CHAPTER 1 – GENERAL

CONTENTS

1 Introduction

For more than a century the famous name of Blohm + Voss has been known for top quality in the design and manufacturing of sea-going vessels, floating cranes, off-shore platforms, complete shipyards and last but not least entire energy systems and power plants.

In 1995 Blohm+Voss Industrie GmbH was founded and took over the power and production engineering activities of Blohm+Voss AG. This was mainly done in order to react with more flexibility to the rapidly changing power engineering market in Europe. As Blohm+Voss Industrie GmbH belonged to the Thyssen Group some restructuring and reorganisation was necessary. Since 1997 Blohm+Voss Industrie GmbH has been part of Thyssen Anlagentechnik which belonged to the Thyssen Industrie AG. Following the merger of the companies Thyssen and Krupp, in March 1999, Blohm+Voss Industrie GmbH became part of ThyssenKrupp Engineering under the new name B+V Industrietechnik GmbH (BVI). In May 2006 MAN TURBO AG, Oberhausen, took over the turbine department of B+V Industrietechnik GmbH. The Hamburg subsidiary of MAN will continue to sell, produce and service the MARC turbine series.

Within the following paragraphs more detailed information about MARC steam turbines and the experience on power plant and water/steam-cycle installations is provided.

1.1 MARC Steam Turbines

BLOHM & VOSS has been building steam turbines since 1906 and is therefore one of the oldest established turbine manufacturers in the world. At all times BLOHM & VOSS steam turbines were built and used for various applications. This guarantees the knowledge and know-how that we want to place at your disposal as a prospective customer.

BLOHM & VOSS / MAN TURBO builds steam turbines of its own design. Permanent research and development ensures our competitiveness for the future.

MAN TURBO has solutions for world wide applications and for various and difficult requirements. Below are the main applications for our steam turbines are listed:

- Industrial Power Plants
- Heating Stations
- Plants for the Chemical and Petrochemical Industry
- Incineration Plants

- Biomass Co-generation Power Plants
- Various Waste-Heat Recovery Projects

BLOHM & VOSS / MAN TURBO has delivered steam turbines as well as complete power plants and is therefore highly competent in the field of turbine operation.

The MARC turbine production, workshop and repair facility is located in Hamburg, Germany. Our service engineers are on call to reach each location round the world within 48 hours.

1.2 Range Of Application

The MARC steam turbine programme includes back pressure and condensing turbines with and without controlled and uncontrolled extractions. Hundreds of BLOHM & VOSS steam turbines have been installed world-wide, operating at low cost with maximum efficiency, high reliability and availability in many different industrial plants, where besides electrical power process steam is required.

MARC steam turbines are in use as generator drives for various industrial applications in pulp and paper, sugar, fertiliser industries etc. and as pump and compressor drives in the chemical and petrochemical industries.

2 Steam Turbine - Design Features

2.1 The MARC - Turbine Concept

The customer's requirement for high economy and maximum reliability and availability has always had utmost priority for the development of MARC turbines.

The MARC concept (**M**odular **AR**rangement **C**oncept), which allows a flexible arrangement of the main components, can effectively fulfil each customer's requirements.

The turbo-generator comprises the following modules:

- Steam turbine
- Epicyclic gearbox directly mounted to the generator for power outputs up to about 25 MW_{el} or parallel shaft gearbox separately located between turbine and driven equipment for power outputs above 25 $MW_{el.}$
- Low pressure lubrication oil system
- High pressure control oil system
- Control system

The modules for the lubrication and control oil system, as well as the monitoring equipment, can be space saving positioned near the turbine.

Advantages to the customer:

- Proved design
- High reliability
- High availability
- High efficiency
- Low investment costs

2.2 Arrangement

The turbine plant will be mounted in a machine hall. Turbine, gearbox and generator rest on a customer supplied concrete base. The vibration isolation of turbine and machine hall will be effected by spring supports with dampers between concrete base and columns. Turbine, gearbox and generator will be delivered pre-assembled. After alignment and fastening, the modules will be fixed with non-shrinking concrete. Turbine and gearbox, as well as gearbox and generator, are connected by flexible curved-tooth couplings in order to ensure smooth running of the whole plant over the whole load range.

It is possible to install both oil systems (HP and LP) nearby or below the turbine plant. The necessary connection pipes between the turbine unit and the oil modules are pre-fabricated at our works for easy, save and fast installation.

The design would also enable a single floor arrangement with easy access to all components of the plant. Due to maximum pre-assembling at our works the plant could be effected quickly and easily.

2.3 General

MARC steam turbines have been designed for utmost reliability. As the highest thermal loads on the steam carrying parts occur on load changes, casings, guide blade carriers and inner casings have been developed for high thermal elasticity.

