Highlights

- A structure of high speed mine submersible pump, and the axial thrust balance measures used the wear ring with balance hole and the thrust institution.
- A discovery of axial thrust deviation between the theory and experiment.
- Observation and explanation of the change of axial thrust components.
- The impeller blade force’s size and direction were changed in the multi-stage case, and it changes the size of the axial thrust.

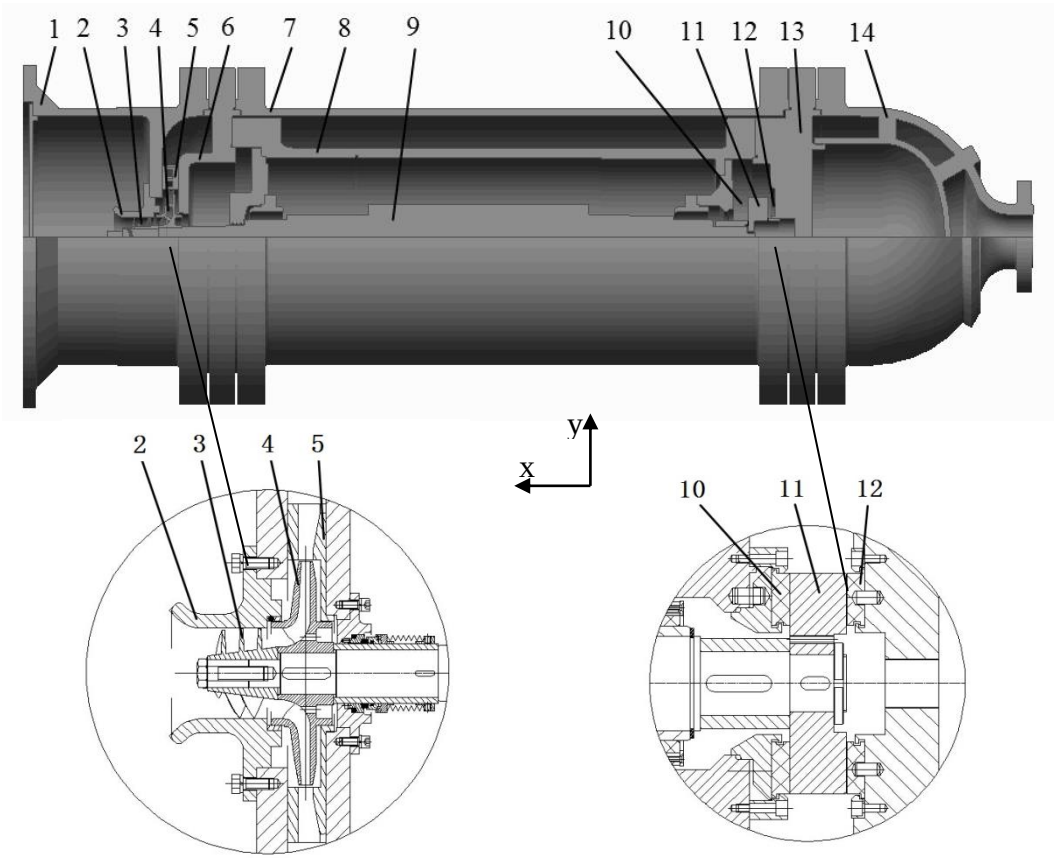
Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

