CREATING VALUE FOR THE WORLD

DOOSAN STEAM TURBINES
Upgraded steam turbines can extend the lifetime of the power plant, raise its efficiency and reduce CO₂ emissions – all at the same time! Doosan is always a step ahead in developing improved power generation technology to provide stable electricity throughout the world.
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INTRODUCTION

Dangjin Thermal Power Plant (Korea), 8 x 500 MW
As a specialized manufacturer of electric power generating equipment, Doosan Heavy Industries & Construction places a high priority on the performance, efficiency, reliability and maintainability of our Steam Turbines through effective design and quality manufacturing. The DOOSAN factory operates under an on-line quality control system throughout the entire manufacturing process from the procurement of raw materials to the shipment of the finished product.

Power stations with DOOSAN Steam Turbines continuously feed information back to our Manufacturing and Design Engineers, who analyze the data and apply the knowledge learned to improve the performance of equipment being manufactured today and designed for tomorrow.

In addition, the ongoing mission of our staff of experienced Research Engineers, with their modern Laboratories and test facilities, is to develop new technologies for the continuous improvement in Steam Turbine performance and reliability.

To effectively meet the fast growing demand for electricity in the wake of the industrialization of our nation, DOOSAN has successfully constructed many large thermal and nuclear power plants in Korea beginning with the Seocheon 200 MW thermal plant in 1978 and the Yonggwang 1000 MW Nuclear plant in 1991.

DOOSAN offers a wide range of Steam Turbines for both fossil-fueled and nuclear plant applications. Our products are constantly evolving to meet the changing needs of our customers.
DOOSAN produces Steam Turbines for both 50Hz and 60Hz applications with ranging 100 MW to 1,100 MW for fossil-fueled reheat cycles and from 600 MW to 1,400 MW for nuclear applications. Throughout the range of sizes and applications, DOOSAN Steam Turbines reflect a consistent philosophy of design and features that ensure high reliability, high efficiency and easy of maintenance.
FOSSIL / NUCLEAR

Fossil

The DOOSAN family of fossil Steam Turbines is illustrated symbolically below. Each turbine configuration covers a range of ratings with a selection of steam conditions and exhaust the individual technical and economic conditions. The upper rating limit shown for each configuration is approximate and will depend, in any specific application, on many variables such as steam conditions, number of admissions, number and location of extractions, back pressure and rotational speed (3000 or 3600 rpm).

Nuclear

While nuclear turbines are available for almost any capacity rating, the licensing requirements for nuclear reactors and the pressures of economy of scale have dictated applications almost exclusively at the higher ratings, with four and six-flow Steam Turbine low pressure exhaust hoods as depicted symbolically below.
DESIGN FEATURES

**50Hz Application**

- For 1800 PSI
- For 2400 PSI
- For 3600 PSI

**60Hz Application**

- For 1800 PSI
- For 2400 PSI
- For 3600 PSI

DOOSAN STEAM TURBINES
→ **D-Series 2-Casings Turbine (up to 450MW)**

- Full/Partial Arc Admission
- Tandem Compound
- Reheat Steam Turbine
- 50/60 Hz Two Flow
- 2 Pole Hydrogen/Water Cooled Generator

→ **G-Series 3-Casings Turbine (up to 700MW)**

- Full/Partial Arc Admission
- Tandem Compound
- Reheat Steam Turbine
- 50/60 Hz Four Flow
- 2 Pole Hydrogen/Water Cooled Generator

→ **G-Series 4-Casings Turbine (up to 1100MW)**

- Full/Partial Arc Admission
- Tandem Compound
- Reheat Steam Turbine
- 50/60 Hz Four Flow
- 2 Pole Hydrogen/Water Cooled Generator
DOOSAN Steam Turbines are “Advanced Reaction” design with the inherently rugged compartment type construction. This is the key factor contributing to their reliability and sustained efficiency.

“Advanced Reaction” can reduce losses of each stage efficiently by lowering steam velocity at nozzle exit and optimum stage count can increase performance with less stages than pure reaction turbine. Optimum stage counts permit larger spacing and heavier, more rugged compartments less sensitive to mechanical damage. This design is also less susceptible to leakage by applying advanced seals.

