供货完成证明（合同完工证明）

利欧集团湖南泵业有限公司为上饶市中心城区排涝站提升改造工程（龙潭、东门）设备采购及安装标项目提供了 3 台 1000ZQB-100 型的潜水轴流泵，叶轮直径 900mm，流量 2.95m³/s，扬程 4.46m；1 台 500ZQB-100 型的潜水轴流泵，叶轮直径 450mm，流量 0.67m³/s，扬程 4.46m。机组设备自 2023 年安装调试运行以来，各项性能参数均达到指定要求，结构合理、振动小、噪音低，设备运行平稳，使用维修方便，各项技术指标均满足预期要求。我公司对贵司的立式轴流泵设备非常满意。

安装调试过程中，利欧集团湖南泵业有限公司的售后服务人员积极配合相关建设施工单位的安装工作和调试工作，确保整个工程顺利竣工，且售后服务及时，态度极好，我公司非常满意。

水泵的使用过程中，利欧集团湖南泵业有限公司的培训和服务人员，定期对水泵的运行及保养提供相应的咨询和服务，保障了整个水泵的正常运行，该公司在产品的设计制造过程中采用多项新技术、新材料和新工艺，产品制造精良，质量好，服务到位。

特此证明！

上饶市中心城区排涝站提升改造工程

建设项目部

2024 年 7 月

联系人：吕平

联系方式：13970304851

Delivery certificate (Contract completion certificate)

We hereby certify that LEO GROUP PUMP(HUNAN) CO., LTD. provided 3 sets of 1000ZQB-100 submersible axial flow pumps with 900mm impeller diameter, 2.95m^3 /s flow rate and 4.46m head and one set of 500ZQB-100 submersible axial flow pump with impeller diameter of 450mm, flow rate of 0.67m^3 /s and head of 4.46m, for Shangrao City Central urban area (Longtan and Dongmen Districts) equipment procurement and installation project. Since the installation and commissioning of the unit equipment in 2023, the performance parameters have met the specified requirements, pump structure is stable, vibration is small, the noise is very low, the equipment runs smoothly, the use and maintenance is convenient, and the technical indicators have met the expected requirements. We are very satisfied with your vertical axial flow pump equipment.

During the installation and commissioning process, the after-sales service personnel of LEO actively cooperated with the installation and commissioning work of the relevant construction units. LEO ensures the smooth completion of the entire project, and their after-sales service is timely and attitude is excellent, our company are very satisfied.

During the use of the pump, the training and service personnel of LEO regularly provide the corresponding consultation and service for the operation and maintenance of the pumps, ensuring a normal operation of the whole pump. The company adopts a number of new technologies, new materials and new processes in the design and manufacturing process of the products, and the products are well-manufactured, with good quality and their service is remarkable.

Shangrao City Central urban area Drainage station Upgrading and Renovation Project

Construction Project Department

July 2024

Contact: Lu Ping

Contact NO. : +86 13970304851

MANOEL ANTONIO SCHIMIDT
Tradutor Público e Intérprete Comercial
Matrícula Nº 490 da Junta Comercial do Estado de São Paulo
Praça da Sé, 21 - 14º Andar - Sala 1.409 – Centro - São Paulo - SP - Tel.: (011) 3291-4420

LIVRO Nº 903 FOLHA 1 TRADUÇÃO Nº **I-213.883/24**

CERTIFICO E DOU FÉ, para os devidos fins, que nesta data me foi apresentado um documento redigido em inglês, o qual passo a traduzir na íntegra, conforme segue:

[PÁGINA ESCRITA EM CHINÊS]
[CONTÉM CARIMBO NO FINAL DA PÁGINA – CARACTERES EM CHINÊS]

Certificado de entrega (certificado de conclusão do contrato)

Certificamos que o LEO GROUP PUMP(HUNAN) CO., LTD. forneceu 3 conjuntos de bombas submersíveis de fluxo axial 1000ZQB-100 equipada com um rotor de 900 mm de diâmetro, vazão de 2,95 m³/s e altura de 4,46 m e um conjunto de bombas submersíveis de fluxo axial 500ZQB-100 com um rotor de 450 mm de diâmetro, vazão de 0,67 m³/s e altura de 4,46 m, para o projeto de aquisição e instalação de equipamentos na área urbana central da cidade de Shangrao (distritos de Longtan e Dongmen). Desde a instalação e o comissionamento do equipamento da unidade em 2023, os parâmetros de desempenho atenderam aos requisitos especificados, a estrutura da bomba é estável, com pouca vibração, baixo nível de ruído, funcionamento suave do equipamento, uso e manutenção convenientes, e os indicadores técnicos atenderam aos requisitos esperados. Estamos muito satisfeitos com o equipamento da bomba de fluxo axial vertical.
Durante o processo de instalação e comissionamento, a equipe de serviço pós-venda da LEO cooperou de forma proativa com o trabalho de instalação e comissionamento das unidades de construção relevantes. A LEO garante a conclusão harmoniosa de todo o projeto, e seu serviço pós-venda é pontual e de excelente atitude, e nossa empresa está muito satisfeita.
Durante a utilização da bomba, a equipe de treinamento e serviço da LEO fornece consultoria e serviço correspondentes para a operação e manutenção das bombas regularmente, garantindo a operação normal do conjunto da bomba. A empresa adota uma série de novas tecnologias, novos materiais e novos processos no projeto e no processo de fabricação dos produtos, e os produtos são fabricados com qualidade e o serviço é notável.

Projeto de atualização e renovação da estação de drenagem da área urbana central da cidade de Shangrao
Departamento de Projetos de Construção
Julho de 2024
Contato: Lu Ping
Número de contato: 13970304851

MANOEL ANTONIO SCHIMIDT

Tradutor Público e Intérprete Comercial
Matrícula Nº 490 da Junta Comercial do Estado de São Paulo

Praça da Sé, 21 - 14º Andar - Sala 1.409 – Centro - São Paulo - SP - Tel.: (011) 3291-4420

LIVRO Nº 903 **FOLHA** 2 **TRADUÇÃO Nº** **I-213.883/24**

****

NADA MAIS constava do referido original, que devolvo ao interessado com esta tradução fiel que conferi, achei conforme e assino, na data abaixo. DOU FÉ.
São Paulo, 31 de outubro de 2024. Expert/2132

[Assinatura Digital]
MANOEL ANTONIO SCHIMIDT
Tradutor Público

RELATÓRIO DE ASSINATURAS

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China National Accreditation Service for Conformity Assessmen

LABORATORY ACCREDITATION CERTIFICATE

(Registration No. CNAS L13022)

Leo Group Pump (Hunan) Co., Ltd. Test Center

(Legal Entity: Leo Group Pump (Hunan) Co., Ltd.)

No.9, Jiuhua Road, Jiuhua Economic-Technological Development Area,

Xiangtan, Hunan, China

is accredited in accordance with ISO/IEC 17025: 2017 General Requirements for the Competence of Testing and Calibration Laboratories(CNAS-CL01 Accreditation Criteria for the Competence of Testing and Calibration Laboratories) for the competence to undertake the service described in the schedule attached to this certificate.

The scope of accreditation is detailed in the attached schedule bearing the same registration number as above. The schedule forms an integral part of this certificate.

Effective Date：2020-01-09

Expiry Date：2026-01-08

Signed on behalf of China National Accreditation Service for Conformity Assessment

China National Accreditation Service for Conformity Assessment (CNAS) is authorized by Certification and Accreditation Administration of the People's Republic of China (CNCA) to operate the national accreditation schemes for conformity assessment. CNAS is a signatory of the International Laboratory Accreditation Cooperation Mutual Recognition Arrangement (ILAC MRA) and the Asia Pacific Accreditation Cooperation Mutual Recognition Arrangement (APAC MRA).

The validity of the certificate can be checked on CNAS website at http://www.cnas.org.cn/english/findanaccreditedbody/index.shtml.

CERTIFICATE OF PRODUCT CERTIFICATION

CHINA CERTIFICATE FOR ENERGY CONSERVATION PRODUCT

CERTIFICATE NO.: CQC21701325100

Valid from: Nov.13,2023

Valid until: Dec.17,2024

NAME AND REGISTERED ADDRESS OF THE APPLICANT	LEO GROUP PUMP(HUNAN)CO.,LTD. No. 9 Jiuhua Avenue, Jiuhua Demonstration Zone, Xiangtan City, Hunan Province
BRAND NAME	LEO
NAME AND REGISTERED ADDRESS OF THE MANUFACTURER	LEO GROUP PUMP(HUNAN)CO.,LTD. No. 9 Jiuhua Avenue, Jiuhua Demonstration Zone, Xiangtan City, Hunan Province
NAME AND LOCATION OF THE FACTORY	LEO GROUP PUMP(HUNAN)CO.,LTD. No. 9 Jiuhua Avenue, Jiuhua Demonstration Zone, Xiangtan City, Hunan Province
PRODUCT NAME, MODEL AND SPECIFICATION	High-efficiency single-stage double-suction centrifugal pump See appendix
THE STANDARDS AND TECHNICAL REQUIREMENTS FOR THE PRODUCTS	GB 19762-2007
TYPE OF CERTIFICATION SCHEMES	Type Testing of Product + Initial Factory Inspection + Follow up Factory Inspection

This is to certify that the above mentioned product(s) complies with the requirements of CQC31-432212-2009.