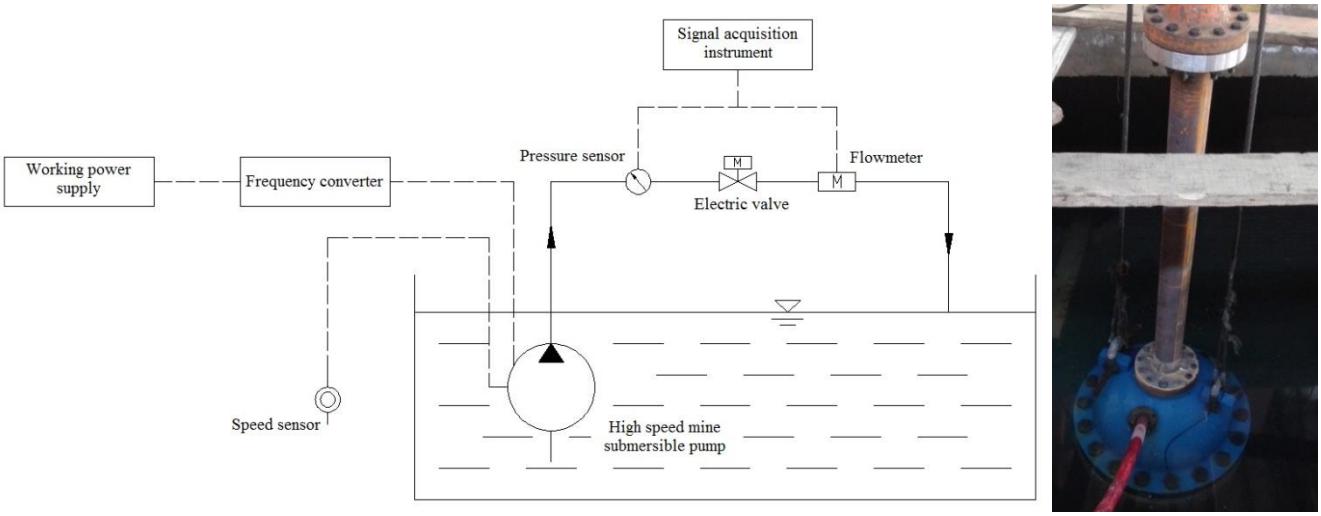
Special thanks are given to the Project supported by National Natural Science Foundation of China (No.51505192), the Top-notch Academic Programs Project of Jiangsu Higher Education Institutions (PPZY2015A086), and the Project supported by Science and Technology Innovation Team of Jiangsu Provincial University in China (No.2015-4).

Figures



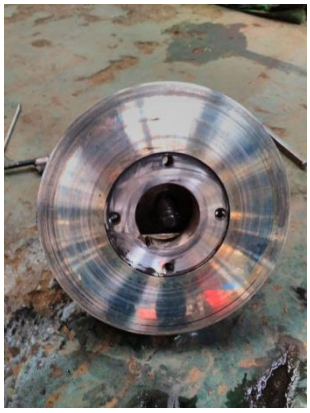
1.Base 2.Inlet section 3.Inducer 4.Impeller 5.Guide vane 6.Middle section 7.Outer cylinder 8.Motor housing 9.Shaft and rotor 10.Lower thrust bearing 11.Thrust plate 12.Upper thrust bearing 13.Motor cover 14.Pump cover

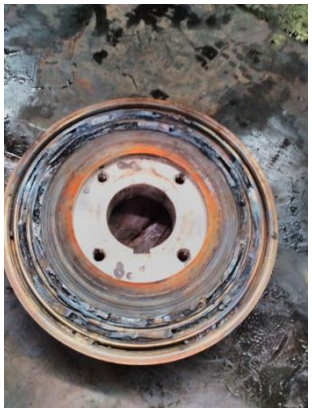
Fig. 1. Structure of the high speed mine submersible pump



(a) Diagram of experimental principle and system (b) Connection of pump on site

Fig. 2. Test of high speed mine submersible pump





(a) the upper surface of thrust plate (b) the lower surface of thrust plate (c) the surface of lower thrust bearing

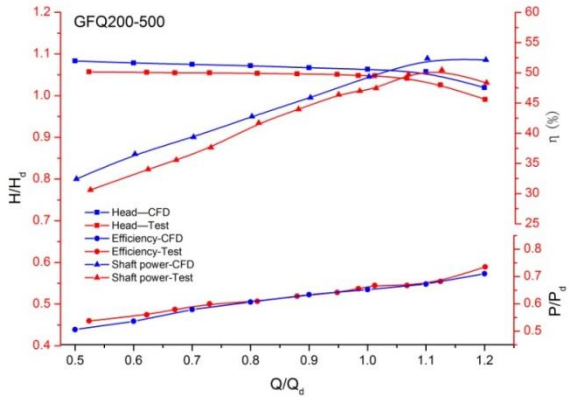
Fig. 3. Test dismantling situation

1.Foundation chamber 2.Middle section chamber 3.Outer cylinder chamber 4.Channel of casing cover 5.Outlet duct 6.Guide vane 7.Front chamber 8.Back chamber 9.Impeller 10.Impeller balance hole 11.Inducer

