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Retrofit of 18K370 steam turbine on the units 7–12 at Belchatow Power Plant

Steam turbine retrofits are proven solutions designed to improve efficiency, reliability and competitiveness of electric power generation in existing power plants. Through the proper utilization of the state-of-the-art steam turbine technology development they allow to obtain, depending on the Customer's needs and expectations: power output increase, decrease of specific fuel consumption, lifetime extension, extension of intervals between major overhauls and overhauls cost decrease. Belchatow Power Plant is the largest lignite-fired power station in Europe. It has twelve units commissioned from 1982 to 1988. From 1997 to 2004 the low pressure (LP) turbine retrofits on the units 1 to 12 were carried out one by one. After their completion the next stage of power station modernization concerning the high pressure (HP) and intermediate pressure (IP) turbines and related auxiliary systems commenced. From 2004 to 2009 the HP and IP turbine retrofits on the unit 3 and 4 were carried out. In 2011 units 5 and 6 will be re-commissioned, following implementation of retrofits of their HP and IP turbines. This paper presents the 18K370 steam turbine retrofits on the units 7–12 and their comparison to steam turbine retrofits on the units 3, 4 as well as 5 and 6.

1 Introduction

Alstom Power is one of the largest suppliers of equipment and services for power generation. Besides turn-key deliveries of complete power plants and district heating plants, Alstom Power offers also boilers, steam and gas turbines, generators, hydro and wind turbines and environment protection installations. The company has extensive know-how and experience in engineering, manufacturing, service and modernization of boilers, steam turbines, generators and auxiliaries.

Thanks to changes in power engineering and energy market in recent years, supply of components, systems and equipment as well as services necessary for steam turbine and generator retrofits and modernizations became an important

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business for Alstom Power. Alstom is the world's leading supplier of steam turbine retrofits not only delivered originally by Alstom, but also by other turbine suppliers. As a consequence of continuing ageing of fleet installed between 1960 and 1990 and significant acceleration of turbine technology development observed in the last 25 years, modernization projects have become one of the most economically viable concepts for restoration and development of power generation capacity. By using state-of-the-art technology, the replacement of worn elements not only restores lifetime and increases availability, but also enhances the efficiency of turbines.

Advantages of steam turbines modernizations involving application of state-of-the-art blading as well as diverse optimisation activities, thus significantly increasing efficiency, include increase of electricity production and decrease of specific fuel consumption. When assessing potential benefits of a retrofit it shall be remembered that possible gains depend not only on the technology level difference: today's vs. that of forty or fifty years ago, but additionally also on improvement of technical parameters related to removal of permanent effects of ageing accrued during the course of operation.

Anticipating the requirements and expectations of the energy market in Poland, Alstom Power has developed and offers a wide range of modernization and service packages basing on Alstom's own technology. It involves among others 200/215 MW and 500 MW turbines of LMZ design, 120 MW turbines of Metropolitan Vickers design and 360 MW turbines of BBC design – see [1–4]. A module structure of the modernization packages facilitates implementation of more or less comprehensive modernization programs to suit the requirements, possibilities and priorities of each power station.

Usually preparation of final technical solution is preceded by preliminary analyses and detailed investigation of local conditions and needs, so it is possible to plan the modernization scope with relatively short payback period as well as to implement the modernization during a major overhaul. When proposing a new solution to a specific power plant, we strive to make the best possible use of the existing equipment, as long as their condition permits compliance with requirements. Alstom Power continues to develop its products. Experience in the recent years indicates that modernization programs which were offered and implemented introducing most recent developments in turbine technology, meet customers' expectations.

2 General information on Bełchatów Power Plant

Bełchatów Power Plant was built in 1970s and 1980s as a state-owned utility, however as a result of privatisation it is now a part of PGE Group (Polska Grupa Energetyczna), one of the largest power generation groups in Europe. PGE operates the following utilities: Bełchatów, Opole, Turów, Dolna Odra, Pomorzany and Szczecin as well as open-pit lignite mines Bełchatów and Turów as a body corporate named PGE Górnictwo i Energetyka Konwencjonalna S.A. (PGE GiEK S.A.).

Bełchatów Power Plant is located in the Lodz voivodship, 160 km to the south west of Warsaw, and is the largest in Poland and the largest in Europe lignite-fired power plant. The power plant comprises twelve 360 MW units commissioned from 1982 to 1988 and one supercritical unit 858 MW commissioned in 2011. Considering the modifications introduced during modernization carried out from 1997 to 2011 on units 360 MW, the actual power output installed in the power plant is 5375 MW and covers more than 20% of electricity produced in Poland.

Each of the twelve subcritical units includes: boiler BB-1150 type, made by Boiler Factory Rafako based on Sulzer and EVT license, 18K360 condensing turbine made by Mechanical Works ZAMECH based on BBC license (see Fig. 1) as well as GTHW-360 generator delivered by Dolnośląskie Zakłady Wytwórcze Maszyn Elektrycznych DOLMEL based on BBC license.

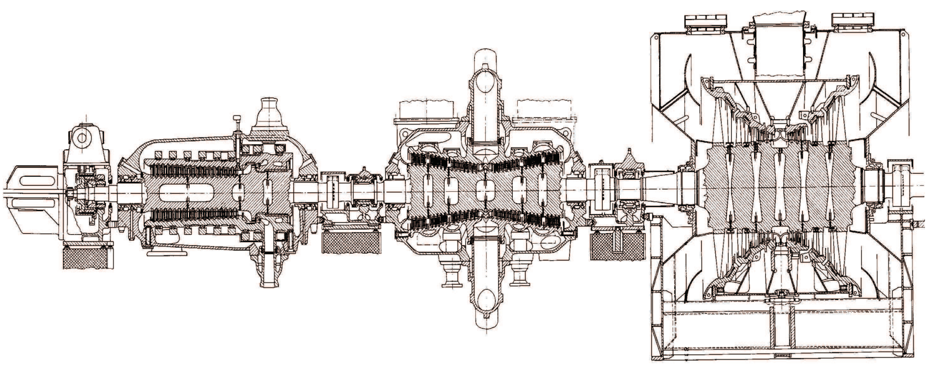

Figure 1. Sectional arrangement of the original 18K360 turbine.

