying rather than plasma spray for abrasion protection.

Spring-back seals, particularly of the repairable type, should be an attractive feature, along with the other improvements mentioned. Spring-backed seals for use in the IP turbine also appear to be quite compatible with the integral covered blading, due to the absence of tenon rivets.

The authors have clearly shown that the current lull in power plant construction can be effectively used to develop needed improvements, which can be applied to both existing and future units.

T. H. McCloskey[2]

The authors are complimented for their very interesting and useful paper, which promises substantial steam turbine reliability and performance improvements utilizing modern state-of-the-art design techniques.

The following comments and questions relate to several design modifications presented in the paper and are intended to clarify certain features of the ruggedized HP/IP turbine.

We concur with the authors' use of the triple-pin, control stage blade root attachment in lieu of the more conventional axial "Fir Tree" root construction. Independent finite element analyses have shown that high cycle fatigue stresses caused by partial arc admission and coupled with high temperature creep are much less likely to occur with the triple pin design as compared to the axial fir tree design (Reiger et al., 1986).

The elimination of the rotor bore represents a significant step advance in conventional large turbine rotor technology resulting in extended operating life, increased cyclic duty operation, and reduced maintenance inspection. This metallurgical advance was made possible in large part by a joint Westinghouse/EPRI research project, which developed and qualified the advanced low impurity rotor forging techniques employed in the ruggedized rotor (Swaminathan and Jaffee, 1986).

Many utilities have retrofitted provisions for fiberscopic examination of internal turbine components without the added need and expense of cylinder cover removal (Ortolano, 1986). Have the authors considered making any provisions in the ruggedized design to include fiberscope provisions to minimize downtime during periodic maintenance inspection?

The projected 120 Btu/kWh heat rate improvement is based solely on aero and thermodynamic design optimization studies. What is the original cycle heat rate from which this gain is projected, and do the authors have any plans to conduct an ASME PTC-6 field performance test to verify this efficiency improvement?

References

Ortolano, R., 1986, "Inspection, Modification, and Repair of Steam Turbine Blading," EPRI Workshop on Steam Turbine Blade Reliability, Mar.

Reiger, N. F., Steel, J. M., and Lam, T. C., 1986, "Development and Testing of a General Purpose Finite Element Code for Stress and Vibration Analysis of Steam Turbine Blade Groups," ASME Paper No. 86-JPGC-Pwr-34.

Swaminathan, V. P., and Jaffee, R. I., 1986, "Significant Improvements in the Properties of CrMoV HP Rotors by Advanced Steel Making," EPRI Workshop on Life Assessment and Improvement of Turbo-Generator Rotors for Fossil Plants, Paper No. CS-4169.

Authors' Closure

The writers wish to thank Mr. Ortolano and Mr. McCloskey for their discussions. Their comments are generated from an extensive industry information base.

Prior to adopting the straight-through control stage design, considerable attention was given to the shock potential on the reaction blades. Flow distribution test and mechanical analyses were performed to ensure blading reliability. In addition, the stress of all areas of the triple pin control stage design were investigated. The authors' company has never experienced a control stage problem with a triple pin design of this type.

While no-bore rotors will require less inspection, provisions have been provided for ultrasonic inspection of the rotor body from the surface. These no-bore rotors provide cyclic duty benefits, as well as permitting performance improvements.

The possibility of fiberscopic inspection has not been specifically provided for in the cylinder design of the first application of this technology. This capability, however, is available for the inlet nozzles and control stage blades with modifications to the turbine inlet piping.

The 120 Btu/kWh heat rate improvement is developed when modifications are made with a basic turbine heat rate of approximately 7800 Btu/kWh. This heat rate improvement is developed from all of the features discussed in the paper for a combined HP-IP element and the reduction in the existing levels of performance aging for this type of equipment. The efficiency improvements will be verified with enthalpy drop test before and after the installation of the ruggedized design.

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