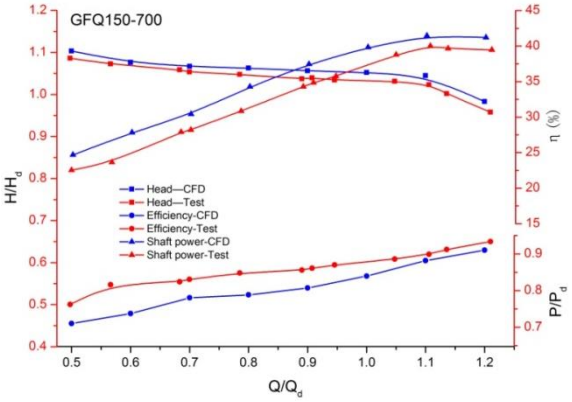
Fig. 4. The whole internal flow computational domain

(a) impeller mesh (b) back chamber mesh (c) guide vane mesh

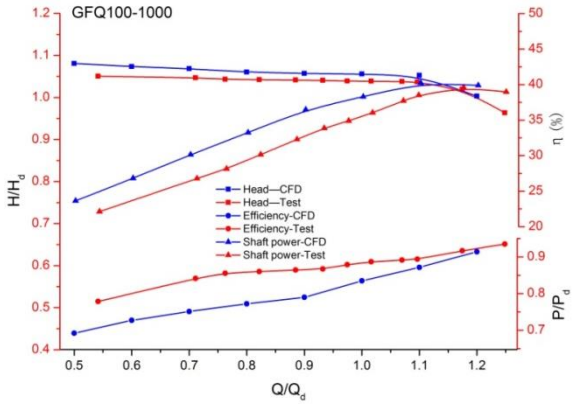
Fig. 5. Structured mesh of the computation domain



(a) GFQ200-500



(b) GFQ150-700



(c) GFQ100-1000

Fig. 6. Comparison between experimental data and numerical simulation

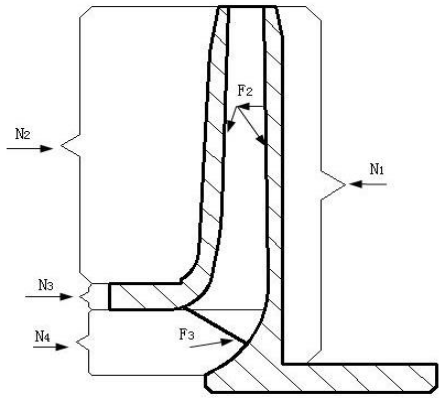


Fig. 7. Axial thrust component of impeller

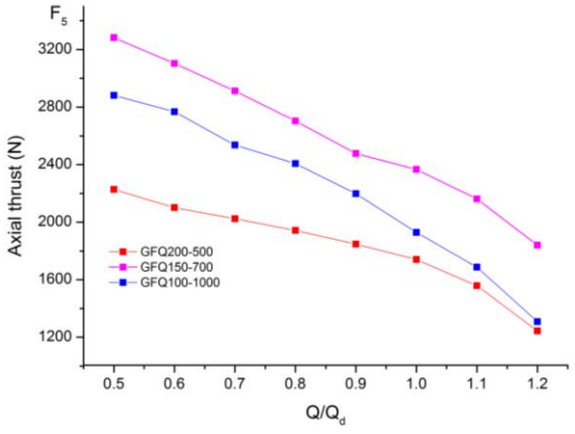
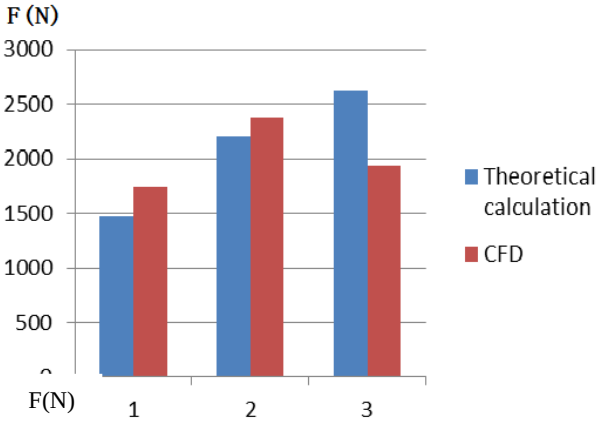


Fig. 8. Hydraulic axial thrust curve



1.GFQ200-500 2.GFQ150-700 3.GFQ100-1000

Fig. 9. Comparison between Theoretical calculation and numerical hydraulic axial thrust results