3 First stage of modernisation of turbines in Bełchatów Power Plant

As of 1992, Bełchatów Power Plant proceeded with modernisation of turbine hall equipment. At first the modernization aimed at improvement of oil system and 18K360 turbine control system. This included replacement of turbine and low pressure (LP) bypass system hydraulic governors with electronic governors. In 1997 modernisation of LP turbines of 18K360 units were commenced. Modernisation of the last, twelfth LP turbine – for unit 2 – was completed in November 2004. LP turbine retrofit (Fig. 2) included replacement of old blading, based on solutions dating back to 1960s (1000 series blade profiles) with new blading of significantly increased efficiency, and involved introduction to the existing casings (outer and inner casing) of the following new components:

- bladed blade carriers for fixed blades as well as
- drum-type welded rotor with reaction-type blading.

The intermediate blade carrier was made of cast steel, whereas the front and rear blade carriers were made of nodular cast iron. The shaft of the new rotor is a four-piece welded rotor: the original rotor was six-piece welded. There are five stages in one flow of the double-flow LP turbine; the first three rows of fixed and moving blades are cylindrical blades, 8000 series profiles, with integral root and shroud milled from bars. The blades are pre-twisted during assembly.

The original exhaust D54 type, exhaust area 2 x 7.09 m^2 is replaced by a modern exhaust, RS37A type, Last Stage Blade exhaust area 2 x 7.2 m^2. Last and penultimate stage fixed blades are made of precision nodular cast iron casts. Last stage blade moving blades are free-standing. Last but one stage blades are machined with integral shroud, thus allowing for better sealing to decrease the leakage at the blade tip.

Low pressure turbine retrofits resulted in turbogenerator heat rate decrease by 3.0–3.6% and turbogenerator power output increase by 10–12 MW (corresponding to 2.9–3.5%). Simultaneously to retrofits of LP turbines 18K360 units, starting from 1999, modernisations (modifications) of high pressure (HP) turbine flow path were carried out, to correct the actual turbine swallowing capacity to obtain rated pressure upstream the stop valves, that is 176,52 bar, for maximum live steam flow 316 kg/s and HP valves wide open. The modification involved replacement of the following components: control stage nozzle ring and first four reaction type stages of fixed and moving blades, by new components of smaller

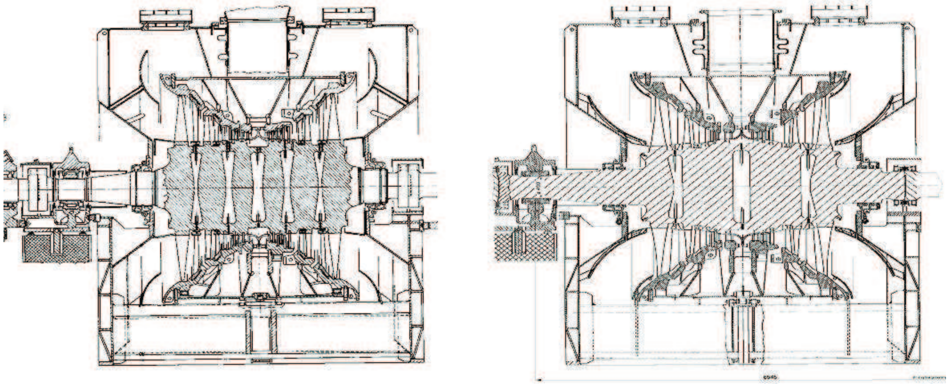

Figure 2. Low pressure turbine 18K360 before and after the retrofit.

swallowing capacity. Thus obtained increase of the expansion line in the HP turbine resulted in the turbine power output increase by 3.0 MW and decrease of turbogenerator heat rate by 0.5%. The modifications of HP turbines (HP turbine of unit 2) were completed in 2004.

Modernisation of intermediate pressure (IP) part for unit 6 was carried out in 2000, involving replacement of the original blading by blading of new types of profiles. As a result of this modernization the turbine power output increased by 3 MW.

4 Scope of modernisation for 18K370 turbine units in Bełchatów Power Plant in 2006–2016

An increase of hazards and operation problems related to ageing of the original equipment, preliminary assessed efficiency margins of thermal cycles and increasingly strict requirements of the European Union directives on environment protection induced the management of Bełchatów PP to commence analyses and studies to determine the areas to be improved and modernised.

The basis to define the objectives and scopes of modernization of power plant equipment were the results of analyses obtained from separate studies carried out in 2002/3003, investigating multiple variants of machine hall and boiler room equipment modernisations, as well as the results of supplementary analyses carried out in 2008 – see [5]. The following modernization tasks were defined as strategic objectives by the power plant:

- Increase of the overall unit lifetime up to 320 000 operating hours.
- Optimisation of the thermal cycle to obtain turbine power output 390 to 400 MW at maximum thermal efficiency.
- Increase of reliability, availability, maintainability to achieve the highest current rates.
- Increase of time between major overhauls.
- Modernization of the boiler firing system to comply with the Union Directive 2001/80/EC on CO emission control below 200 mg/mN^3 and NOx emission control below 200 mg/mN^3, when firing guarantee lignite, at the boiler load range 40% to 100% maximum continuous rated load (MCR).
- Provide possibility for automatic start-up, shut-down and operation in the entire load range.
- Increase of operational flexibility, ensuring operation at the load range 40% to 100% MCR.
- Ensure compliance of parameters of equipment and systems within power plant units with the Grid Code requirements.