Date of original issued: Dec.17,2021

The validity of the certificate is subject to positive result of the regular follow up inspection by issuing certification body until the expiry date.

Accredited by China National Accreditation Service for Conformity Assessment CNAS C001-P

The certificate information is available through the QR code below or CNCA's website: www.cnca.gov.cn

SIGNATURE: 谢肇煦

CHINA QUALITY CERTIFICATION CENTRE

CERTIFICATE OF PRODUCT CERTIFICATION

CHINA CERTIFICATE FOR ENERGY CONSERVATION PRODUCT

CERTIFICATE NO.：CQC21701325100

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This certificate and attachments shall be used at the same time, and the verification instructions can be found in the main certificate.

序号	泵型号	流量 (m^3/h)	扬程 (m)	比转速	额定转速(r/min)	电机功率 (kW)	临界汽蚀余量(m)	泵效率 (%)	节能评价值 (%)
1	GSX80-215	165	58	78	2970	45	4.6	79	79
2	GSX80-215M	140	52	78	2970	37	4.2	78.4	78.4
3	GSX80-285	235	100	62	2970	110	6.7	76	76
4	GSX80-285M	200	90	62	2970	90	6	75.6	75.6
5	GSX80-315	160	130	42	2970	110	4.3	67.5	67.5
6	GSX80-315M	135	116	42	2970	90	4	66.8	66.8
7	GSX80-345	110	40	42	1480	22	2.3	65.9	65.9
8	GSX80-345M	95	36	42	1480	18.5	2.1	65.3	65.3
9	GSX100-260	300	79	84	2970	110	7.3	81.4	81.4
10	GSX100-260M	260	71	84	2970	75	6.6	80.9	80.9
11	GSX100-325	380	129	60	2970	200	11	77.3	77.3

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12	GSX100-325M	325	116	60	2970	160	9.9	76.7	76.7
13	GSX100-365	280	190	40	2970	250	4.9	69	69
14	GSX100-365M	240	172	40	2970	200	4.4	68.5	68.5
15	GSX100-410	190	54	40	1480	45	2.5	67.9	67.9
16	GSX100-410M	160	49	40	1480	37	2.3	67.3	67.3
17	GSX125-225	160	13	117	1480	11	1.5	81.9	81.9
18	GSX125-225M	137	12	117	1480	7.5	1.4	81.2	81.2
19	GSX125-300	540	112	86	2970	250	8.2	83.5	83.5
20	GSX125-300M	465	101	86	2970	200	7.4	83	83
21	GSX125-355	485	170	60	2970	355	6.8	78.1	78.1
22	GSX125-355M	410	152	60	2970	280	6.1	77.6	77.6

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23	GSX125-390	320	50	60	1480	75	2.3	76.7	76.7
24	GSX125-390M	275	45	60	1480	55	2.1	76.2	76.2
25	GSX125-475	340	79	44	1480	132	2.7	71.7	71.7
26	GSX125-475M	290	71	44	1480	90	2.4	71.2	71.2
27	GSX150-355	450	40	90	1480	75	2.6	83.3	83.3
28	GSX150-355M	385	36	90	1480	55	2.4	82.8	82.8
29	GSX150-455	520	69	60	1480	160	3.5	78.3	78.3
30	GSX150-455M	450	62	60	1480	132	3.2	77.8	77.8
31	GSX150-560	600	109	40	1480	280	4	71.5	71.5
32	GSX150-560M	515	98	40	1480	220	3.6	71	71
33	GSX100-165	160	28	130	2970	18.5	4.3	82	82

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34	GSX100-165M	135	26	130	2970	15	4	81.3	81.3
35	GSX125-195	280	42	130	2970	45	5.4	83.7	83.7
36	GSX125-195M	240	38	130	2970	37	4.9	83.3	83.3
37	GSX125-245	540	63	132	2970	132	7.9	85.9	85.9
38	GSX125-245M	465	57	132	2970	110	7.1	85.4	85.4
39	GSX150-170	140	8.3	153	1480	5.5	1.7	81.4	81.4
40	GSX150-170M	120	7.5	153	1480	4	1.5	80.7	80.7
41	GSX150-300	490	23	130	1480	45	2.8	85.6	85.6
42	GSX150-300M	420	21	130	1480	37	2.5	85.1	85.1
43	GSX200-200	250	9	193	1480	11	2.4	83.4	83.4
44	GSX200-200M	214	8.1	193	1480	7.5	2.2	82.9	82.9

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45	GSX200-250	490	14	194	1480	30	2.2	85.6	85.6
46	GSX200-250M	420	13	194	1480	22	2	85.1	85.1
47	GSX250-200	420	8.3	266	1480	15	2.6	83.3	83.3
48	GSX250-200M	360	7.5	266	1480	11	2.4	82.8	82.8
49	GSX200-425	770	56	86	1480	185	3.7	83.9	83.9
50	GSX200-425M	660	51	86	1480	132	3.3	83.2	83.2
51	GSX200-530	830	95	60	1480	315	3.6	78.6	78.6
52	GSX200-530M	710	86	60	1480	250	3.3	78.2	78.2
53	GSX200-655	810	156	41	1480	500	3.2	71.3	71.3
54	GSX200-655M	695	141	41	1480	400	2.9	71	71
55	GSX250-480	1200	69	92	1480	315	4.2	85.1	85.1

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56	GSX250-480M	1030	62	92	1480	250	3.8	84.8	84.8
57	GSX250-610	1280	121	62	1480	630	4.1	79.7	79.7
58	GSX250-610M	1100	109	63	1480	500	3.7	79.3	79.3
59	GSX250-770	1260	205	42	1480	1120	4.7	72.4	72.4
60	GSX250-770M	1070	184	42	1480	900	4.2	72.1	72.1
61	GSX300-550	1770	98	86	1480	710	5	85.9	85.9
62	GSX300-550M	1520	88	86	1480	560	4.5	85.6	85.6
63	GSX300-705	1880	167	59	1480	1250	4.6	80.5	80.5
64	GSX300-705M	1610	151	59	1480	1000	4.1	80.2	80.2
65	GSX350-685	2020	60	88	980	450	4.5	86.2	86.2
66	GSX350-685M	1720	54	88	980	355	4.1	85.8	85.8

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67	GSX350-690	2520	155	73	1480	1600	7	86.6	86.6
68	GSX350-690M	2160	140	73	1480	1250	6.3	86.3	86.3
69	GSX350-780	2690	200	62	1480	2240	5.9	81.2	81.2
70	GSX350-780M	2290	180	62	1480	1800	5.5	80.9	80.9
71	GSX350-845	2020	98	61	980	800	4	80.7	80.7
72	GSX350-845M	1720	90	60	980	630	3.5	80.3	80.3
73	GSX400-800	3170	78	90	980	900	5	87.1	87.1
74	GSX400-800M	2690	72	88	980	710	5.4	86.7	86.7
75	GSX400-970	3170	130	62	980	1600	5.5	80.3	80.3
76	GSX400-970M	2690	116	62	980	1250	5	81.2	81.2
77	GSX500-920	4700	110	85	980	2000	7.3	87.8	87.8

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78	GSX500-920M	4000	100	84	980	1600	6.6	87.6	87.6
79	GSX600-1000	6500	120	94	980	2800	8.3	88.3	88.3
80	GSX600-1000M	5500	115	89	980	2500	7.4	88.1	88.1
81	GSX600-1000J	4000	43	95.6	590	630	3.7	90	88.2
82	GSX600-1020	7200	147.5	84	980	400	6.7	87.9	87.9
83	GSX600-1115	6500	90	88	740	2240	6.2	88.3	88.3
84	GSX600-1115M	5500	80	88	740	1600	5.6	88.1	88.1
85	GSX700-990	7200	83	98	740	2240	6.5	89.4	89.4
86	GSX150-280	820	83	133	2970	250	10.4	86	86
87	GSX150-280M	700	75	133	2970	200	9.4	85.7	85.7
88	GSX200-345	760	32	130	1480	90	3.6	85.9	85.9

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89	GSX200-345M	650	29	130	1480	75	3.2	85.4	85.4
90	GSX250-390	1070	40	131	1480	160	4.7	86.8	86.8
91	GSX250-390M	920	36	131	1480	132	4.2	86.4	86.4
92	GSX300-330	1120	25	191	1480	110	4.7	86.9	86.9
93	GSX300-330M	960	23	188	1480	90	4.2	88.7	88.7
94	GSX300-450	1730	55	131	1480	355	5.4	87.8	87.8
95	GSX300-450M	1480	50	130	1480	280	4.9	87.5	87.5
96	GSX350-385	1770	33	195	1480	200	6.5	87.9	87.9
97	GSX350-385M	1520	30	194	1480	185	5.8	87.6	87.6
98	GSX350-450	2850	49	184	1480	500	9.2	88.9	88.9
99	GSX350-450M	2445	44	184	1480	400	8.3	88.5	88.5

CERTIFICATE OF PRODUCT CERTIFICATION

CHINA CERTIFICATE FOR ENERGY CONSERVATION PRODUCT

CERTIFICATE NO.：CQC21701325100

paper:

