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Two-shaft Turbine Feed Pumps For Nuclear Power Station and Thermal Power Station

It is still remembered pictures of the disaster at Fukushima-1Nuclear Power Plant, when because of the earthquake and then tsunami on the station, electricity was aborted and the regular cooling systems are stopped on all three working electrical power units. In this situation it was necessary to resort to the cooling of the fuel slug with sea water, but the water level is falling at its uninterrupted supply to the cooling system. Water cooling is not produced proper results due to destruction of the pipelines in the fall of large emergency aggregates of pumps. Probably, before this disaster, no one could not imagine what could happen, that all the backup cooling systems will fail. However it has happened ... the reactor cooling system with de-energized electric pump and torn pipelines of sea water feeding, could not carry the residual heat off the reactor and, as a result, Japan, in addition to the disruption of natural character, and even passed through the atomic shock.

Generally speaking, the use of feed electric pumps (FEP) in nuclear power plant can be considered a fashionable trend. Tianwan nuclear power plant - is the largest object of economic cooperation between China and Russia, the general plan which provides for the construction of 8 electrical power unit in deaerating-feed unit (DFU) of which five feed electric pumps will be set. It is worth noting that earlier feed pumps installed with turbine drive (TFP) in all NPT with WWER-1000 in DFU.

Transition to the use of high-power electric motors as the drive of feed pumps totally leads, besides of increased cost of the project, to a number of additional difficulties:

- significantly increased capacity of transformers intended for their auxiliaries
- increase the number of high-voltage communication devices;
- there was a question about the transition of their own auxiliaries with a voltage of 6 kW to 10 kW due to the high starting currents of motors.

Moreover, the acute problem of the feed control FEP, depending on the capacity of the main turbine, by using the electric motor as the drive feed pumps. The most common way is the regulation by throttling of flow at the exit of the FEP that leads to rapid wear of supply valve, constant services and replacements. This method is also not suitable in terms of energy efficiency. Application systems with the inverter motor speed, as well as controlling systems of rotor speed pump via the hydraulic coupling do not always produce the desired effect. The energy efficiency of these methods depends on the head characteristics of the system. At the same time the cost of their implementation is relatively high and often exceeds the cost of the entire FEP. Overall FEP with auxiliary units (the hydraulic coupling or VFD and their maintenance systems) has significant mass and dimensions parameters that creating large inertial loads on supply pipelines in the event of external action in the form of seismic activity.

All this predetermine to examine the issue about returning to the use of turbine-driven feed pumps, which have a simpler design, the best mass and dimensions parameters and operational characteristics for fixing in DFU system the new power units of thermal and nuclear power stations. [1]

JSC "LGM" plant (Moscow) has developed a fundamentally new design standard series TFP of two-shaft type, the overall view of the design is shown in fig. 1.

2.