To accomplish the above strategic objectives, for each unit decided to carry out the following:

- Modernization of the turbine island, including: HP and IP turbine, modernization of turbine auxiliaries and extraction pipework, retrofit of the generator, modernization of the turbine governing and protection system as well as instrumentation and control (I&C) equipment of the turbine island,
- Modernization of the boiler including: pressure part, firing system, flue gas and air ductwork, retrofits of forced draft (FD) and induced draft (ID) fans, boiler I&C equipment.
- Replacement of live steam and reheat steam pipework,
- Modernization of boiler air preheater.
- Modernization of electrostatic precipitator,
- Modernization of the unit distributed control system.
- Installation of the new flue gas-flue gas heat exchanger.

5 Retrofit of 18K370 turbines for units 7–12

In November 2010 PGE Górnictwo i Energetyka Konwencjonalna S.A. Branch Bełchatów Power Plant in Rogowiec and ALSTOM Power Sp. z o. o. in Warsaw Branch in Elbląg concluded a contract for modernisation and overhaul of HP turbine, IP turbine and turbine auxiliary systems for 18K370 turbines, units 7–12 in Bełchatów Power Plant. Apart from the aforementioned results of analyses, it is also the experience gained during the comprehensive modernizations of units 3, 4, 5 and 6 that shaped the final scope of the turbine retrofits for these units.

According to the contract, the following is assumed as the main parameters of the thermal cycle: for live steam upstream the turbine: pressure182 bar, temperature 557 °C and flow 312.5 kg/s, for reheat steam: pressure 42.24 bar and temperature 568 °C. The feedwater temperature downstream the HP regeneration was assumed at 255 °C. This actually meant increase of thermal cycle parameters with respect to their original values, in particular: for live steam upstream the turbine: pressure increase by 12.9 bar, temperature increase by 22 °C and flow increase by 10 kg/s (corresponding to 3.3%), for hot reheat steam: pressure increase by 2.93 bar and temperature increase by 33 °C. The assumed feedwater temperature downstream the HP regeneration is higher by 6.5 °C.

Essential components of the scope of delivery listed in the modernization contract for turbine island of units nos. 7–12 are as follows:

- HP turbine retrofit – new HP turbine including HP steam admission system,
- IP turbine retrofit – new IP turbine including IP steam admission system,
- modernisation of extraction pipework for extractions A1–A7,
- modernisation of the gland steam system,
- modernisation of turbine drain system,
- new IP-LP cross-over pipe,
- modernisation of control oil system pipework,
- modernisation of jacking oil system,
- modernisation of turning gear,
- LP turbine overhaul,
- modernisation of turbine governing and protection system,

– electronic turbine controller Controsteam P320V3,

– instrumentation and control equipment,

– modernisation of IP-LP bypass system.

As a part of turbine retrofit the existing HP and IP modules as well as associated steam admission systems are replaced by new components based on the standard Alstom's reheat turbine modules, taking into consideration the necessary limitations, since the existing turbogenerator foundations as well as front pedestal and HP/IP and IP/LP bearing pedestals are to be re-used.

6 Retrofit of HP module of 18K370 turbines for units 7–12

The casing of the new reaction-type HP turbine (Fig. 3) is a double-shell casing and consists of:

- outer casing,
- inner casing with fixed blading,
- bladed rotor,
- outer casing end glands (front and rear),
- balancing piston sealing rings.

Steam admission system of the original HP turbine (see Figs. 1 and 4), adapted for turbine nozzle control consisted of four separate valve casings, arranged symmetrically on the turbine foundation and connected by interconnecting piping with HP turbine casing. Each valve casing houses one stop/control valve. Interconnecting piping supplied steam to individual control stage nozzle segments in the inner casing. The new HP turbine solution involves throttling control rather than nozzle control. Therefore the location and number of inlet nozzles changed significantly. The steam to HP turbine is admitted from the two valve chests bolted on both sides of the outer casing. Each chest houses one stop valve and one control valve. Via the control valve diffusers, the steam is admitted to the two appropriately shaped half spirals integral with the inner cylinder. Such tangential steam admission fully utilizes kinetic energy of the admitted steam (Fig. 5).

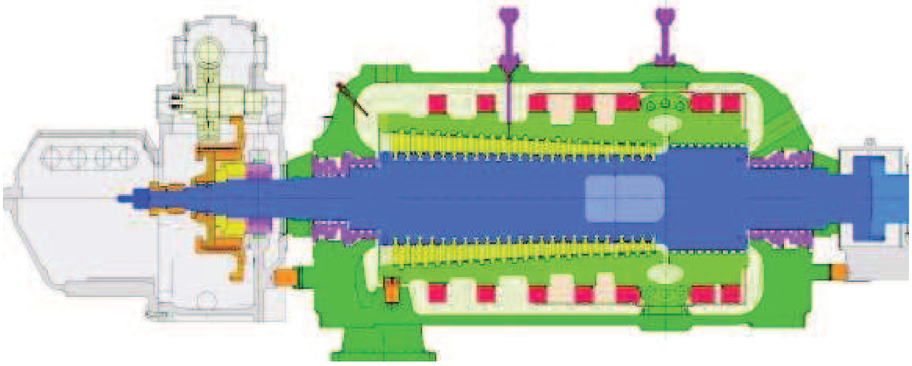

Figure 3. Sectional arrangement of HP turbine after retrofit.