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序号	泵型号	流量 (m^3/h)	扬程 (m)	比转速	额定转速(r/min)	电机功率 (kW)	临界汽蚀余量(m)	泵效率 (%)	节能评价值 (%)
100	GSX350-530	2830	76	132	1480	800	7.4	88.8	88.8
101	GSX350-530M	2420	69	131	1480	630	6.7	88.5	88.5
102	GSX400-440	2020	22	187	980	185	5.6	88.2	88.2
103	GSX400-440M	1720	20	185	980	132	5.1	87.9	87.9
104	GSX400-525	4200	68	174	1480	1000	9.7	89.7	89.7
105	GSX400-525M	3600	61	175	1480	800	8.8	89.3	89.3
106	GSX400-535	2020	36	129	980	280	4.2	88.2	88.2
107	GSX400-535M	1720	32	130	980	200	3.7	87.8	87.8
108	GSX400-580	3700	91	131	1480	1250	8.9	89.4	89.4
109	GSX400-580M	3170	82	132	1480	1000	8	89.1	89.1
110	GSX450-490	3700	62.5	174	1480	800	7.8	89.4	89.4

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序号	泵型号	流量 (m^3/h)	扬程 (m)	比转速	额定转速(r/min)	电机功率 (kW)	临界汽蚀余量(m)	泵效率 (%)	节能评价值 (%)
111	GSX450-490M	3170	56	175	1480	630	7.2	89.1	89.1
112	GSX500-525	3170	32	176	980	355	7.4	89.1	89.1
113	GSX500-525M	2690	28	180	980	280	6.5	88.7	88.7
114	GSX500-625	3170	47	132	980	560	5.4	89.1	89.1
115	GSX500-625M	2690	43	130	980	400	4.9	88.7	88.7
116	GSX500-715	4700	60	134	980	1000	7.2	89.8	89.8
117	GSX500-715M	4000	56	130	980	800	6.6	89.6	89.6
118	GSX600-610	4700	37	193	980	630	8.4	89.8	89.8
119	GSX600-610M	4000	34	189	980	500	7.8	89.6	89.6
120	GSX600-810	6500	78	129	980	1800	8.4	90.3	90.3
121	GSX600-810M	5500	70	129	980	1400	7.1	90.1	90.1

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序号	泵型号	流量 (m^3/h)	扬程 (m)	比转速	额定转速(r/min)	电机功率 (kW)	临界汽蚀余量(m)	泵效率 (%)	节能评价值 (%)
122	GSX700-670	6500	47	189	980	1120	8.6	90.3	90.3
123	GSX700-670M	5500	42	189	980	800	7.7	90.1	90.1
124	GSX700-775	6500	34	182	740	800	6.9	90.3	90.3
125	GSX700-775M	5500	32	175	740	630	6.5	90.1	90.1
126	GSX700-830	9000	44	177	740	1400	8.3	90.9	90.9
127	GSX700-830M	7600	40	174	740	1120	7.5	90.6	90.6
128	GSX700-870	6500	53	131	740	1250	6.3	91	90.4
129	GSX700-870M	5500	48	129	740	900	5.6	90.1	90.1
130	GSX700-995	9000	66	130	740	2240	7.6	90.9	90.9
131	GSX700-995M	7600	59	130	740	1600	6.9	90.6	90.6
132	GSX800-790	7740	24	206	590	710	4.1	90.6	90.6

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序号	泵型号	流量 (m^3/h)	扬程 (m)	比转速	额定转速(r/min)	电机功率 (kW)	临界汽蚀余量(m)	泵效率 (%)	节能评价值 (%)
133	GS1000-13/10	13000	61	133	595	2800	7	91.5	90
134	GS1000-13M/10	12000	50	149	595	2240	6.6	91	90
135	GS1200-19/10	12000	47	154.9	590	2000	6	92	92
136	GSX300-225	710	8.3	347	1480	30	3.8	82.7	82.7
137	GSX300-225M	609	7.5	347	1480	22	3.4	82.2	82.2
138	GSX300-255	790	12	278	1480	37	4.2	84	84
139	GSX300-255M	677	11	274	1480	30	3.8	83.6	83.6
140	GSX350-300	1260	16	282	1480	75	5.9	85.2	85.2
141	GSX350-300M	1080	14	289	1480	55	5.3	84.9	84.9
142	GSX400-340	1800	22	266	1480	160	8.9	86	86
143	GSX400-340M	1543	20	264	1480	132	8	85.7	85.7

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序号	泵型号	流量 (m^3/h)	扬程 (m)	比转速	额定转速(r/min)	电机功率 (kW)	临界汽蚀余量(m)	泵效率 (%)	节能评价值 (%)
144	GSX450-390	2690	30	258	1480	280	8.8	86.8	86.8
145	GSX450-390M	2306	27	258	1480	220	7.9	86.5	86.5
146	GSX500-385	2020	13	277	980	90	3.7	86.3	86.3
147	GSX500-385M	1720	12	271	980	75	3.3	85.9	85.9
148	GSX500-450	4200	38	270	1480	560	12	87.8	87.8
149	GSX500-450M	3601	34	271	1480	450	10.8	87.4	87.4
150	GSX500-495	3170	22	234	980	250	6.8	87.1	87.1
151	GSX500-495M	2690	20	231	980	200	6.2	88	88
152	GSX600-575	4700	28	237	980	450	8.3	89.1	89.1
153	GSX600-575M	4000	26	232	980	355	7.5	88.9	88.9
154	GSX700-535	4700	24	267	980	400	7	87.9	87.9

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序号	泵型号	流量 (m^3/h)	扬程 (m)	比转速	额定转速(r/min)	电机功率 (kW)	临界汽蚀余量(m)	泵效率 (%)	节能评价值 (%)
155	GSX700-535M	4000	21	272	980	315	6.1	87.7	87.7
156	GSX700-600	4700	19	318	980	355	7	86.8	86.8
157	GSX700-600M	4000	17	318	980	280	6.3	86.6	86.6
158	GSX700-615	6500	36	231	980	800	9.1	89.6	89.6
159	GSX700-615M	5500	32	232	980	630	8.1	89.4	89.4
160	GSX700-680	6500	24	237	740	560	7.2	89.6	89.6
161	GSX700-680M	5500	22	232	740	450	6.5	89.4	89.4
162	GSX800-590	6500	30	265	980	710	8.5	88.4	88.4
163	GSX800-590M	5500	26	272	980	500	7.3	88.2	88.2
164	GSX800-640	6500	23	324	980	560	8.9	87.3	87.3
165	GSX800-640M	5500	21	319	980	450	8.1	87.1	87.1

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序号	泵型号	流量 (m^3/h)	扬程 (m)	比转速	额定转速(r/min)	电机功率 (kW)	临界汽蚀余量(m)	泵效率 (%)	节能评价值 (%)
166	GSX800-770	9000	29	242	740	900	8.7	90.2	90.2
167	GSX800-770M	7600	27	234	740	710	7.9	89.9	89.9
168	GSX900-685	9000	24	278	740	800	7	89	89
169	GSX900-685M	7600	22	273	740	630	6.4	88.7	88.7
备注：序号 81、135 为新增加型号。									

X-240904-03
苏州相城

TEST REPORT

Sample Name: Submersible pump

Pump Model: 800QZ-125

Sample No.: H2409138

Test No.: 2024102903

Inspection Type: Performance Test

Manufacturer:LEO GROUP PUMP(HUNAN) CO., LTD.

Consignor:LEO GROUP PUMP(HUNAN) CO., LTD.

Test Center of LEO GROUP PUMP(HUNAN) CO., LTD.

TEST REPORT

Test No.: 2024102903

Sample Name	Submersible pump	Pump Model	800QZ-125
Client	LEO Group Pump (Hunan) Co.Ltd.	Address	Jiuhua Demonstration Area, Xiangtan, Hunan
Manufacturer	LEO Group Pump (Hunan) Co.Ltd.	Address	Jiuhua Demonstration Area, Xiangtan, Hunan
Sample Provider	LEO Group Pump (Hunan) Co.Ltd.	Address	Jiuhua Demonstration Area, Xiangtan, Hunan
Sample Quantity	1 set	Contact	
Sample No.		Tel.	
Sample status		Ready date	2024/10/29
Test Accuracy	ISO9906 Gr. 2B	Testing Date	2024/10/29
Test Item	Flow, Head, Shaft Power, Efficiency		
Test Standard	BSEN ISO 9906-2012 Rotodynamic pumps-Hydraulic performance acceptance tests-Grades 1、2 and 3		
Conclusion	According to "BSEN ISO 9906-2012 Rotodynamic pumps-Hydraulic performance acceptance tests-Grades 1、2 and 3" Gr. 2B, pump is qualified.		
Declaration			
Remark			

Tested By: 蒋伯录 Reviewed By: 段可海 Approved By: 罗波

Judgment of Test Results

Test No.: 2024102903

Sample Model	800QZ-125	Test No.	3	Manufacturer	LEO GROUP PUMP(HUNAN) CO., LTD.
Test Type	Performance Test	Test Accuracy	Grade2B	Test Date	2024/10/29

Instruments and Parameters

Flow Measurement	Electromagnetic flowmeter_08071177_0_16000	Power Measurement	Low Voltage Broadband Bower Analyzer
Inlet Pressure Measurement	/	Speed Measurement	Photoelectric tachometer UT371_30_60000
Outlet Pressure Measurement	Pressure transmitter_-100_150	Noise Measurement	
Vibration Measurement	Vibration Meter_1307102（20-2000Hz）_1_3000	Barometric Pressure Measurement	Empty box barometer_DYM3 11111423__