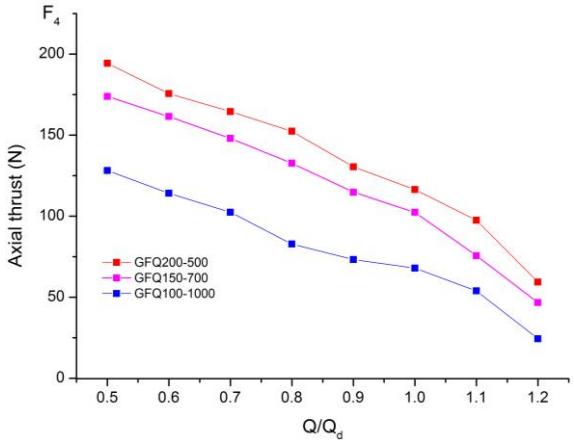


Fig. 10. Inducer blade force curve Q/Q_d

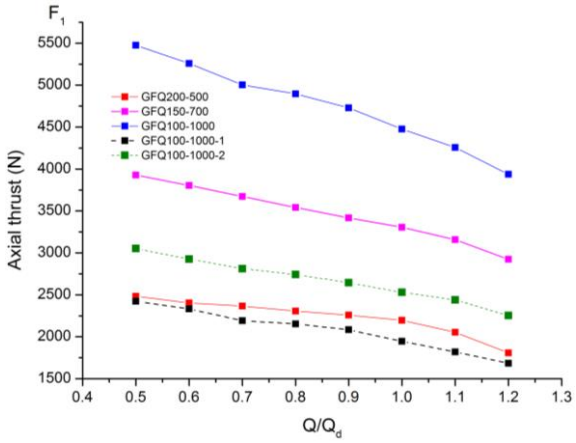


Fig. 11. Impeller cover plate force curve Q/Q_d

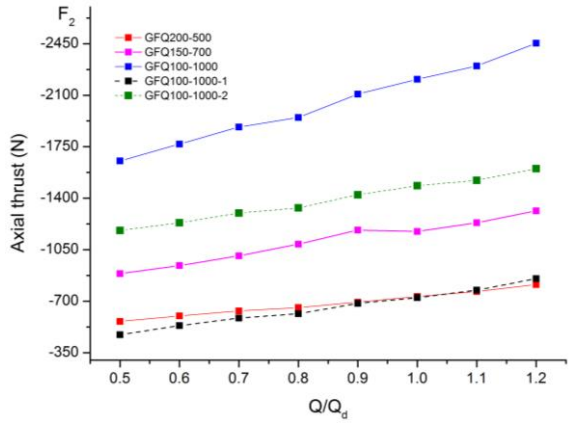


Fig. 12. Impeller cover internal flow force curve Q/Q_d

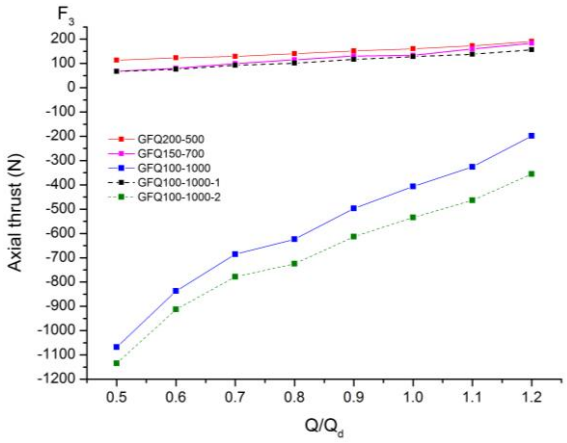


Fig. 13. Impeller blade surface force curve Q/Q_d

Tables

Table 1. Axial thrust of high speed mine submersible pump

model	F_1/N	T_2/N	F_4/N	F_5/N	T_4/N	F/N
GFQ200-500	1648	-293.3	116.5.	1471.2	4211.9	5683.1
GFQ150-700	2289	-187	102.4	2204.4	4299.2	6503.6
GFQ100-1000	2786	-232.1	67.9	2621.8	4367.7	6989.5

Table 2. The impeller blade surface area and the projected area

	PSA/mm^2	PSPA/ mm^2	SSA / mm^2	SSPA / mm^2
GFQ200-500	4929.1	1657.1	5163.5	1783.9
GFQ150-700	4574.1	1427.3	4684.3	1572.7
GFQ100-1000	3695.4	1340.7	3782.7	1441.5

*PSA: pressure surface area;

PSPA: pressure surface projected area in the vertical direction;

SSA: suction surface area;

SSPA: suction surface projected area in the vertical direction.