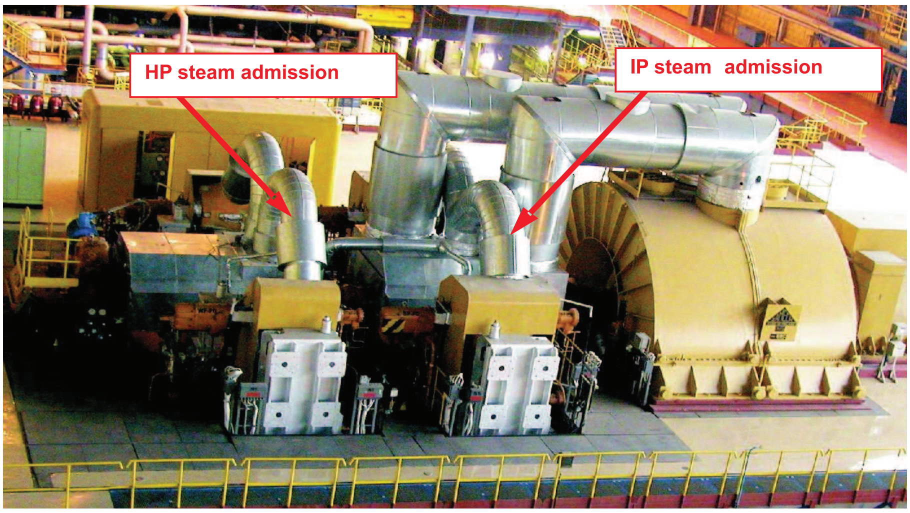

Figure 4. 18K370 turbine with original HP turbine steam admission systems.

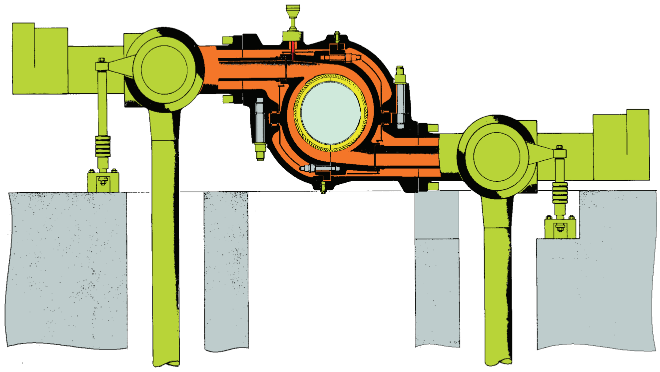

Figure 5. HP turbine admission system with two inlet half spirals.

The first HP turbine stage supplied with steam through two half spirals is an axial-radial stage (Fig. 9). For the new HP turbine, 23 axial stages follow the fist axial-radial stage.

The outer casing and gland casings are cast steel, Stg30T type. Outer casing has a horizontal joint flange, splitting the casing into two halves, held together by hydraulically tightened joint plane bolts. Since the newest generation blading with 8000 and 9000 series profiles was used instead of the original 1000 profiles, despite the fact that the number of stages increased from 20 to 24, it was possible to decrease the length of the blading system by approx. 300 mm – as measured from the inlet nozzle plane – and to shorten the outer casing by approx. 215 mm. Owing to the decrease in length of the blading system, it was possible to increase the number of sealing rings in the balance piston gland from the standard six rings to nine rings. At the same time the number of sealing rings in the first segment of the HP turbine outer shaft glands increased from the standard two to three – see Fig. 3. Previously in HP turbine retrofits for units 3, 4, 5 and 6 the standard numbers of sealing rings was applied. Sealing rings in the first segment of the HP turbine outer shaft glands are provided as "abradable coating seals" – see Fig. 6.

Since after the HP turbine retrofit the existing front pedestal and HP/IP pedestal will be re-used, the new solutions involves HP turbine casing paws appropriately longer than those used in the standard Alstom's reheat turbine modules. This is a significant change with respect to HP turbine retrofits for units 3, 4, 5 and 6, where standard-sized paws are used and the turbine outer casing barrel is longer than the standard one.

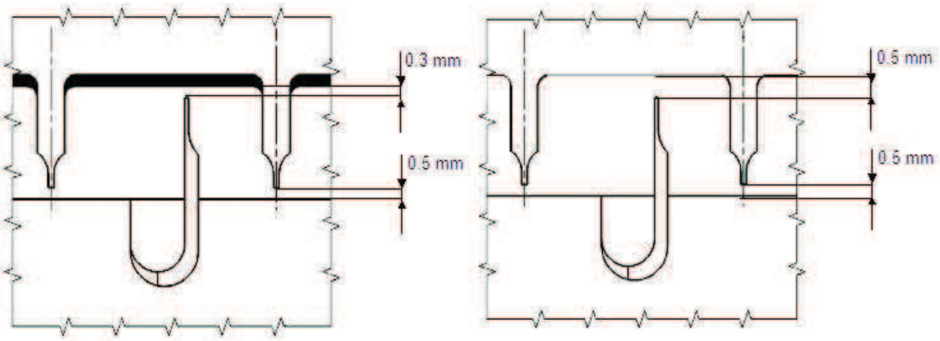

Figure 6. Comparison of sealing clearances of glands with „abradable coating seals" and with conventional sealing rings.

The new inner casing is a casting of high-alloy cast steel Stg9T. Vertical joint plane splits the casing into two halves. The two inner casing halves are held together by seven forged shrink rings made of St12T steel. The use of shrink rings to hold together the HP cylinder halves is a characteristic design feature of steam turbine solutions by Alstom.

The new inner casing is supported in the outer casing using two pairs of paws located nearby the horizontal joint flange, at the steam inlet and outlet respectively. In the lower half of the new inner casing there are two keys provided to maintain the axial position of the casing in the lateral directions. The applied system of keys and paws allows maintaining proper coaxial alignment of the casing, at the same time providing for free thermal expansion of the inner casing in all directions. The part of the inner cylinder subject to the highest temperature difference is covered by heat shield. It is thus possible to maintain the temperature differences and stress in the cylinder and shrink rings at an acceptable level.