Inlet Pipe Diameter at Pressure-measuring point, ϕ	/	Outlet Pipe Diameter at Pressure-measuring point, ϕ	1200mm
The Distance between Inlet Pressure Gauge and Datum Plane	0mm	The Distance between Outlet Pressure Gauge and Datum Plane	1590mm

External Diameter of Impeller/Runner Width.	/	Test Motor	8-90KW	Test Motor Efficiency	0.91
Impeller Material	/	Barometric Pressure	0.1011	Medium Temperature	23℃

Specified Performance

Flow (l/s)	Head (m)	Speed(rpm)	Shaft Power (kW)	Efficiency (%)	NPSH (m)
2000	2.3	730	62.64	72	

Tested Performance

Flow (l/s)	Head (m)	Speed(rpm)	Shaft Power (kW)	Efficiency (%)	NPSH (m)
2000	2.36	730	63.96	72.35	

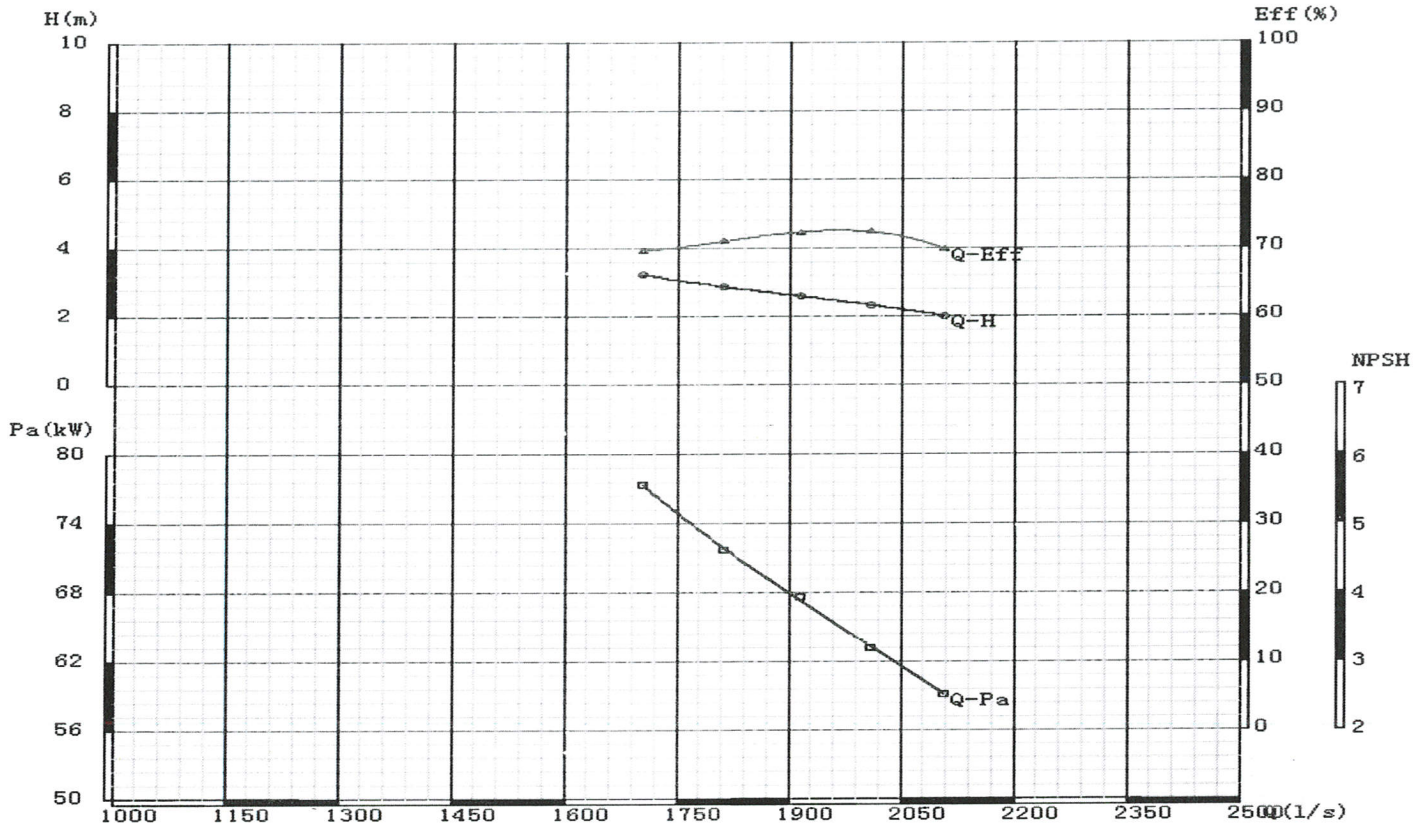
Test Analysis

Flow at small flow point (l/s)		Flow at design flow point (l/s)	2000	Flow at design flow point (l/s)	
Flow Deviation（l/s）		Flow Deviation（l/s）	/	Flow Deviation（l/s）	/
Head Deviation（m）		Head Deviation（m）	0.06	Head Deviation（m）	
Flow Head Qualified or Not based on Grade 2B		Flow Head Qualified or Not based on Grade 2B	Qualified	Flow Head Qualified or Not based on Grade 2B	
Efficiency of Determination		Efficiency of Determination	72.35	Efficiency of Determination	
95% Specified Efficiency		95%Specified Efficiency	68.4	95%Specified Efficiency	
Efficiency Qualified or Not based on Grade 2B		Efficiency Qualified or Not based on Grade 2B	Qualified	Efficiency Qualified or Not based on Grade 2B	
NPSHr Qualified or Not		NPSHr Qualified or Not		NPSHr Qualified or Not	

Conclusion	**According to standard BSEN ISO9906-2000 Gr.2B, it's Qualified.**
Tested by	**ZhuRenwei and DaiBoling**

Performance Curve

Test No.: 2024102903



Performance Test Data

Calculated Data						Converted Data			
Flow (l/s)	Suction Head(m)	Discharge Head(m)	Total Head(m)	Power (kW)	Speed (r/min)	Flow (l/s)	Head (m)	Power (kW)	Efficiency (%)
1702.58	0	3.23	3.23	77.42	730	1702.58	3.23	77.42	69.68
1811.15	0	2.87	2.87	71.74	730	1811.15	2.87	71.74	71.08
1913.37	0	2.6	2.6	67.6	730	1913.37	2.6	67.6	72.19
2008.81	0	2.32	2.32	63.14	730	2008.81	2.32	63.14	72.41
2105.56	0	2	2	59.18	730	2105.56	2	59.18	69.81

X-240P04-03

TEST REPORT

Sample Name: Submersible pump

Pump Model: 800QZ-125

Sample No.: H2409139

Test No.: 2024103105

Inspection Type: Performance Test

Manufacturer:LEO GROUP PUMP(HUNAN) CO., LTD.

Consignor:LEO GROUP PUMP(HUNAN) CO., LTD.

Test Center of LEO GROUP PUMP(HUNAN) CO., LTD.

TEST REPORT

Test No.: 2024103105

Sample Name	Submersible pump	Pump Model	800QZ-125
Client	LEO Group Pump (Hunan) Co.Ltd.	Address	Jiuhua Demonstration Area, Xiangtan, Hunan
Manufacturer	LEO Group Pump (Hunan) Co.Ltd.	Address	Jiuhua Demonstration Area, Xiangtan, Hunan
Sample Provider	LEO Group Pump (Hunan) Co.Ltd.	Address	Jiuhua Demonstration Area, Xiangtan, Hunan
Sample Quantity	1 set	Contact	
Sample No.		Tel.	
Sample status		Ready date	2024/10/31
Test Accuracy	ISO9906 Gr. 2B	Testing Date	2024/10/31
Test Item	Flow, Head, Shaft Power, Efficiency		
Test Standard	BSEN ISO 9906-2012 Rotodynamic pumps-Hydraulic performance acceptance tests-Grades 1、2 and 3		
Conclusion	According to "BSEN ISO 9906-2012 Rotodynamic pumps-Hydraulic performance acceptance tests-Grades 1、2 and 3" Gr. 2B, pump is qualified.		
Declaration			
Remark			

Tested By: 戴伯灵 Reviewed By: 段可洵 Approved By: 吴波

Judgment of Test Results

Test No.: 2024103105

Sample Model	800QZ-125	Test No.	3	Manufacturer	LEO GROUP PUMP(HUNAN) CO., LTD.
Test Type	Performance Test	Test Accuracy	Grade2B	Test Date	2024/10/31

Instruments and Parameters

Flow Measurement	Electromagnetic flowmeter_08071177_0_16000	Power Measurement	Low Voltage Broadband Bower Analyzer
Inlet Pressure Measurement	/	Speed Measurement	Photoelectric tachometer UT371_30_60000
Outlet Pressure Measurement	Pressure transmitter_-100_150	Noise Measurement	
Vibration Measurement	Vibration Meter_1307102（20-2000Hz）_1_3000	Barometric Pressure Measurement	Empty box barometer_DYM3 11111423__