Design principles of all turbine types:

- Maximum symmetry of the upper and lower casing halves.
- Symmetrical temperature distribution at the circumference in all cross-sections and under all load conditions.
- Maximum uniformity of material distribution in the individual casing cross-sections with gradual transition to the necessary flange thickness at the casing joint.
- Thermal elastically suspended guide blade carriers/inner casings.

The design is further distinguished by the following features:

- Drum-type rotor
- Reaction blading
- Labyrinth glands
- Multi-face sleeve bearings

2.4 Casing

The horizontally split turbine casing is of cast steel construction for the HP-part and of fabricated steel construction for the LP-exhaust part. The balance piston and the support for the inner casing and the guide blade carriers are integrated in the HP-part. The variable casting pattern is optimised for the specific requirements so that the turbine casing is always a solid homogenous casting.

To keep the thermal stresses resulting from temperature changes on turbine start-up and on load changes low, the mass distribution in all cross-sections is largely symmetrical to the centre. Changes of required cross-section are carried out with gradual transitions.

The steam inlet chest with the control valves is a separate casting and flanged to the casing.

Centring of the casing to the rotor is ensured as follows:

- Vertically by supporting the brackets of the upper casing half on the lower casing half off the front bearing pedestal and at the rear turbine end by lateral brackets directly on the baseframe,
- Horizontally by casing guides at the bottom casing half ends to the bearing pedestals and to the foundation

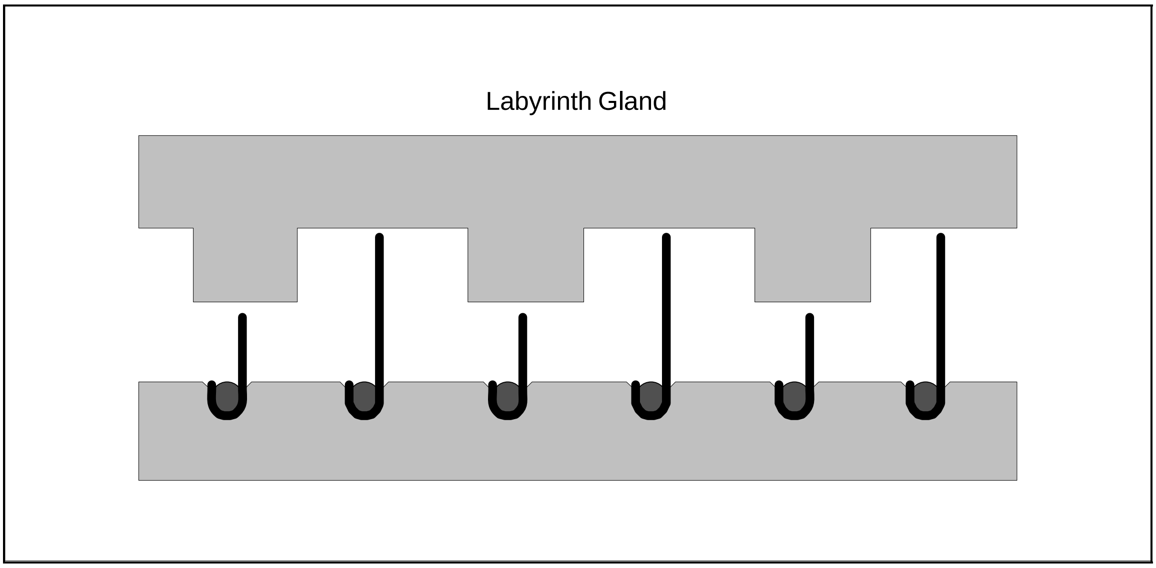
For pipe connections, such as steam inlets for additional steam, extractions, uncontrolled extractions, gland steam leak-off etc. the foundry welds on pipe pieces before the final heat treatment to avoid subsequent welding on the casting.

Turbine castings are subjected to the "Technical Terms of Delivery for high-temperature steel castings according to DIN 17245“.

The rough-machining, heat-treatment and quality tests are carried out by the foundry before supply.

2.5 Glands, Balance Piston

The steam sealing glands between casing and rotor at the casing ends as well as at the balance piston are of the labyrinth type. The sealing strips made of heat-resistant material are caulked into the rotor. In case of metal-to-metal contact at the sealing strips, the frictional heat is absorbed by the casing, thus preventing local overheating and deformation of the rotor. In this way the turbine remains operative.



2.6 Inner Casing and Guide Blade Carrier

The reaction blading part of the turbine is mainly divided into sections according to the number of the required bleeds (extractions). The guide blades are fitted in guide blade carriers. The steam flow direction is equal for every reaction section. The steam leakage over the first balance piston will be led into the second blading section.