A start-up probe is located in the same section as the inlet half spirals – see Figs. 3 and 7. The steam temperature at the inlet to the HP (IP) flow path measured by the start-up probe is used by thermal stress evaluation unit to calculate the temperature distribution in the HP (IP) turbine rotor. Thermal stress evaluation unit is an integral part of the turbine controller and controls the turbine speed and loading gradients so as to prevent build-up of excessive thermal stress during start-up and turbine load changes. A ventilation probe is installed above the fourteenth stage blades to monitor the temperature in the HP turbine flow path during low steam flow operation – see Fig. 3.

The new, drum-type HP turbine rotor shaft is a two-piece welding, welded from two forged pieces: the inlet part forged from St10/2TS steel and the exhaust part forged from St459TS steel. After blade assembly on the finish machined rotor shaft, the reaction stage blade shrouds are finish machined. To balance the thrust from the blading, the rotor on the modernised HP turbine part is provided with an appropriately sized balance piston. The diameter of the rotor journal is as per original design. Since the feed water temperature is lower than for modernisations of units 5 and 6, i.e. 255 °C rather than 275 °C, the additional, eight stage of regeneration and related steam extraction from HP turbine implemented for those units was here unnecessary.

7 Retrofit of IP module of 18K370 turbines for units 7–12

The casing of the new reaction-type IP turbine (Fig. 7) is a double-shell casing and consists of:

- outer casing,
- inner casing with fixed blading,
- bladed rotor,
- outer casing end glands (front and rear),
- two-stage balancing piston sealing rings.

Steam admission system of the original IP turbine (see Figs. 1 and 4) consisted of four separate valve chests, arranged symmetrically on the turbine foundation and connected by interconnecting piping with two inlet nozzles (upper and lower) provided in the middle of IP turbine cylinder. Each valve casing houses one IP stop/control valve (intercept valve). Inlet nozzles supplied steam to the upper and lower section admitting steam to the double-flow blading system.

The new IP turbine solution involves single-flow rather than double flow design. At the same time the configuration of the IP steam admission system was modified. This resulted in a significant change in location of reheat steam inlet nozzles. Steam to the IP turbine is supplied through two valve casings bolted on both sides of the IP outer casing. Each valve casing houses one stop/control (intercept) valve. Via the valve chest outlet nozzles the steam is admitted to the two appropriately shaped half spirals integral with the inner casing (see Fig. 8).

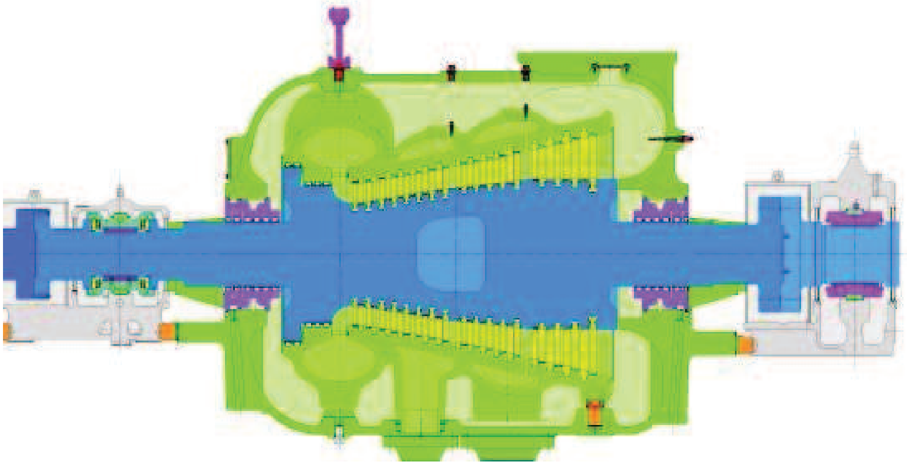

Figure 7. Sectional arrangement of IP turbine after retrofit.

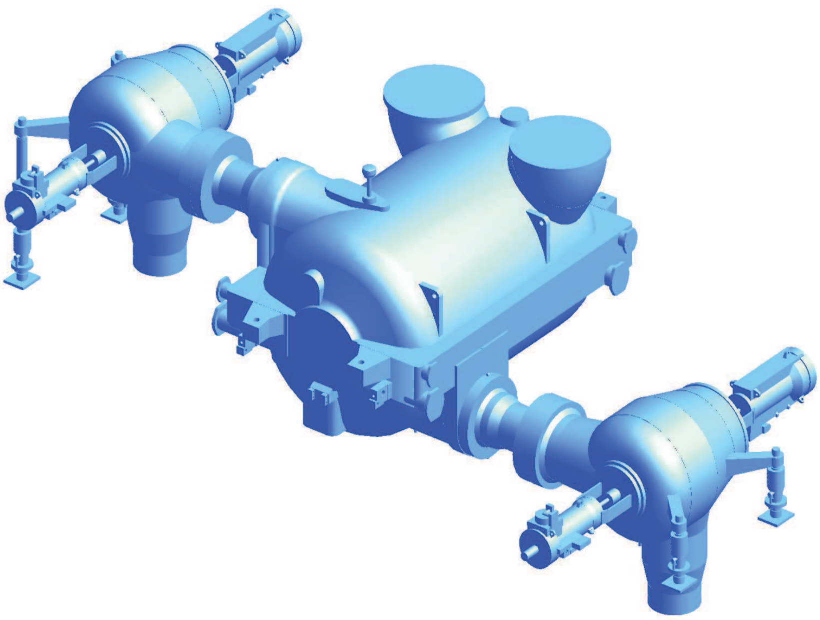

Figure 8. IP turbine admission system with two inlet half spirals.