Inlet Pipe Diameter at Pressure-measuring point, ϕ	/	Outlet Pipe Diameter at Pressure-measuring point, ϕ	1200mm
The Distance between Inlet Pressure Gauge and Datum Plane	0mm	The Distance between Outlet Pressure Gauge and Datum Plane	1590mm

External Diameter of Impeller/Runner Width.	/	Test Motor	8-90KW	Test Motor Efficiency	0.91
Impeller Material	/	Barometric Pressure	0.1011	Medium Temperature	23℃

Specified Performance

Flow (l/s)	Head (m)	Speed(rpm)	Shaft Power (kW)	Efficiency (%)	NPSH (m)
2000	2.3	730	62.64	72	

Tested Performance

Flow (l/s)	Head (m)	Speed(rpm)	Shaft Power (kW)	Efficiency (%)	NPSH (m)
2000	2.35	730	63.51	72.56	

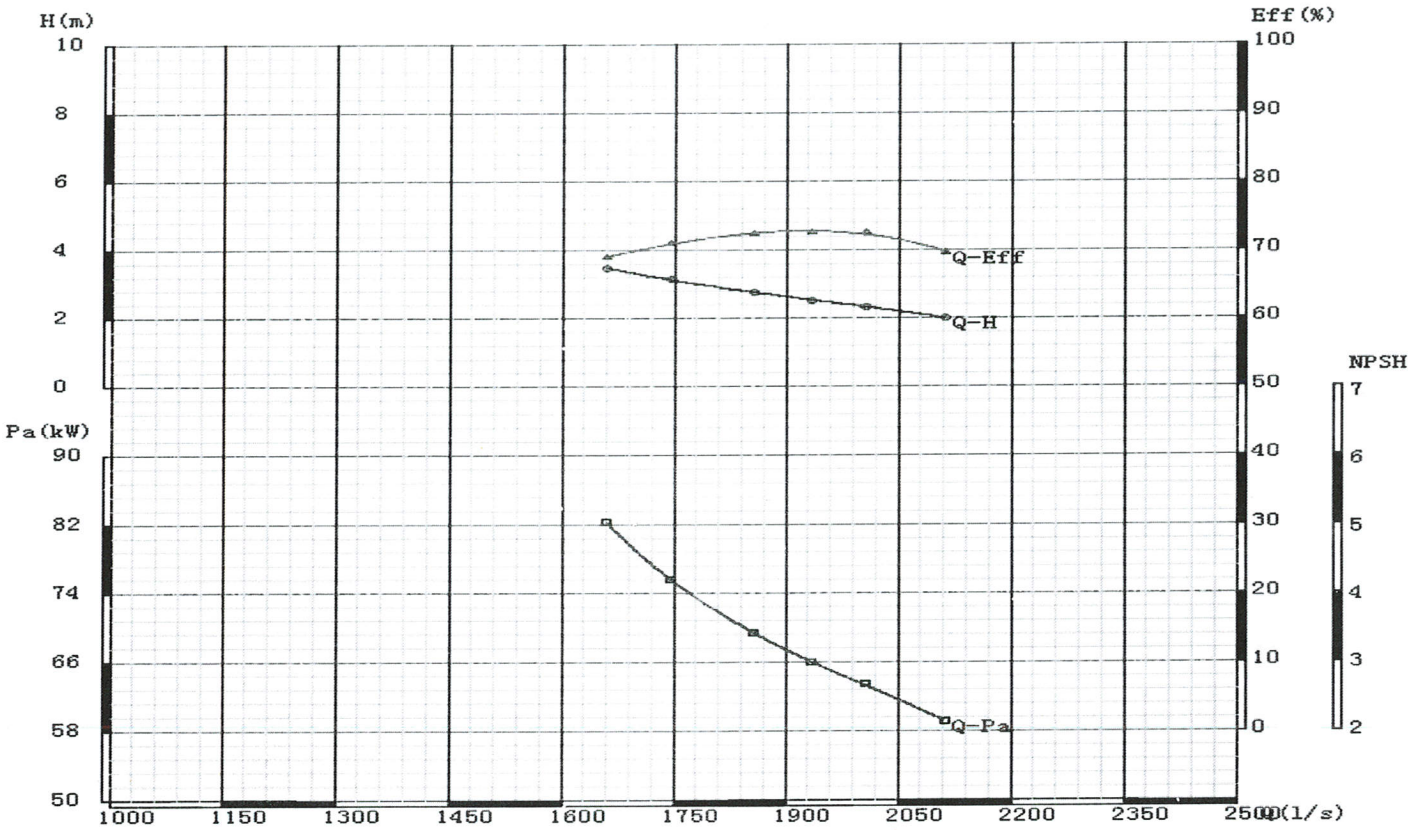
Test Analysis

Flow at small flow point (l/s)		Flow at design flow point (l/s)	2000	Flow at design flow point (l/s)	
Flow Deviation（l/s）		Flow Deviation（l/s）	/	Flow Deviation（l/s）	/
Head Deviation（m）		Head Deviation（m）	0.05	Head Deviation（m）	
Flow Head Qualified or Not based on Grade 2B		Flow Head Qualified or Not based on Grade 2B	Qualified	Flow Head Qualified or Not based on Grade 2B	
Efficiency of Determination		Efficiency of Determination	72.56	Efficiency of Determination	
95% Specified Efficiency		95%Specified Efficiency	68.4	95%Specified Efficiency	
Efficiency Qualified or Not based on Grade 2B		Efficiency Qualified or Not based on Grade 2B	Qualified	Efficiency Qualified or Not based on Grade 2B	
NPSHr Qualified or Not		NPSHr Qualified or Not		NPSHr Qualified or Not	

Conclusion	**According to standard BSEN ISO9906-2000 Gr.2B, it's Qualified.**
Tested by	**ZhuRenwei and DaiBoling**

Performance Curve

Test No.: 2024103105



Performance Test Data

Calculated Data						Converted Data			
Flow (l/s)	Suction Head(m)	Discharge Head(m)	Total Head(m)	Power (kW)	Speed (r/min)	Flow (l/s)	Head (m)	Power (kW)	Efficiency (%)
1658.98	0	3.49	3.49	82.25	730	1658.98	3.49	82.25	69.06
1745.58	0	3.14	3.14	75.63	730	1745.58	3.14	75.63	71.1
1855.64	0	2.76	2.76	69.37	730	1855.64	2.76	69.37	72.43
1933.58	0	2.52	2.52	65.92	730	1933.58	2.52	65.92	72.51
2004.83	0	2.34	2.34	63.42	730	2004.83	2.34	63.42	72.57
2110.13	0	1.99	1.99	59.13	730	2110.13	1.99	59.13	69.67

中国石油天然气集团公司
CHINA NATIONAL PETROLEUM CORPORATION

物资供应商准入证

CERTIFICATE OF MATERIAL SUPPLIER

使 用 说 明
Instructions

1. 本证书由中国石油天然气集团公司统一印制。
   This certificate shall be printed solely by CNPC.

2. 本证书在集团公司及其全资子公司、直属企事业单位具有同等效力。
   This certificate shall be equally effective for CNPC, its wholly-owned subsidiaries and institutions directly under CNPC.

3. 证书中准入产品是依据《SY/T-5497石油工业物资分类与代码》分类进行填写。
   The Permitted Products list in this certificate shall be filled by reference to "SY/T-5497 Oil Industry Material Category and Code".

4. 供应商仅可在准入产品范围内向中国石油天然气集团公司供货。
   Certified supplier can only supply commodities to CNPC in the range of Permitted Products.

5. 物资部门按照分级目录，负责对辖区内准入产品进行变更的审核、批准。
   Procurement departments shall be responsible to review and approve the change of permitted products under their administration, in accordance with classification catalogue.

6. 供应商考评分级依据年度考评结果，由物资部门进行填写。
   The assessment and classification of suppliers shall be subject to annual assessing results, and shall be filled by procurement departments.

供应商名称：
Supplier Name

湖南利欧泵业有限公司

准入证编号：
Certificate No.

01001003901

发证单位：
Issue Unit

中国石油天然气集团公司

物资采购管理部

准入章：
Certificate stamp

中国石油天然气集团公司
物资供应商
准入专用章

供应商类型：
Supplier Type

总部管理　　制造商

供应商编码：
Supplier Code

1764567

工商注册号：
License No.

430300000041248

组织机构代码：
Organization Code

55760935-8

法定代表人/负责人：
Legal Representative

欧亚云

单位地址：
Address

中国湖南湘潭市九华示范区九华大道9号

发证日期：
Issue Date

2012 年 Y　10 月 M　30 日 D

准 入 产 品
Permitted Products

物资代码 Code	大 类 Category 1	中 类 Category 2	小 类 Category 3	品 名 Product Name	物资类别 Type	备 注 Remarks	审核单位 Review Unit
26010101	通用机械设备	工业泵	离心泵	单级离心清水泵	一级		中国石油天然气集团公司供应商审核章
26010102	通用机械设备	工业泵	离心泵	多级离心清水泵	一级		中国石油天然气集团公司供应商审核章
26010103	通用机械设备	工业泵	离心泵	单级离心油泵	一级		中国石油天然气集团公司供应商审核章
26010107	通用机械设备	工业泵	离心泵	锅炉给水泵	一级		中国石油天然气集团公司供应商审核章
26010120	通用机械设备	工业泵	离心泵	真空泵	一级		中国石油天然气集团公司供应商审核章

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年度考评审核记录
Annual Assessment and Review Record

考评年度 Year of Assessment	综合评级 Grade	年审有效期 Valid Period of Annual Review	考评审核单位 Assessment Unit
2014年度		2014年10月30日 至 2015年10月30日	中国石油天然气集团公司 供应商审核章

LEO GROUP PUMP(HUNAN) CO., LTD.