The steam tight connection between steam inlet chest and turbine casing is performed via diffusor type valves with a piston ring sealing construction. In order to keep the required opening forces low, the valves are partly pressure balanced. The reaction guide blading as well as the nozzles for the control valves are fitted in the turbine casing. The nozzles are divided into nozzle groups according to the number of control valves. The steam sealing between turbine casing and rotor is of the labyrinth type.

The guide blade carrier, as support for the guide blading of the reaction section, is a forged or cast steel construction and horizontally split as well as the turbine casing. It is designed axially symmetrical with gradual transition to the necessary flange thickness at the casing joint.

The guide blade carrier rests axially steam-tight against a shoulder in the turbine casing and can move radially with thermal expansion. The suspension in the turbine casing ensures the concentric position of the guide blade carrier to the turbine rotor by means of a system of guide pieces.

The guide blade carriers are subjected to the "Technical Terms of Delivery for high-temperature steel castings according to DIN 17245“.

The rough machining, heat-treatment and quality test are carried out by the foundry before supply.

2.7 Blading

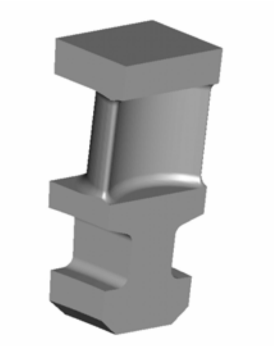
The blading consists of:

- A single-row impulse wheel as a control stage.
- A multi-stage reaction part.
- The guide blades are fitted in guide blade carriers.

The rotor blades have milled shrouds.

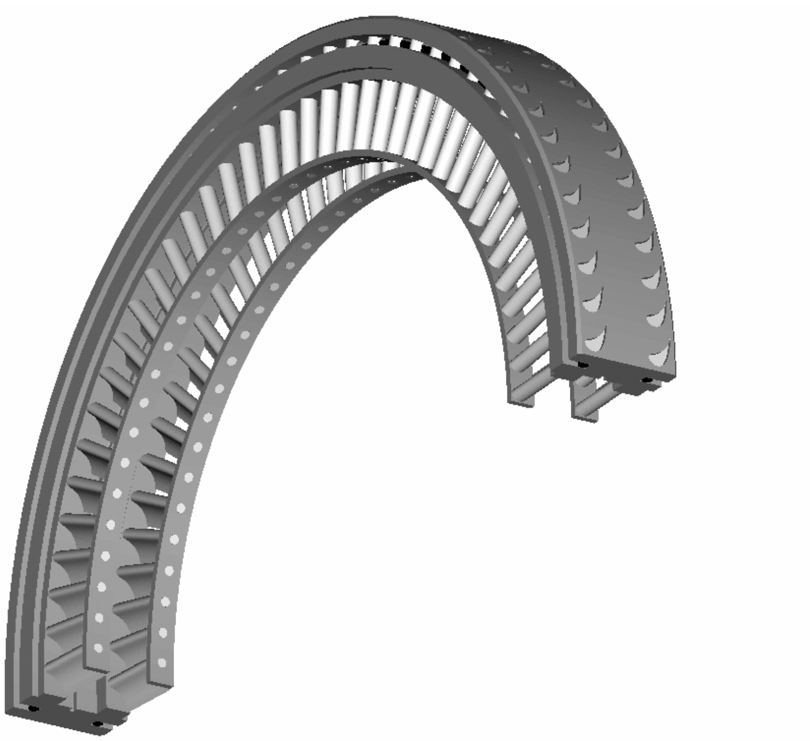
The reaction blading ensures high reliability and economy due to:

- High mechanical and thermal strength in both guide blades and rotor blades to withstand operating stress, as well as a large sectional modulus to avoid unacceptable vibration, high blading efficiency at both rated and part load as a result of a large shock-free entry angle range, and
- Sealing of the blade tips against guide blade carrier and rotor, by shrouds and sealing strips or one-sided thinning.

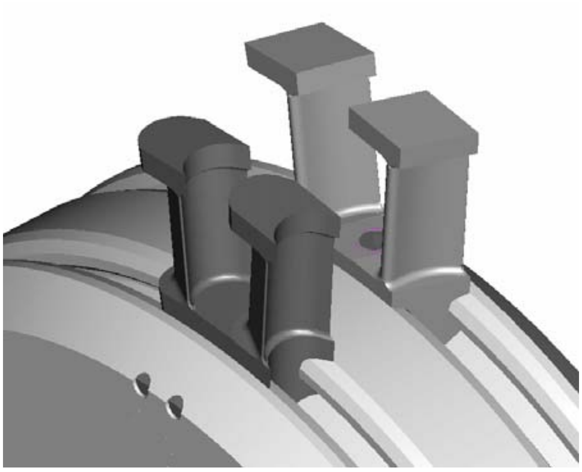


Reaction blading with integrated shroud (HP-blading)

Twisted blade of a condensing turbine



Half-Ring with two guide blades rows



Fixing of running blade

2.7 Turbine Rotor

The turbine rotor is of the drum type. The rotor together with balance piston, impulse wheel disc and drum part is a solid forging.