The first IP turbine stage is an axial-radial stage – similar to the first stage of HP turbine. For the new IP turbine, 16 axial stages follow the fist axial-radial stage.

The IP turbine outer casing and end gland casings are cast steel, Stg30T type. Outer casing has a horizontal joint plane, splitting the casing into two halves, held together by hydraulically tightened joint flange bolts made of St460TS steel. Since the newest generation blading with 8000 and 9000 series profiles was used instead of the original 1000 profiles, and the IP turbine is a single-flow (1 x 17 stages) rather than a double-flow design (2 x 16 stages), despite the fact that an IP balance piston had to be added, it was possible to decrease the length of the blading system by approx. 720 mm – and to shorten the outer casing barrel by app. 690 mm.

Owing to the decrease in length of the blading system, it was possible to increase the number of sealing rings in the first segment of the IP turbine outer shaft glands from the standard two to three – (see Fig. 7). Sealing rings in the first segment of the outer shaft glands are implemented as "abradable coating seals" (see Fig. 6). Previously in IP turbine retrofits for units 3, 4, 5, 6 the standard numbers of sealing rings in glands were applied.

Since for the IP turbine retrofit the existing turbine foundation and HP/IP and IP/LP bearing pedestal will be re-used, the new solutions involves IP turbine casing paws appropriately longer than those used in the standard RT turbine modules. For previous IP turbine retrofits for units 3, 4, 5 and 6, standard-sized paws are used and the turbine outer casing barrel was significantly longer than the standard one. Thanks to the existing LP turbine, modernised in 1999, the new cross-over pipe consists of two lines, diameter 1016 x 10 mm, as for the original turbine, rather than one line, diameter 1520 x 10, as is applied for the standard single-flow IP Alstom's reheat turbine module. Therefore the upper half of the IP turbine outer casing includes two rather than one outlet nozzle.

The new inner casing is a casting of high-alloy cast steel Stg9T. Horizontal joint splits the casing into two halves. Both halves of the inner casing are held together by hydraulically tightened joint flange bolts made of St12T steel. The new inner casing is supported in the outer casing using two pairs of paws located nearby the horizontal joint flange, at the steam inlet and outlet respectively. In the lower half of the new inner cylinder there are two keys provided to maintain the axial position of the casing in the lateral direction. A start-up probe is located in the same section as the inlet half spirals (see Fig. 7).

The new, drum-type IP turbine rotor shaft is a two-piece welding, welded from two forged pieces: the inlet part forged from St10/2TS steel and exhaust part forged from St459TS steel. To balance the thrust from the blading, the rotor on the modernised IP turbine part is provided with an appropriately sized two-stage balance piston. The sealing rings of the balance piston gland are "abradable coating seals" type. The diameter of the rotor journal is as per original design.

8 HP and IP turbine flow path

HP and IP turbine first stage fixed blades (axial-radial stages – see Fig. 9) are C000 profile blades, with C-shaped roots, installed in appropriate circumferential grooves machined in generatrix of the gap between the inlet half spirals and inner casing inside. Appropriate shape of the first stage fixed blade roots and shrouds allows to introduce necessary pretension during assembly of blades.

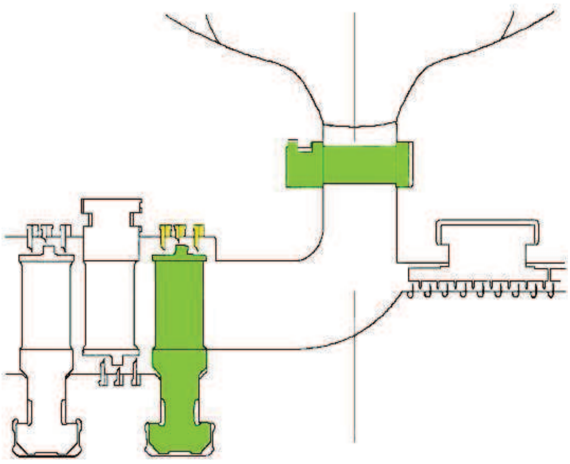

Figure 9. Axial-radial stage.

Reaction stages of the new HP and IP turbines are equipped with the newest generation of high-efficiency blades (HPB2) (Fig. 10). Design features of such blades include:

- optimised radii between the airfoil and shroud as well as between the airfoil and root,
- thin trailing edges,
- optimised airfoil shape to fit the three-dimensional flow.

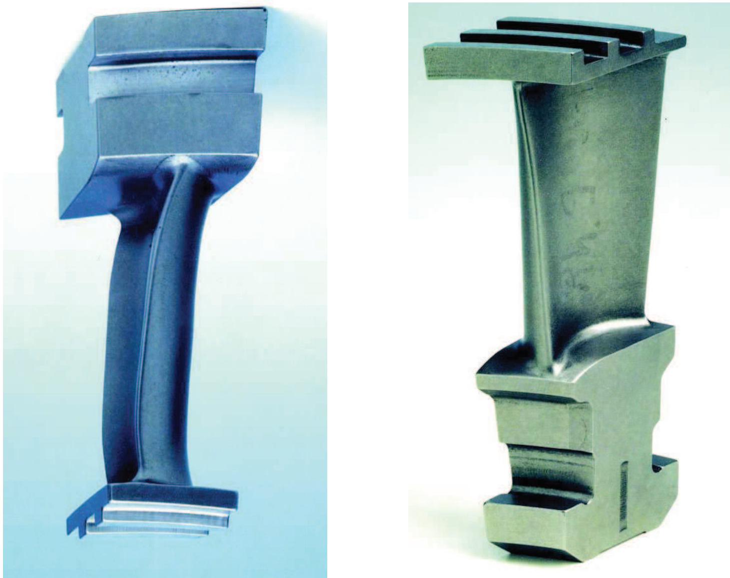

Figure 10. HPB2 type fixed and moving blade.

