Development of high head multi-stage pump with large capacity for large-scale water supply system


Shiro Matsui[*1] (1963)


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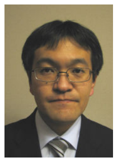
Tomohiro Naruse[*3] (1970)

1. Outline

California, which has an abundance of water resources in its northern regions, is carrying out multi-purpose projects for distribution of water to its large cities in the south. The most important pumping station in the state's water conveyance system at the A.D.Edmonston Pumping Plant operates 14 large pumps that are of the largest scale in the world. The station lifts up water 600 meters. However, pump efficiency decreases due to deterioration over the years and repair period increase due to cavitation damage, which results in lower maintenance efficiency. To improve the performance, the Edmonston plant has begun a renovation project to replace four pumps.

Hitachi was awarded a contract of this project. Utilizing the unique high technology and applied the state-of-the-art Computational Fluid Dynamics (CFD) analysis to complete the hydraulic design work, we attained the highest level of efficiency in the world for the development of this class of multi-stage pumps. In addition, using optimum structural design and high-quality production technology, we succeeded in manufacturing a highly reliable large-capacity pump. The first new pump went into operation in June 2007.

2. Technological Content

The key factor in deriving the optimal design for the multistage diffuser pump was obtaining an understanding of the hydraulic configuration. Mutual influences of a wide range of component elements that forms. To ascertain internal flow conditions, we made various uses of CFD technology. Along with this, a Design of Experiment (DOE) was adopted for parameter design, and a comprehensive and systematic approach was applied to investigate and determine the optimum hydraulic configuration.

In regard to pump suction performance which affects reliability, we had to assign first priority to suppressing the occurrence of cavitation that can damage the impeller blade. To do this we adopted a pre-rotational suction casing that would guide flows to the impeller with minimum interference with rotating shaft. By using CFD, we optimized the hydraulic configuration, obtained uniform flow distribution in circumferential direction, eliminated impeller inlet instability, and achieved appropriate flow speed at the impeller inlet. As a total of all these activities, we succeeded in designing the hydraulic configuration, which enabled to drive the pump in lowering suction pressure cavitation.

As a result, in on site measurements of the prototype pumps in operation, we attained an efficiency level of 92%, the highest level in the world for four-stage pumps. As for cavitation damage, none was found after 8,000 hours of operation. The fact that the surfaces were still in good condition confirmed the suitability of the design technology we applied to these high-performance pumps, and indicated that there would be no problems in future long-term operation.

Our challenge was to employ both technologies to yield high performance by precision manufacturing of impeller blades and high reliability by raising the material quality at the same time. This was realized by fabricating closed impeller type pumps by a completely new one-piece forging and five-axis machining process that we developed. The realization of these technology by automatic processing made it possible to improve the impeller blade profile precision, and by a repeat effect, we were able to minimize differences in dimensional precision. Fig. 1 shows the pump structure, and Fig. 2 and 3 show the prototype pumps.

3. Summary

The first large-capacity multistage pump developed is already in operation. Its high efficiency and superior performance have been confirmed. The improved efficiency results in the significant reduction of the electric power consumption of the drive motor, which enabled energy savings at the facility. The reduced energy consumption also means less CO_2 emissions, which contributes to prevention of global warming. We have been directed to proceed with manufacturing the remaining three pumps on schedule. We hope our achievement will contribute to the happy life of people in South California.

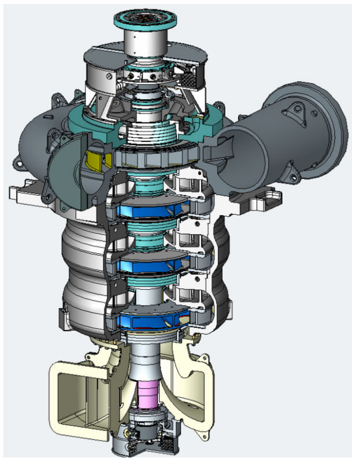
Fig.1 Pump structure


Fig.2 Completion of the pump assembly

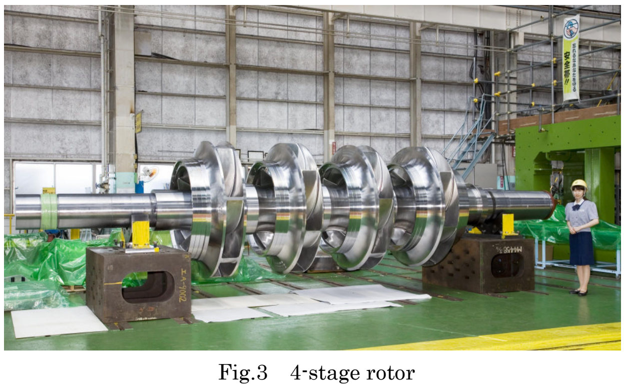
Fig.3 4-stage rotor

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