Advanced Reaction Technology Stage With Wheel and Diaphragm Construction

- Optimum reaction increasing the performance through the low velocity at nozzle exit
- Lower root diameter increasing the performance through the lower loss on the blade surface
- Optimum stage count increasing the performance with less stage than reaction turbine
- Rugged Construction
- Lower thermal stresses
- Opposed-Flow HP-IP section
- Opposed-Flow LP section
- Lower axial thrust forces

**Reliability and Efficiency**

**CENTERLINE SUPPORT**

- Eliminates distortion & Misalignment
- Maintains proper seal clearances

**Turbine centerline support system**
MAINTENANCE FEATURES / TWO BEARINGS PER ROTOR

**Maintenance Features**

- General uncluttered arrangement
- Minimum number of piping connections
- Casings split at horizontal joint
- Two bearings per rotor
- Easy bearing access
- Provisions for station balancing
- Hydraulically extended coupling bolts
- Access covers for visual inspections
- Access ports for borescope inspections

**Two Bearings Per Rotor**

- Shorter bearing span
- Smaller rotor diameter
- Additional bearing damping
- Factory balance of individual rotors
- Easier station balance
- Easier bearing alignment
- Improved rotor Stability
DOOSAN turbine rotors are single piece forgings which undergo a quality heat treatment for high temperature stabilization. The forging is quenched and tempered through air cooling rather than oil, resulting in a more uniform microstructure, thus making it very stable at high steam temperatures. Our NDE specialists inspect each rotor for internal flaws and defects using a variety of in-process tests and inspection techniques including a very sensitive peripheral ultrasonic test. After being precision machined, the buckets are assembled to the wheels and finally the complete rotor assembly undergoes a multi-plane balance in our modern high speed balancing facility.
**TURBINE BUCKET**

**Turbine Bucket**

DOOSAN turbine buckets are manufactured from chromium steel bar and/or forged stock. They are extremely resistant to corrosion and erosion, and have a high degree of vibration damping. Prior to machining, the bucket material is first subjected to several stringent tests including ultrasonic inspection for internal material flaws. After machining, each bucket is thoroughly checked by magnafux to ascertain that it is free from surface defects. The aerodynamic shape of the DOOSAN Steam Turbine bucket is designed for the highest efficiency and years of quality performance. Conventional shaped ‘Pine tree’ dovetails hold the shorter buckets to the rotor wheels. Finger type dovetails with alloy steel pins secure turbine buckets over 20 inches long. The outer tips of the buckets in both the high and low pressure stages of the turbine are fitted with bucket covers to prevent steam leakage between the bucket and the spill strips located on the stationary diaphragms. Erosion shields are available for the last stage buckets, if necessary, to prevent erosion from low pressure, cooler steam which may contain a small amount of damaging moisture.
Outer Ring  
Partition (Nozzle)  
Web (Inner Ring)  
Packing Ring  

REMOVABLE RADIAL SPILL STRIPS  
STEAM BALANCE HOLES  
SMALL ROTOR PACKING DIAMETERS AND MORE PACKING TEETH  
EASILY REMOVED SPRING BACKED PACKINGS  

Spill Strip (Ring Segment)  
STEAM BALANCE HOLES CONTROL THRUST
**Nozzle Box and Diaphragm**

The DOOSAN Steam Turbine nozzle diaphragms are designed for high efficiency from the first stage to the last. The configuration and location of the diaphragms characterized by the impulse turbine design have the advantage of excellent steam flow characteristics and rigid strength. Steam flow concerns include steam path contour, leakage control, nozzle area, nozzle angle, and flow coefficient. Lower bending stress and deflection due to the high stage pressure drop are the main structural advantages.

In smaller diaphragms, nozzle partitions are inserted into a punched band for easier welding and to maintain proper uniform throat conditions between partitions.

With larger diaphragms, the nozzle partitions are welded directly to fabricated or forged outer rings and inner web plates.
The DOOSAN Steam Turbine includes two journal bearings for each rotor and one thrust bearing for turbine train. Journal bearings are designed to carry the rotor weight as well as the various dynamic radial loads which may occur over the operating range of the turbine. In addition, they are designed as elliptical bearings, giving them the proper dynamic characteristics to provide smooth, stable operation with minimum vibration.