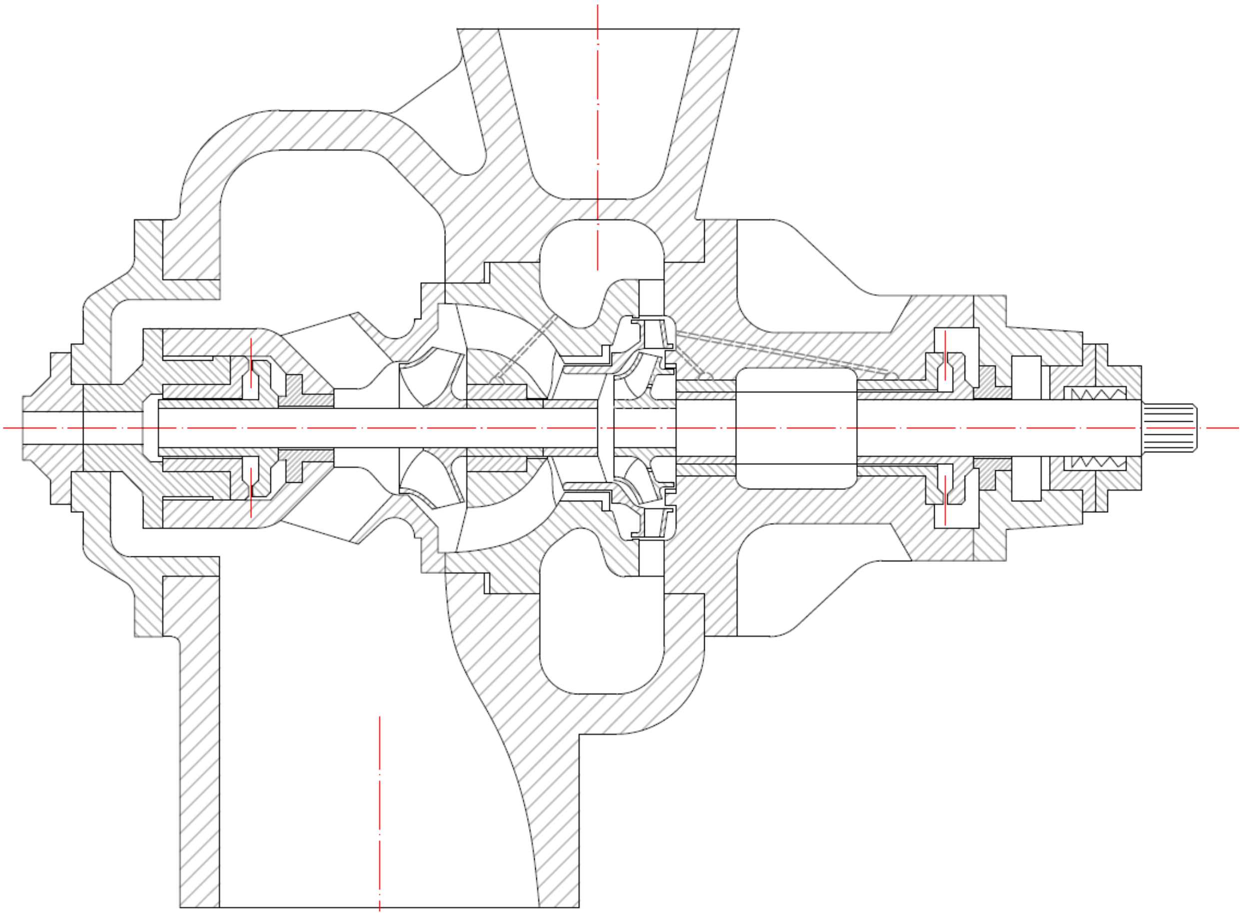

Fig.1 TFPA 4000/80

Operation principle of the pump, which is based on two stages – power-assisted (low-speed), and the main (high-speed) connected by full-flow turbine, positioned on the peripheral of the main stage impeller, it is described in article [2].

This pump scheme permits to increase the pump cavitating speed to C ~ 8000 with low vibration levels on the design elements by elimination cavitating facts in the pump flow part, and the optimal matching rate speeds of pumping steps.

Based on the above, the project of high-speed (n = 8000 rpm) turbine feed pump on the parameters of TFPA 4000/80 with minimal mass and dimensions parameters was created. The effective geometry and parameters of the pump performance are shown in the lists 1, 2 and fig. 2.

Parameters	Indication	Power-assisted stage	Main stage
Rate	Q, m^3/day	1.11	
Head	H, m	120	800

Rate speed	n, rpm	2800	8000
Specific speed	n_s	297	204
Cavitation margin	Δh, m	20	
Efficiency	h	0.84	

List 1. TFP 4000/80 parameters

Impeller parameters	Indication	Power-assisted stage	Main stage
Inlet diameter	D_1, mm	250	385
Outlet width	b_2, mm	55	100
Outlet blade angle	b_2, ^{o}	21	23
Vane number	z	7	6

List 2. The impellers TFP 4000/80 main geometry

Rotors structural dimensions of the power-assisted and main stages provide their work in the "stiff shaft" state with a safety margin above the first critical speed. Hydrostatic bearings, running on the controlled fluid, are supporting elements of pumping steps. Power-assisted and main stages blocks are inserted in the pump casing, and centered and connected. Pump stages unloading from axial forces is carried hydrostatic anvils, combined with supporting units. Thus, created design of a new two-shaft TFP has a virtually unlimited service life and, in combination with the maximum mass and dimensions parameters, it is competitive as compared with units that were created on the basis of the motor drive. This design is particularly relevant in the drafts of NPP and TPS power units, located in seismically active zones.