Reaction stage blades (fixed and moving) are milled as solid pieces from steel bars, steel grade St12T, StT17/13W or X20Cr13QT800, depending on the operating temperature and stress level. Shroud and root are an integral part of the blade. Moving blades are fixed in T-type grooves arranged circumferentially around the rotor shaft. During assembly the moving blades are prestressed by twisting the shroud section with respect to root section. By introducing such prestress it is possible to maintain uninterrupted (closed) circumference of blade row in changing operating conditions, thus eliminating the risk of resonance frequencies of vibration and consequently damage to blades during turbine operation in permissible load and speed range. Fixed blades of axial stages are provided with H-shaped roots, installed in appropriate circumferential grooves in the inner cylinder. Some of the fixed blade stages are also prestressed in the same manner as moving blades. Figure 11 shows assembly of fixed and moving blades. Interstage sealings and blade tip sealings (Fig. 12) are so called "interleaved, labyrinth type", where castellated ribs machined on the surface of the fixed and moving blade shrouds mate with the sealing strips caulked in the rotor shaft and in the inner cylinder. Axial and radial clearances for sealings in the blading system are optimised considering the actual differential expansions, rotor vibration amplitude and journal bearing clearances.

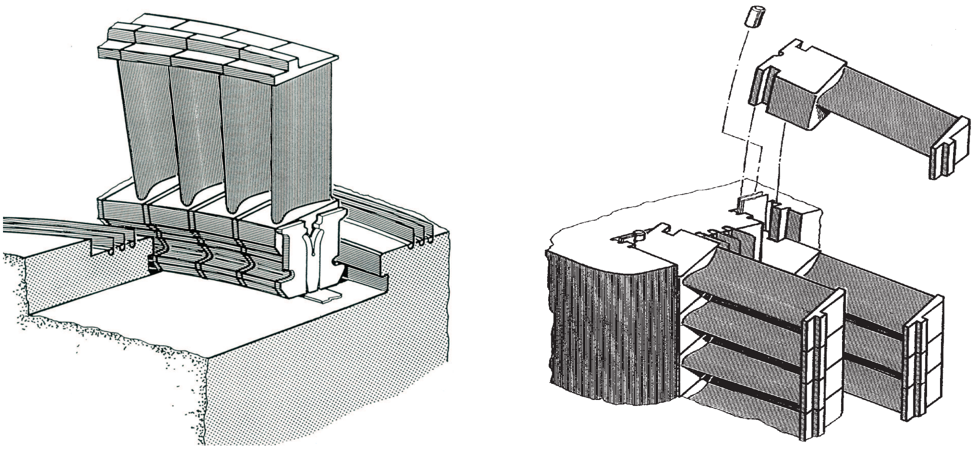

Figure 11. Assembly of moving and fixed blades.

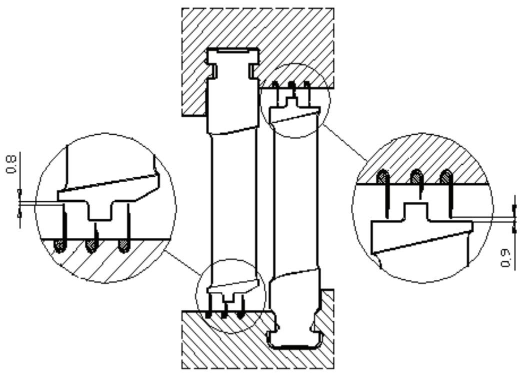

Figure 12. Interstage sealing in blading path.

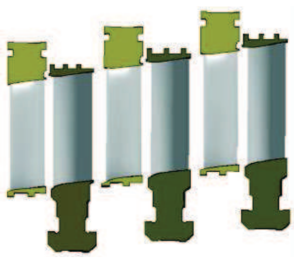

Figure 13. IP turbine blading with gap masking.

An additional feature to increase the blading efficiency, introduced as a part of HP and IP turbine retrofit of 18K370 turbines, units 7–12 in Bełchatów Power Plant is so-called gap masking (see Fig. 13). It is based on the change of the shape of blading path external boundaries (at the root and tip) to decrease the efficiency losses generated by the extraction of the energy from the steam path mainstream to support the re-circulating vortex motion set up in the hub and tip cavities at blade cascades inlet. Besides the modified shape of blading path external boundaries is addressed to minimise the harmful impact of leakages through interstage sealings on the steam path mainstream flow.

9 Summary

According to the contract signed in November 2010, 18K370 turbines of units 7 to 12 in Bełchatów Power Plant will be modernised one by one. The first unit to be re-commissioned after retrofit of its HP and IP turbines is unit 7 – in February 2012, and the last to be re-commissioned is unit 12, in September 2016. 18K370 turbine, unit 7, commissioned in 1985, was modernised for the first time in 1999 after 93660 operating hours. The present modernization, of much larger scope, is carried out after further 13 years of operation (and more than 85 thousand operating hours).

The retrofit of 18K370 turbine, units 7–12, selected as the subject of this paper is on one hand an example of development of the retrofit concept itself, and on the other hand – an example of gradual mastering of technical solutions applied to retrofit specific types of steam turbines. The modernization tasks under the aforementioned contract are in fact a part of a much wider retrofit project of units 7–12. Integrated approach to retrofits of essential equipment within the unit helps to optimise the solution to maximize the economic effect the net present value (NPV) and internal rate of return (IRR) across the entire scope of the project.

Retrofit of HP and IP turbines (see Figs. 14 and 15) will allow to obtain in new operation conditions (as compared to the turbine condition and thermal cycle parameters prior to the retrofit):

- Increase of HP turbine efficiency at full load by 4.3 %.
- Increase of IP turbine efficiency at full load by 1.7%.