CFD Hydrodynamics Analysis Report of An Integrated Prefabricated Pump Station

LEO GROUP PUMP(HUNAN) CO., LTD. Technical Department

On June 24,2024

Catalogue

1. Overview

1.1 Analysis object

The analysis object is the 700 QZ-70J integrated prefabricated pump station model provided by Leo Group Pump Hunan Co., Ltd., the cylinder size is Φ4200XH8850 mm, the pump station adopts cast steel cylinder and anti-silt accumulation base design, with two axial flow pumps, in addition, the pump station also includes: basket grille, pressure pipe and other equipment, the structure diagram is shown in Figure 1-1.

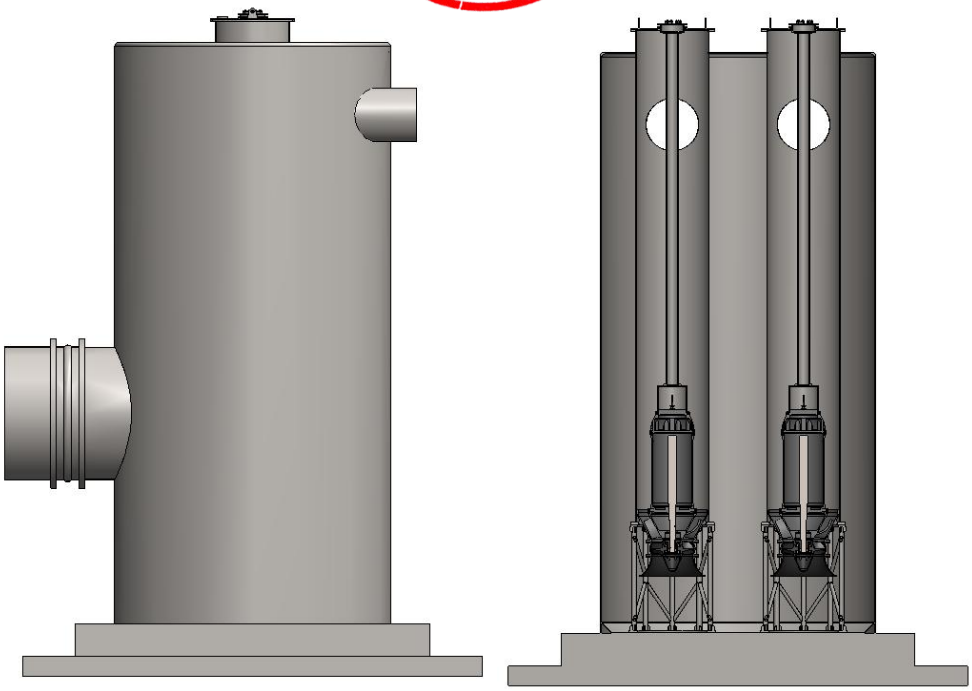


Figure 1-1, Structure of the pump station

1.2 CFD analysis process of integrated prefabricated pump station

The flow state of the integrated prefabricated pump station determines the inflow condition of the pump, thus affects the stability of the pump unit. Therefore, CFD analysis analyze the internal flow field of the cylinder and determine the shape design of the bottom of the cylinder.

The CFD analysis process of the integrated prefabricated pump station mainly

includes four stages: three-dimensional model, grid division, flow field solution and post-processing. ANSYS, the most widely used one in the world, is used to conduct the CFD analysis of the integrated pump station. The specific process is shown in Figure 1-2.

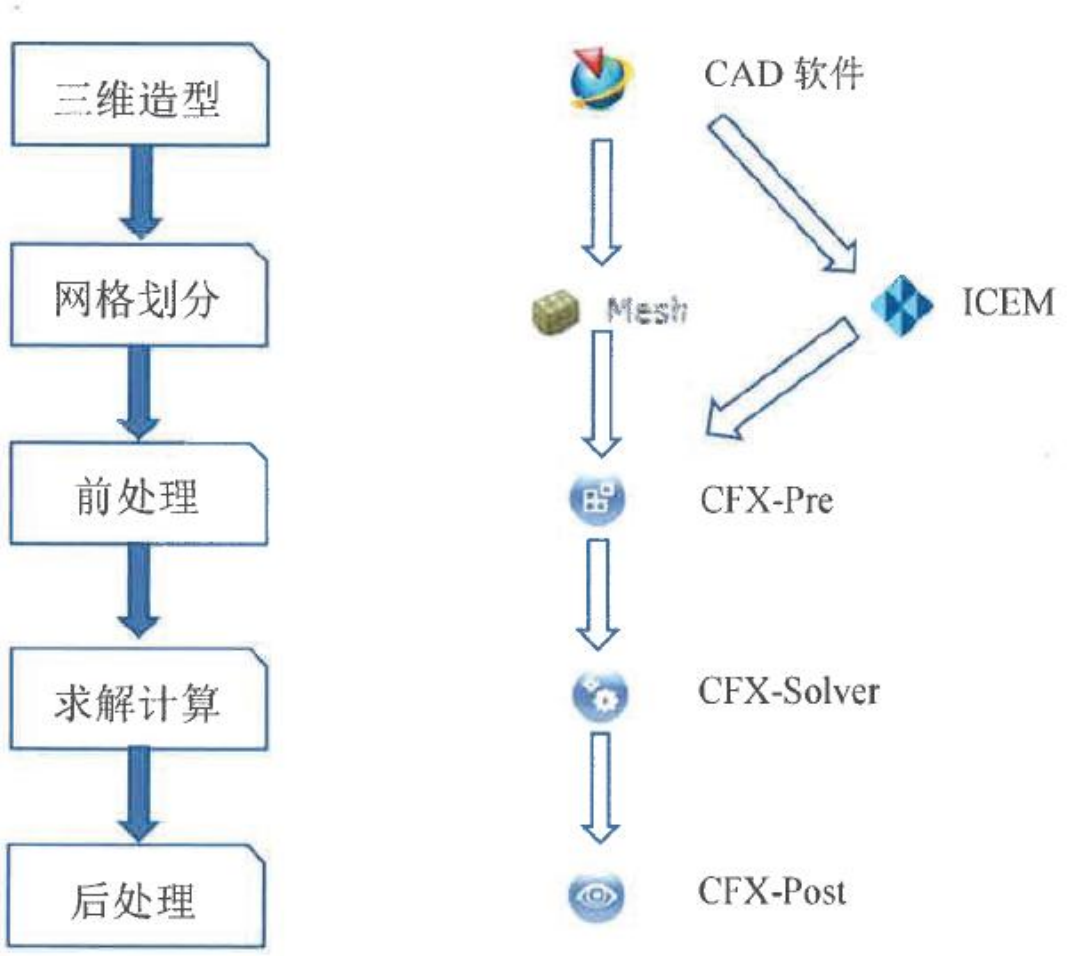


Figure 1-2 The CFD calculation flow

1.3 Control equation

Fluid flow in the pump station follows the conservation of mass, energy and momentum, which can be described by the desired control equation. The CFD solution is to solve these discretized governing equations to obtain the flow variables such as the pressure and velocity of the fluid domain at each point. The flow in the

pump station in this analysis is three-dimensional incompressible turbulent flow. Considering the fluid heat exchange is:

(A) Conservation of mass (continuous) equation:

$$\frac{\partial(\rho u)}{\partial x}+\frac{\partial(\rho v)}{\partial y}+\frac{\partial(\rho w)}{\partial z}=0$$

Where: ρ -is the density of the fluid;

Coordinate components of u, v, w − velocity.

(B) Conservation of momentum (N-S) equation:

$$\begin{cases}\dfrac{\partial(\rho u)}{\partial t}+div(\rho uu)=div(\mu gradu)-\dfrac{\partial p}{\partial x}+S_u\\ \dfrac{\partial(\rho v)}{\partial t}+div(\rho vu)=div(\mu gradv)-\dfrac{\partial p}{\partial y}+S_v\\ \dfrac{\partial(\rho w)}{\partial t}+div(\rho wu)=div(\mu gradw)-\dfrac{\partial p}{\partial z}+S_w\end{cases}$$

Where: Su, Sv, Sw- -the generalized source term of the momentum conservation equation;

U — a fluid absolute velocity vector;

μ — kinetic viscosity;

t— time.

For turbulence, if the control equation of 3 D transient is solved directly, the direct simulation method is needed, but this requires high memory and speed of the computer, and it is difficult to adopt in practical engineering. The widely used method in engineering is to homogenization the transient N-S equation, supplement other equations reflecting the turbulent characteristics, and form a closed system of equations to solve them.

