STREBL ENERGY™
RENEWABLE ADVANCED TECHNOLOGIES

Equipment and Methods of Solution of Power-Plant Units

The following scheme of Delivery for a Power-Plant Unit" illustrates in a well arranged manner the scope of the deliveries our firm provides for 100 MW units of conventional condensing power plants. When calculating the economies for 0.05 USD/kWh and 3.5 USD /GJ of heat, it is possible to save up to USD 600,000 per year per unit by employing the modifications described.

Conception of Solution for Individual Technological Assemblies

1. Heater Level Regulation

When re-pumping condensate at saturation limit temperature, high cavitation wear of valves occurs. ZK and AZ type valves (explained hereinafter) that feature cavitation zone moved to a special nozzle built-in device ensure enhanced resistance against cavitation, which fact means a considerable maintenance and material cost saving of approximately 4,000 USD/year.
Cost of delivery: ca. USD 20,000

2. Condensate Pump Minimum Rates

Considerable cavitation wear also occurs at condensate pump minimum rate when re- pumping condensate into condenser and throttling condensate at the by-pass valve. When using anti-cavitation valves, a saving of approximately 1,000 USD/year can be achieved.
Cost of delivery: ca. USD 3,000

3. Level Control in Feeding Tanks

The operating practice taken from Czech and German power plants operation has also pointed out to the need of a first-class control valve of service life period with guaranteed controlling characteristics longer than one overhaul period. That represents a saving of approximately USD 6,000 per a period between two overhauls.
Cost of delivery: ca. USD 18,000

4. Boiler Feeding

Our aim is to ensure a full range of feeding in one branch from 0 to 100%. The valve is designed in order to continuously keep the required control characteristics even at minimum flow and maximum pressure difference that occurs upon boiler start-up, to achieve reliable control within the entire range, to work noiselessly and to feature long service life. We offer state-of-the-art and well-tried nozzle valves of ZK and AZ type. This valve complies both with the condition of a shut-off valve and the condition of a regulating valve within the flow range from 0 to 100%.

Valve Design Description

The valve is specially designed to transfer the process of pressure throttling from the cage trim to the system of radial nozzles. This eliminates cavitation and erosion of the cage trim itself. Gradual radial nozzle consists of several cases fitted into each other and provided with 19 radial holes. The holes run parallely, however shifted from case to case, forming thus intermediate turbulent (expansion) chambers. As required, it is possible to additionally re- adjust the flow cross section (kvs) and the characteristic (linear or equal-percentage) by means of a simple intervention (covering by-pass holes) to achieve whole travel motion of the valve.

The cage trim of a conventional control valve is loaded with very high flow during the opening process. Our valve, has the regulation cage trim separated with packing and regulating edge. When the opening process begins, the cage trim is moved from the seat by the packing edge without increased flow. Only from certain travel point, the regulating edge of piston gradually releases the rings of nozzles in the gradual radial nozzle. The regulation characteristic is kept within the range of the flow quantity from 0 to 100%.

During closing, the regulating edge reduces the flow and its speed; after that the sealing of piston reaches the seat. When installing ZK and AZ type valves, it is not necessary to install shut-off fittings before. The valve shows low noise level in all regulation positions (less than 85 dB).

Servo-Actuator Design Description
The valve is equipped with a regulating electrical actuator with a frequency converter, having a lot of advantages:

1. The connection of servo-actuator – valve provides incomparably lower mechanical play.
2. Frequency converter control is absolutely continuous with "soft" stops.
3. It is possible to software-adjust velocity and torque characteristics with all safety limitations. The result consists in lower mechanical stress of the servo-actuator and the valve, and longer service life and high control accuracy. By signaling the cases of exceeding the set up limits and by safe stopping the servo-actuator, it is possible to avoid possible seizure of the valve. Parameters can be set up by means of a PC through an RS485/422 serial interface and MOD-BUS protocol.

Owing to simple adaptation, actuator and servo-actuator control with frequency converters is the most progressive trend used in the world.

When enumerating the economies gained from the installation of the new valve in terms of less extensive maintenance, lower number of fittings, unit reliability a service life economies of the entire feeding branch, it is possible to save approximately 20,000 USD/year. In the feeding circuit, it is possible to save, in comparison with the original solution with 30 % of branches, 3 to 5 pieces of fittings.
Cost of delivery: ca. USD 25,000

5. Feeding Pump Minimum By-pass
Here again, the above described nozzle valve is used. The valve does not require energy reducer but, on the contrary, it is able to continuously regulate minimum quantity recirculation. It is also able to eliminate sudden load of feeding pump in feeding water flow- rate jump increase that occurs with conventional valve in its open - close mode, and complies also with the requirement for the promptness of feeding water regulation intervention upon jump decrease.