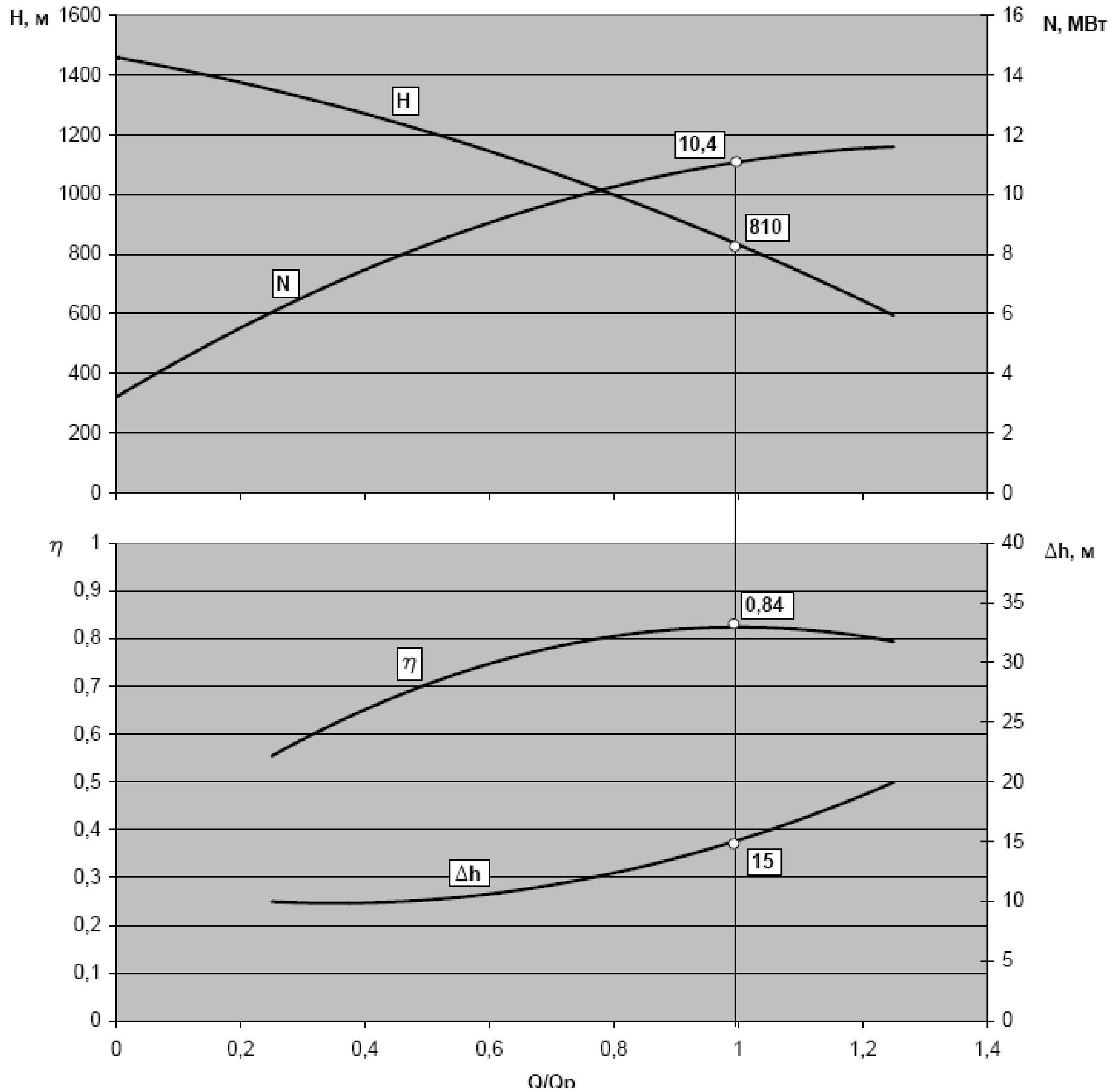

Fig.2 TFPA 4000/80 characteristics

In conclusion, it should be noted that based on two-shaft design considered above, condensate pumps have already been created and successfully operated for thermal power stations (see List. 3).

№	Pump type	n, rpm	Application	Dh, m
1	КсВ 80/160 (50/50)	3000	Condensate pump of turbine (N=16...25mW)	0,5
2	КсВ 125/140 (125/55)	3000	Condensate pump of turbine (N=35mW)	0,7
3	КсВ 200/130 (200/220)	3000	Condensate pump of turbine (N=80mW)	0,7
4	КсВ 315/160 (315/80)	3000	Condensate pump of turbine (N=110mW)	1,0
5	КсВ 500/85	1800	Condensate pump of turbine (N=250...300mW)	1,2

List 3. Two-shaft condensate pump

Conclusions

1. Two-shaft pump scheme allows to create a high speed turbine feed pump TFP, which do not required mass and dimensions parameters, while providing a wide range of rates regulation (0,2 ... 1,2) Q_p with high energy and resource indicators.
2. Two-shaft pump cavitating speed C ~ 8000 makes it possible to exclude boost pump and gear of speed-down of the driven turbine to the pump, which should have a positive impact on the resource index of the unit.
3. Reduced mass and dimensions parameters of feed (FP) and condensate (C) pumps, made by two-shaft scheme, under the influence of external forces give the minimum inertial loading on the connecting pipelines, which increases the performance reliability of the power units, located in seismically active zones.

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