In this analysis, the k- ε model is used to solve the turbulence, which is derived from the mathematical method of the instantaneous N-S equation. It is more suitable in the internal flow field of the impeller machinery with large streamline curvature and vortex and rotation. The equations k and ε equations are as follows:

$$\frac{D(\rho k)}{Dt}=\frac{\partial}{\partial x_j}\left[\left(\mu+\frac{\mu_t}{\sigma_k}\right)\frac{\partial k}{\partial x_j}\right]+\tau_{ij}\frac{\partial \overline{u}_i}{\partial x_j}-\rho\varepsilon$$

$$\frac{D(\rho\varepsilon)}{Dt}=\frac{\partial}{\partial x_j}\left[\alpha_\varepsilon\left(\mu+\frac{\mu_t}{\sigma_\varepsilon}\right)\frac{\partial_\varepsilon}{\partial x_j}\right]+C_{\varepsilon I}^{*}\frac{\varepsilon}{k}\tau_{ij}\frac{\partial \overline{u}_i}{\partial x_j}-C_{\varepsilon 2}\rho\frac{\varepsilon^2}{k}$$

Where ρ is the fluid density and μ t is the turbulent viscosity, defined as:

$$\mu_t=\rho C_\mu\frac{k^2}{\varepsilon}$$

Where $C_{\varepsilon 1}^{*}=C_{\varepsilon 1}-\frac{\eta\left(1-\frac{\eta}{\eta_0}\right)}{1+\beta\eta^3}$，$\eta=\frac{(2E_{ij}\cdot E_{ji})^{0.5}k}{\varepsilon}$，$E_{ij}=\frac{1}{2}\left(\frac{\partial u_i}{\partial x_j}+\frac{\partial u_j}{\partial x_i}\right)\eta_0=4.377$，$\beta=0.012$，$C_\mu=0.0845$，$\alpha_k=1.39$，$C_{\varepsilon 1}=1.42$，$C_{\varepsilon 2}=1.68$。

2. 3 Dimension Modeling and Mesh Division

The commercial 3 D software SolidWorks was used to shape the overcurrent area of the pump station, as shown in Figure 2-1, and the pumps are numbered.

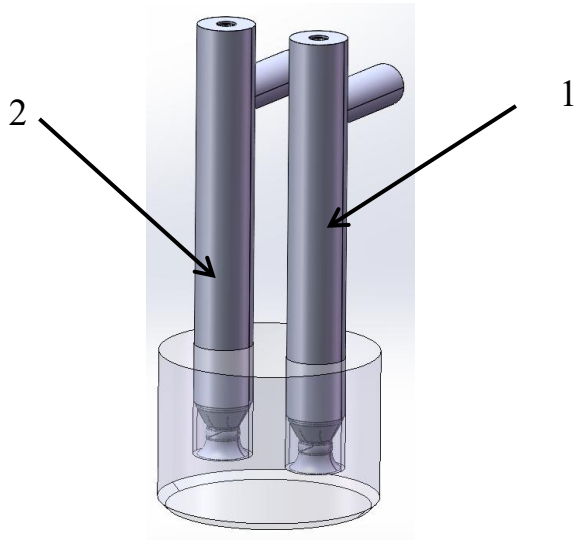


Figure 2-1 The 3 D model of the water body in the integrated pump station

The fluid in the pump station is continuously flowing, and it is difficult to directly solve the continuous fluid domains. Therefore, the current CFD technology needs to discretize the continuous fluid domain with the help of grid division, and solve the discrete equations, which can greatly reduce the difficulty of numerical calculation and improve the accuracy of solution. In terms of computational stability, structured grid is better than unstructured grid, and the interpolation error and other aspects are smaller. However, from the perspective of conformal of the model, unstructured mesh is much better than structured mesh, and can make grids with good conformal effect with a relatively small grid amount. Due to the complex flow area in the pump station, the unstructured grid adopted in this paper is designed for better adaptability.

As shown in Figure 2-2, the entire water body is grid-divided as tetrahedral unstructured in ANSYS, and the area of the impeller of the pump outlet pipe is locally encrypted. Theoretically, the number of grids can have some effect on the computational accuracy and speed. The increase of the number of grids will improve the calculation accuracy, but considering the calculation time and calculation cost, the number of grids should not be too much, so it is necessary to conduct the grid irrelevant check. Table 2-1 shows the grid-independent check of the computational domain.

According to the three sets of grid scheme of grid density, compare the flow loss (m), the results show that the thin grid scheme will cause some deviation in the calculation results, and the dense grid is more appropriate, and the dense grid calculation deviation is 1.2%. After comprehensive consideration, choose the dense grid scheme, the total number of grid is 3496782.

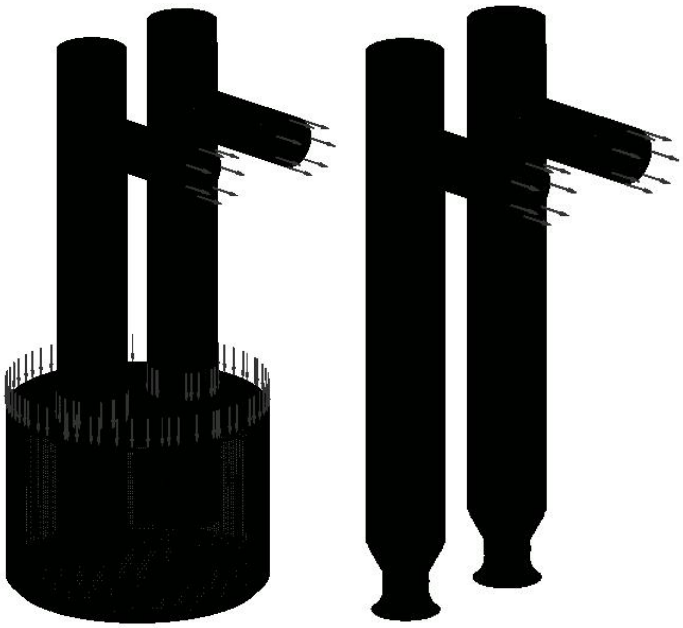


Figure Figure 2-2, the grid division

Table 2-1 Grid-independent examination

The degree of density	mesh quantity	Flow loss (m)
Sparse	1639648	0.53
Mideum	3496782	0.66
Dense	5697138	0.65

3. Boundary Conditions

CFD analysis of the internal flow of the integrated pump station. According to the characteristics of the pump station and the influence on the calculation convergence, the inlet of the pump station is set as constant pressure inlet according to the flow rate, the outlet is set as mass flow, the interface between the impeller and static parts is set as Stage (Mixing-Plane), and the other solid walls are set as smooth and without slip.

4. Computer Calculation

Two starting conditions of the pump station (one open and two fully open) are calculated and solved respectively, compare the flow field distribution, and finally give suggestions. The calculation domain of the two boot cases is shown in Figure Figure 4-1.

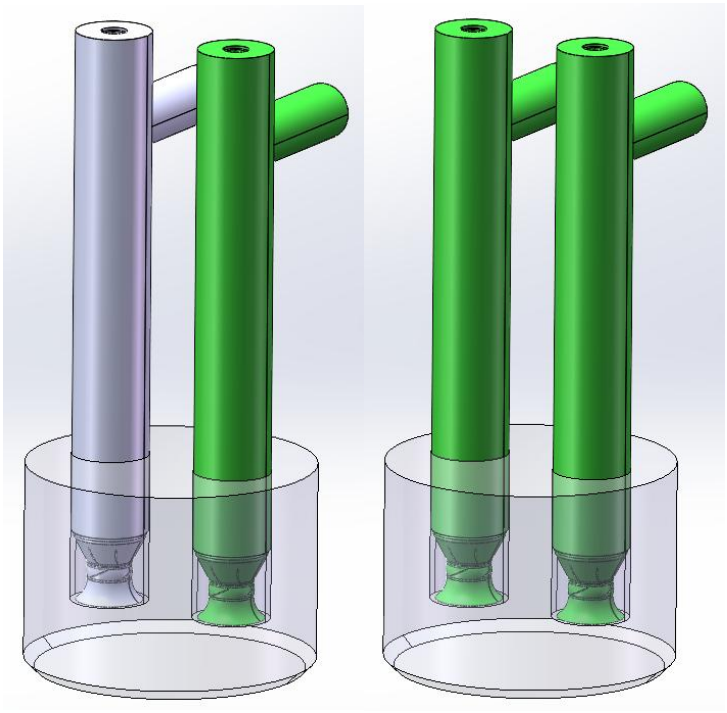


Figure 4-1 Combination of two boot conditions

5. Flow Field Display

5.1 The 3 D Flow Field Distribution of the Cylinder

As shown in Figure 5-1, the three-dimensional flow line and velocity vector distribution inside the pump station in two starting state, it can be seen that the water flow from the inlet level to the pump inlet evenly into the pump, the pump inlet inflow, the pump inlet and the cylinder base flow rate is dense, indicating that the large flow rate has a strong suction effect on the bottom. The comparison shows that when the two pumps are opened at the same time, the flow inside the cylinder is almost

symmetrically distributed, and the inflow conditions of the pump are very good.