By using frequency converter at the drive, it is possible to achieve valve opening in increased speed operation (required time less than 5 s) when, due to a defect, the quantity pumped through the feeding pump falls under the allowable minimum.

The valve shows low noise level in all regulation positions (less than 85 dB). The valves offered by our firm save the excessive load of feeding pump drive and stabilize feeding regulation in transition states during feeding pump minimum rate opening and closing. The saving achieved by installing the new conception amounts approximately to 4,000 USD/year.
Cost of delivery: ca. USD 6,000

6. Level Regulation in High-Pressure Heaters
Here, the same applies as for low-pressure heater, the requirement for a high-quality control valve being, however, still higher for the reason of higher temperatures and pressure differences.
Cost of delivery: ca. USD 13,000

7. - 8. Boiler Blowdown and Sludge Blow-off
Here again, it is possible to fully utilize the advantage of already above described ZK and AZ valve design, separated packing and regulating edges, and moving saturated water expansion to the system of labyrinths. The valves feature high resistance against cavitation and long service life. Valve untightness causes unnecessary loss of a large amount of boiler water of high heat content. The loss of heat and auxiliary demineralized water amounts approximately to 90,000 USD/year.
Cost of delivery: ca. USD 15,000

9. – 10. Superheated and Inter-superheated Steam Temperature Regulation
The perfection of desuperheat station has a direct impact upon the service life of steam lines and the function of the whole system. The spraying process itself cannot be solved only by using simple spraying (with turbulent or atomization chamber).

Atomization turbulent chambers are particularly unsuitable with the out-dated system of spray water steam condenser (Doležal system) where condensate is injected under pressure proportionate to the pressure loss of superheater first stage, since the condenser pressure value equals to the boiler drum pressure value. This pressure difference is too low for good atomization through turbulent nozzle.

When regulated through injection, steam temperature is decreased by spraying water in it, the amount of which is controlled by means of an injection valve. The delay in this regulation system is very low and high cooling effect is achieved. The system using steam condenser (Doležal system) delays this dynamic system unnecessarily. This system found its substantiation in the past when quality DEMI water could not have been produced and suitable injection valves featuring precise characteristics and, at the same time, shut-off function were not available. The use of steam condenser decreased salinization of superheaters and the whole turbine. This method has become outdated today. In our power plants, boilers have been reconstructed by installing Venturi ejectors providing direct injection of feeding water through a controlled valve that strictly adheres to the linear characteristics and, at the same time, is absolutely tight in its "closed" position.

Physical Precondition of Perfect Cooling

For complete and quick evaporation of injected water, it is necessary to enter the water in steam in such a manner that it covers the largest possible surface, at best in the form of fine droplets suitably dispersed in the steam flow.

The flow of the two-phase medium consisting of superheated steam and water droplets must be arranged in order to prevent water from condensing on piping walls, causing excessive local cooling and, consequently, crack occurrence.

Description of Built-in Ejector Supplied

The proposed steam desuperheater station consists of a Venturi tube and an attemperator located at the Venturi tube intake part - refer to the attached diagram. The function of the desuperheater station is based on water film disintegration at the injection nozzle outlet edge. The basic principle of water film disintegration is completed with slight rotation of inlet water in the injection nozzle water chamber ended with an outlet slot. The rotation causes water droplets moving slightly across the steam flow towards the external wall of the flow channel.

Venturi tube is designed as a separate body inserted in the piping and can be taken out of the piping after flame-cutting the welded joints. The inlet part of the tube is continuously formed and changed into a long diffuser. It is built in the steam piping.

Venturi tube, at the same time, provides a screening function protecting the piping against the impact of water droplets. It is fixed in the piping with its front part. The rear part is a sliding one. The space between the tube and the piping is ventilated with a moderate flow of steam. A cylindrical screen follows the Venturi tube.

The calculation of pressure loss of Venturi tube proper gives the value of approximately 0.03 bar, so that relative pressure loss amounts to 0.1%. The pressure loss of the entire desuperheater (Venturi tube, attemperator and screen) will be approximately a double of the amount, i.e. no more than 0.2 %. Thanks to considerably large relative area of disintegrating surface of the advancing water film, desuperheater features good atomization for already minimum weight flow-rates.

Water Inlet and Injection

Water inlet and injection is achieved by means of an inter-annular nozzle located in Venturi tube inlet part. This nozzle is washed with steam from both external and internal sides, which fact is particularly significant in the case of the outlet edge where water film becomes disintegrated. Water rotates in the water chamber inside the injection nozzle and flows out through a slot into the internal cylindrical channel, forming a water film on its wall. The water film disintegrates at the outlet edge.