The rough machining, heat treatment and quality test of the rotor are carried out by the forging supplier before supply.

After machining, the fitting of rotor blades and sealing strips for the glands and balance piston, and the subsequent finish machining, the rotor will be balanced at operating speed. Additional the rotor balance will be checked above overspeed. Than the shaft vibrations of the rotors are considerably below the values permitted by API.

2.8 Bearing Pedestals

The turbine bearings (radial and axial) are located in two horizontally split bearing pedestals of fabricated steel construction, separate from the turbine casing.

The front journal bearing and the thrust bearing, the measuring pick-ups for bearing temperatures, speed and rotor position, are located in the front bearing pedestal.

The rear journal bearing and measuring pick-up for the bearing temperature are located in the rear bearing pedestal.

Besides the above mentioned measuring pick-ups, different measuring elements for turbine supervision - for instance for vibration monitoring - can be installed in bearing pedestals.

An auxiliary drive for the rotor turning gear can/will be installed at the front bearing pedestal.

The exhaust casing connection to the baseframe is the fixed-point of the turbine. The thermal expansion of the turbine casing is directed to the front bearing pedestal which slides on the baseframe guided by a parallel key.

As the turbine rotor is axially fixed in the thrust bearing of the front bearing pedestal, the thermal expansions of rotor and casing are compensated.

Sealing between shaft and bearing pedestal against oil leakage is carried out by means of sealing rings with non-contacting labyrinths.

2.9 Bearings

The turbine rotor is based in two radial journal bearings and axially fixed in an axial thrust bearing.

The journal bearings are of the tilting pad type, enabling a stable rotor position.

The axial thrust bearing is designed as a double-sided segmental sleeve bearing which absorbs the remaining thrust from the reaction blading not compensated in the balance piston.

All bearings are feeded with pressurised oil.

2.10 Control Valves

The steam control valves (diffusor type), have the advantage of smaller valve dimensions and this design will allow a greater number of valves and nozzle groups. Therefore the throttling losses are kept small. This will be important for part load opartion and good efficiencies will be achieved. Due to the small valve dimensions, the valves can be actuated directly.

The valve cones are fitted in a valve bar and have shafts of different lengths. The valve bar is lifted by two parallel moving valve spindles, thus raising the valve cones successively in accordance to their shaft lengths. Cone form and lift overlapping of the valves are selected so that a linear valve lift steam flow characteristic is achieved. The diffusors are of corrosion resistant steel and are fixed in the admission chest. Valve spindles, valve cone and bar consist of heat resistant steels with hardened surfaces. Thus a great wear resistance is ensured.

The hydraulic actuator with double-acting piston drive (servomotor) is connected to the HP-control oil system. Parallel motion of the two valve spindles with traverse and valve cones in a tight connection is carried out by a lever system. The servomotor follows every impulse from the turbine governor with great precision. On turbine tripping and full-load disconnection the servomotor immediately closes the valves by means of oil pressure.

In case of failing oil pressure the trip valve and the control valves are closed by springs, thus achieving double safety. Furthermore, the moving parts are made of non-corrosive, self-lubricating materials and require no maintenance.

The valve spindles are sealed either by Lentz bushes with gland steam leak-off or in the case of higher steam conditions by pre-compressed graphite laminated glands, which require no maintenance, and reinforced carbon guide bushes.

2.11 Trip valve

The trip valve is the main shut-off valve (fast closing) of the turbine. It is used to release or stop the steam supply to the turbine and is designed as an oil pressure dependent trip valve.

The control oil pressure drops by de-energizing of the solenoid valve and as the result the trip valve will close.

In case of an emergency stop both valves (the trip valve and the control valves) close immediately by means of springs. The trip valve is connected to the admission chest of the turbine casing.

2.12 Steam Strainer

The steam strainer is integrated with the trip valve casing and protects the turbine against impurities contained in the live steam. The strainer is provided with a perforated insert of stainless chrome-nickel steel. The inclined position of the strainer socket and the oversized insert (the insert surface is many times larger than the nominal size) ensure lowest flow resistance and pressure loss even with a partly clogged insert.