The thrust bearing establishes and maintains the axial position of the turbine-generator rotor train and resists all the axial loads developed by the turbine-generator during operation. Each bearing has a spherical ball seat and provisions for shims allowing easy adjustments and alignment of the bearing to the rotor journal both vertically and horizontally.

All journal bearings are readily accessible and are split at the horizontal centerline allowing for quick removal and replacement with a minimum of disassembly work.
TURBINE CASING AND EXHAUST HOOD

Turbine Casing and Exhaust Hood

The Doosan’s high pressure Steam Turbine casing is a cast steel structure with a verified design and construction to prevent cracks during the casting. After rough machining, the cast steel is subjected to detailed non-destructive inspections of ultrasonic and radiographic tests. The casing flanges are designed to be relatively thick to prevent steam leakage. The low pressure exhaust hood and inner casing are fabricated from steel plate. Bolted access covers are easy to inspect the internal steam path components. An expansion joint designed into the crossover pipe decrease thermal stresses and distortions for the exhaust hood, and heat baffles welded on the surface of the inner casing prevents heat deformation. All turbine casings have a bolted horizontal joint flange for relatively easy and quick maintenance.
STEAM SEAL SYSTEM / LUBRICATION OIL SYSTEM

**Steam Seal System**

Turbine performance and efficiency depend upon a reliable steam seal system which minimizes any harmful air leakage into the turbine and steam leakage between turbine stages or into the turbine room. Labyrinth packing seal between the stationary blade and the shaft. Tip seals between the stationary blade and the shroud of rotating blade. Both labyrinth seals are divided into segments, secured from behind by a dovetail and held firmly in place by pressure springs. The labyrinth design provides a high resistance path against steam leakage while allowing for sufficient clearance between the rotor and the stationary components, thus avoiding rotor rubs during operation.

**Lubrication Oil System**

The primary consideration of the DOOSAN lube oil system is reliability. All systems are designed with three independent sources of power for pumping oil. System controls are designed such that each back-up emergency pump starts automatically if oil pressure drops to a preset level. In critical areas, redundant pressure switches add to this reliability.
The DOOSAN product line of steam valves and valve arrangements provide as few valve casings as possible while still providing high efficiency partial arc control. All valves are designed with vertical stems and horizontal steam joints, permitting easy disassembly and reassembly using station cranes.

For lever operated valves, the valve stem parts can be completely disassembled without disturbing the servo motors. This concern with maintainability avoids the extra time and work associated with disconnecting electrical and high pressure hydraulic connections.

**Main Steam Valves**

**Distributed Control System**

The DOOSAN Steam Turbine controls and monitoring systems are the latest in digital technology for highly reliable electro-hydraulic control. The DOOSAN Distributed Control System offers a common architecture for small, medium and large Steam Turbines controls, Turbine-Generator monitoring systems and Generator excitation systems.
RESEARCH AND DEVELOPMENT

Research and Development

The DOOSAN Research and Development Center with well equipped laboratories and state-of-the-art facilities can perform a wide range of tests and investigations. The R&D group conducts ongoing research programs aimed at enhancing turbine performance with current attention focused on turbine buckets, stage performance and steam path design.

Research Engineers conduct many other studies including rotor dynamics, aerodynamics and computerized modeling of Steam Turbines and turbine components.

Many of our R&D projects are carried out in close cooperation with our customers to develop innovative ideas for improving Steam Turbine design, efficiency and performance.
Service Engineering

For every Steam Turbine added to our installed fleet, the DOOSAN mission is to provide quality customer service over the entire useful life of that turbine.

Service Engineering is responsible for communications between the customer and the various DOOSAN service facilities and for the coordination required to concentrate these resources on the specific needs of the customer. Our Service Engineering facilities are always available to plan maintenance programs, identify the services and materials required, and to assure that these will be ready when needed.

DOOSAN Service Programs, coordinated by a local Service Engineer familiar with the customer’s organization and specific needs, are the best in the industry.

DOOSAN Service Engineering team add great value to a Doosan Steam Turbine by minimizing the cost of generating power over the entire service life of the equipment.
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