By installing the new injection system, it is possible to save the cost related particularly to the replacement of transfer piping between individual superheaters where, in case of insufficient atomization, thermal load due to differential temperature of the piping surface, piping destruction, or even superheater service life reduction may occur. The saving resulting from spared forced boiler repairs and reconstruction amounts approximately to USD 490,000 per unit during the period between two overhauls. Another aspect consists in final saving of fittings and maintenance works by excluding stand-by branches and shut-off fittings. In the power plant (5 x 200 MW), the number of 300 steam temperature control fittings decreased to the number of required 60 pcs while improving the equipment reliability.
Cost of delivery: ca. USD 150,000

11. - 12. Installation of BY-PASS Stations
In most power-plant units of 55 MWe output and higher, by-pass stations are used for unit cut-offs and start-ups. By-pass stations enable automatic regulation of units, flexible response to non-standard operating conditions and thus also reduced time required for start-up - approximately 1 hour (in comparison with ca. 10 hours in TG without by-passes). Using by- passes enables to hold turbine speed, to keep condenser level, to decrease the noise level of the entire power-plant unit, and turbine start-up and cut-off. By-passes enable easier and more flexible start-ups and cut-offs, since no large amount of demineralized water has to be available.

For example, if a 100 MWe unit operated without by-passes is cut off, approximately 200 t of demi-water escapes into atmosphere, which means USD 600 per start-up when considering USD 3 per m^3. Also, by reducing the time of unit start-up by one hour, it is possible to save up to USD 4,000 in fuel consumption. With the number of 20 start-ups per year, the saving amounts up to USD 100,000 per unit.

The by-pass stations supplied by our firm again include valves with combined shut-off and regulation functions, completed with a two-stage system of steam cooling by means of turbulent chambers and already before described Venturi attemperator. When cooling steam, they consume the amount of cooling water corresponding to the balance consumption without unnecessary oversprays. The system is capable to finely regulate the output from zero to 100 %, or to make a quick by-pass and cool the entire output range and, subsequently, to close absolutely tight.
Cost of delivery: ca. USD 150,000

13. Automatic Turbine Drainage System
Automatic turbine drainage system radically increases operating safety, heats and drains steam lines and turbine bodies without operator interventions, excluding the portion of human factor. We offer to reconstruct the turbine drainage system in order to reduce losses in the drainage system and to increase TG reliability.

Currently, the turbine is drained by using an outdated and ineffective method of using orifice plates or shut-off valves. It has totally four drain orifice plates and five shut-off valves providing drainage. Drain manifolds are interconnected at individual branches in terms of unit safety against water induction into the turbine.

Steam escape in the orifice plate drainage method represents an absolute loss of both not produced electrical energy and heat, since the outlets from the orifice plates are connected directly to flash tanks. When the turbo-set operates stable, almost no condensate forms in the turbine in the area of steam above the saturation curve. The orifice plate drainage system, however, does not take this fact into account and lets high power content steam escape. Also in the area of supersaturated steam, it releases stream-condensate mixture independently on real amount of condensate formed.

The calculation of energy losses is made according to the actual installation sizes of orifice plates. After having deducted respective temperature gradients at the plate and calculated steam flow-rate amount, the not produced electrical energy loss itself can be calculated with relative precision. The calculation takes into account the installation sizes of orifice plates. In consideration of the fact that most plates have to cope with over-critical pressure gradient in two-phase flow, erosion occurs and orifice plate cross-sectional area of flow increases, resulting in significantly higher impact on the thermodynamic efficiency of the machine than considered in the calculation that takes into account the losses for new, unworn orifice plates.

In case orifice plate drainage is eliminated (i.e., in substance, certain part of turbine blading by-passed), 2,800,000 kWh/year would be gained during the considered 7,000 operating hours yearly, which amounts to approximately USD 140,000 yearly at the price of electrical energy being 0.05 USD/kWh. In view of the wear of orifice plates and valves, the real price should be considerably higher. Another and main advantage consists in safe attendance-free operation of drain batteries.

By using automatic drain valves the piping remains condensate-free. As soon as condensate appears before the valve, bimetallic plates react and drain it immediately. After condensate is drained, steam starts to act on the bimetallic plates that will press the cone into the seat with considerable force. This simple principle together with high reliability provide for considerable economies without any loss of steam in the steam trap. Drain piping free from condensate also provides for more reliable operation of the turbine without any possibility of water induction into the flow section of the turbine resulting in an accident to the machine. When using other turbine drain systems, condensate level in the drain piping is, admittedly, kept in sufficient distance from turbine blading but in case of sudden load removing (machine outage), rapid pressure drop occurs in every drain manifold. This results in rapid boiling of condensate which may result in condensate droplets entering the flow section of the turbine.