Consequently for full load operation of the turbine (for live steam flow 312.5 kg/s – that is by 3.3 % higher than prior to the retrofit), turbine power output will

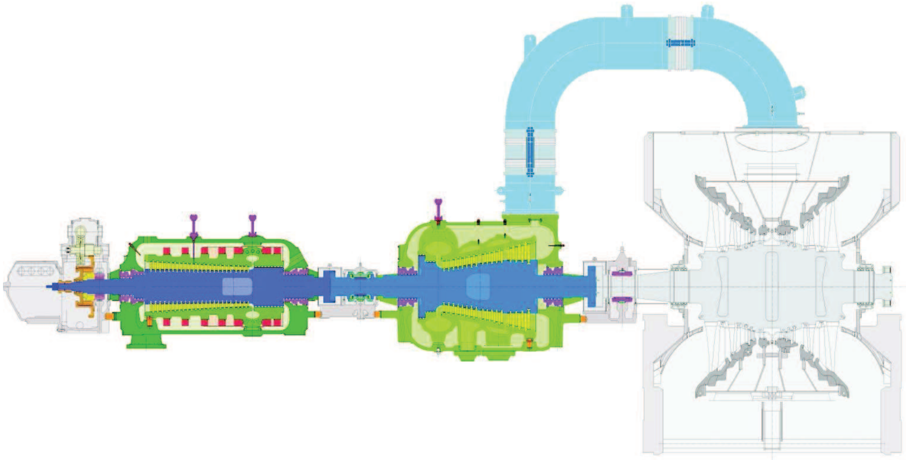

Figure 14. Turbine after HP and IP turbine retrofit — sectional arrangement.

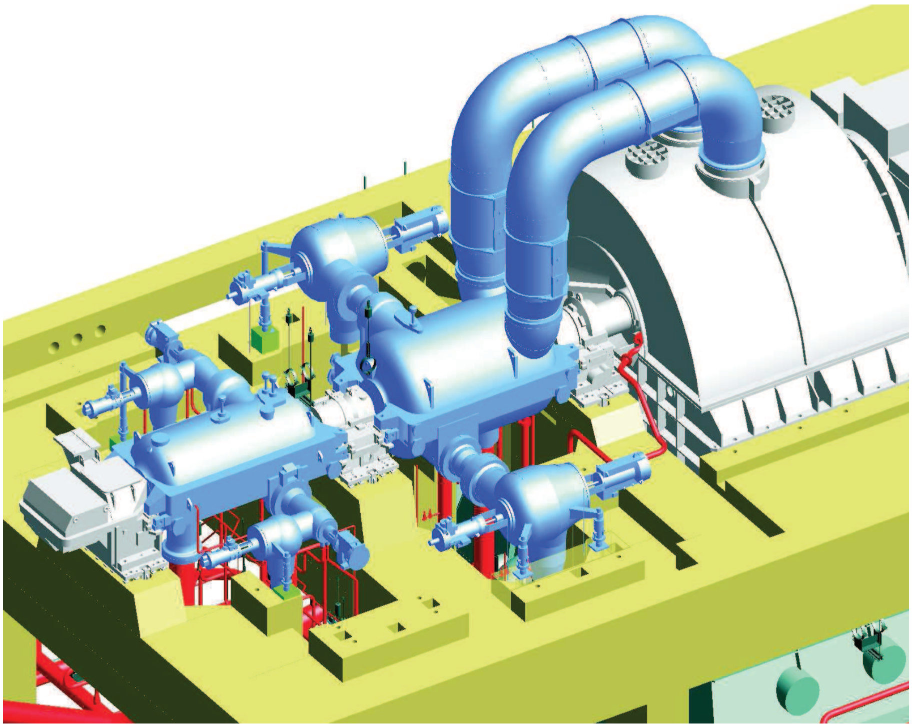

Figure 15. Turbine after HP and IP turbine retrofit on foundation.

increase by 9.3% and heat rate will decrease by 3.1%. Naturally, proportionally to decrease of heat rate the rate of atmospheric emissions will also decrease. At the same time, the scope of retrofit will cause full restoration of life time (for further 200000 operating hours) for all hot turbine components.

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Retrofit turbin 18K370 na blokach 7–12 w Elektrowni Bełchatów

S t r e s z c z e n i e

Retrofity turbin parowych stanowią sprawdzone rozwiązanie służące poprawie sprawności, niezawodności i konkurencyjności wytwarzania energii elektrycznej w istniejących elektrowniach. Poprzez odpowiednie wykorzystanie najnowszych osiągnięć rozwoju techniki turbinowej pozwalają one uzyskać, zależnie od potrzeb i oczekiwań Klienta: przyrost mocy, obniżenie jednostkowego zużycia paliwa, przedłużenie żywotności, wydłużenie okresów międzyremontowych i obniżenie kosztów remontów. Elektrownia Bełchatów jest największą w Europie elektrownią opalaną węglem brunatnym. Składa się z dwunastu bloków uruchomionych w latach 1982–1988. W latach 1997–2004 przeprowadzono stopniowo modernizacje części NP turbin 18K360 na blokach 1 do 12. Po ich zakończeniu rozpoczęty został kolejny etap modernizacji urządzeń elektrowni, tym razem dotyczący miedzy innymi części WP i SP turbin oraz związanych z nimi układów pomocniczych. W latach 2004–2009 w wykonano retrofity części WP i SP turbin na blokach 3 i 4. W roku 2011 zostaną uruchomione po retroficie części WP i SP turbin bloki 5 i 6. Niniejszy referat prezentuje rozwiązania retrofitów turbin parowych 18K370 na blokach 7–12 i ich porównanie do retrofitów turbin na blokach 3, 4 oraz 5 i 6.