Cost of delivery: ca. USD 75,000

14. Extraction Flap Valves
We supply non-return flap valves with quick-acting function actuated by protection signals for all turbine extraction rates. As required by the customer, flap valve drives may be either pneumatic or hydraulic operated. Flap valves provide for complete closing of extraction in the event of machine outage and back flow prevention.
Cost of delivery: ca. USD 50,000

15. Reduction Stations
We supply complete reduction stations with automatic drainage system consisting of the following components - steam desuperheaters and ZK and AZ valves, enabling regulation from 0 to 100% similarly to by-passes with noise level of up to 85 dB.
Cost of delivery: ca. USD 22,000

16. Turning Reduction Installation
Turning reduction equipment is installed in steam piping with the aim to gain electrical energy within the process of steam pressure reduction. Pressure reduction is determined by operational needs of the following steam distribution system. Steam for unit consumption itself is usually reduced from HP part outlet from the parameters of at least 2 MPa , 320o C to 1.1 MPa and temperature approximately of 220o C. This provides a usable isoentropic gradient of 135 kJ/kg which can additionally be used in electrical energy production. With usual steam flow rate of 15 t/h, it is possible to generate more than 250 kW of power output. Turning reduction generates kWh 1,750,000 in the value of USD 87,500 in the period of 7,000 operating hours. It is a small rotary machine featuring impulse blading, dimensioned for the flow rate corresponding to unit consumption. Steam entering distribution nozzle group will not be throttled and will transfer its usable temperature and pressure gradient with minimum losses into kinetic energy.

Flowing steam piping has two groups of distribution chambers with nozzle regulation incorporated. A superposed control valve will keep the pressure at the turning reduction outlet at the value required for the unit consumption itself.
Cost of delivery: ca. USD 100,000

17. Turbine Regulation Modernization
The existing level of the regulation systems of not reconstructed turbines K-100/3600 corresponds to the technical level of time turbines were designed when turbine regulation was dependent on complicated hydraulic mechanisms with high regulation deviations and without electronics applied.

The new conception is based on the combination of an electronic control system (regulation oil pressure tuning with electrohydraulic converters) with an up-to-date conception of hydraulic servo-actuators. Further, it is important to reconstruct valves themselves, to optimize their cones and replace labyrinth glands that let through live steam otherwise usable in the turbine with a new type of glands made of expanded graphite.

It is possible to effect fundamental changes in the control of regulating valves. The central cam-operated servo-actuator can be cancelled. Every regulating valve will be controlled with a new separate hydraulic servo-drive connected to the existing valve chambers. The connection will be made by means of new stands. These servo-actuators, "indirect" servomotors owing to their conception (force transmission by means of a lever mechanism), will have their hydraulic parts located out of HP regulating valve chambers and installed towards the stand between the HP and MP bodies where there is enough space for them. Therefore, they will not be located above any hot part of the turbine.

Individual servo-drives will be equipped with electrohydraulic converters, contactless transmitters of both limit positions made by Honeywell, continual position transmitter, and a control magnet.

The inlet piping of distributing oil and regulating oil to respective drives of HP regulating valves and LP retaining valves will be routed (for the reason of fire safety) inside the servo- drive waste oil piping. Temperature dilatation will be eliminated by using flexible bellows in the waste oil piping and by using corrugated stainless steel hoses in the pressure oil piping.

The retaining valves will be controlled by using a method identical with HP regulating valves. Here again, the existing camshaft will be dismantled and the servomotor and retaining valves controlled by separate servomotors of a design similar to HP regulating valves. Within the reconstruction of the turbine control system, the system of turbine protection against overspeed will also be reconstructed. The existing hydraulic protecting system will be replaced with highly reliable Woodward Protech 203 channel electronic system.

High-pressure lifting pumps featuring the system of rotor lifting before turning device start-up and upon run-out will be newly installed in the lubricating oil circuit.

Oil management will be completed with a Duplex change-over filter for distributing oil filtration.

Advantages of the Proposed Conception

1. Increase of operating safety and reliability.
2. Possibility to quickly hold the turbine at actual speed during protection intervention.
3. The steam escaping through the old labyrinth packing of regulating and retaining valves could be utilized to generate 260 kWe of electrical energy, which means a loss of kWh 1,820,000 amounting to USD 91,000 at the price of 0.05 USD/kWh during the period of 7,000 operating hours.
4. By decreasing the number of unit outages and the start-up speed, it is possible to save at least another USD 30,000.

Cost of delivery: ca. USD 295,000