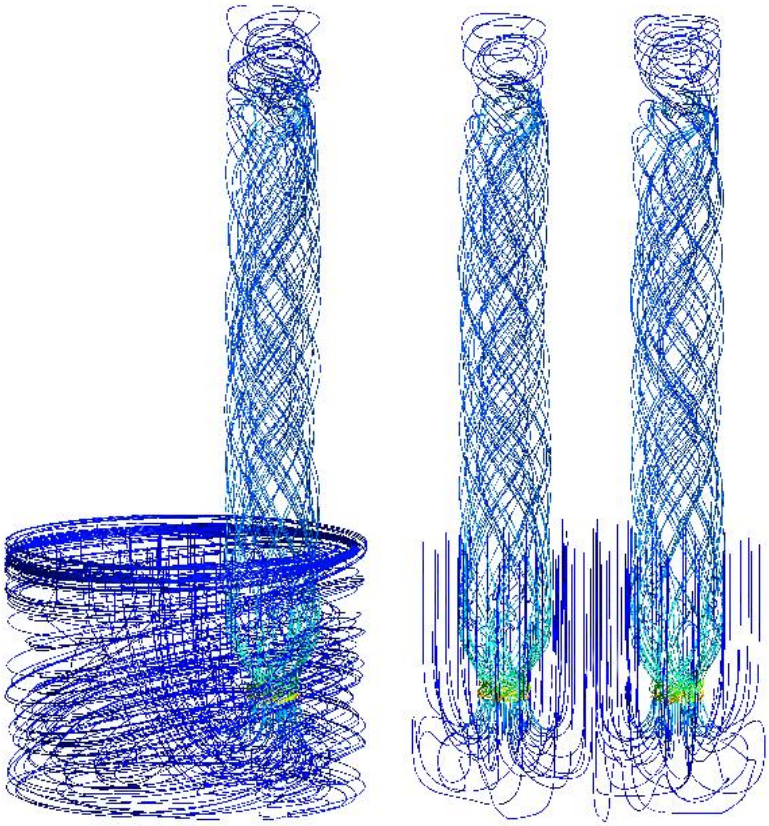
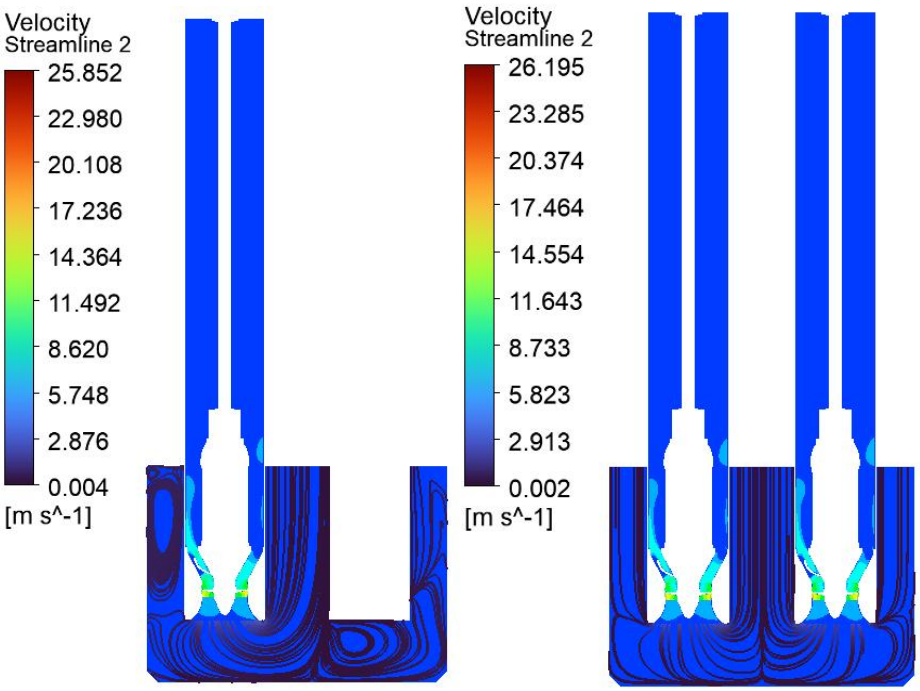


Figure 5-1 Three-dimensional flow inside the cylinder and the pump

5.2 Flow State Inside the Cylinder

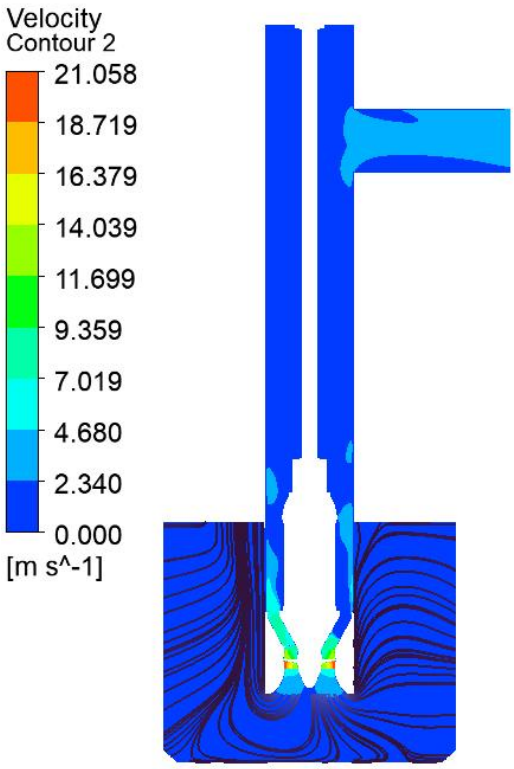
In order to more carefully check the flow field at the bottom of the cylinder, check the velocity streamline distribution in the central cross section of the pump, as shown in Figure 5-2, when a single pump is running, the medium in the pump will produce cyclone, with a large prerotation at the pump entrance; When two pumps are started at the same time, the internal flow state of the cylinder is good, the symmetry of the whole flow is very good, the medium basically enters the pump along the axis, and the import prerotation is very small.



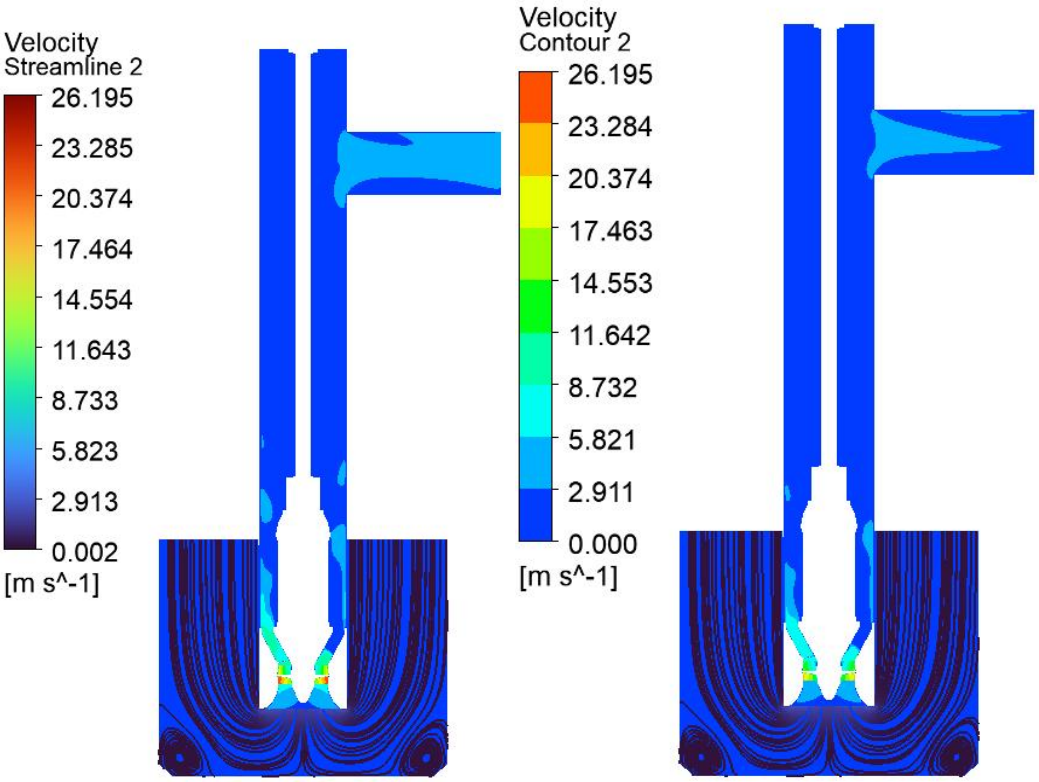
(A) Pump status (B) Two pumps status

Figure 5-2 Flow field distribution of central cross section of water pump

Figure 5-3 shows the velocity flow diagram of the longitudinal profile of the center line of each water pump. Figure (a) shows the velocity flow diagram of the longitudinal profile of the pump center line when the single pump starts and running; (b) ~ (c) is the velocity flow diagram of the longitudinal profile of the pump center line when the two pumps are starting and running. When a single pump is running, the longitudinal profile cylinder is relatively chaotic, and the flow state of the pump inlet is asymmetric; when the two pumps operate at the same time, the internal flow state of the cylinder is good, the symmetry of the whole flow is very good, the medium basically enters the pump along the axial direction, the pump inlet streamline is smooth, basically no prerotation.



（ a）



（ b）（ c）

Figure 5-3 Flow field distribution of longitudinal section of water pump

6 Conclusion

When the integrated prefabricated pump station starts and runs the two pumps at the same time, the internal flow state of the cylinder is good, and the overall state is symmetrical. The inlet inflow condition of the pump is very good.

利欧集团湖南泵业有限公司

一体化预制泵站内部 CFD 流体力学

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告

利欧集团湖南泵业有限公司技术部

2024 年 6 月 24 日

Technical department

目录

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1.概述

1.1 分析对象

分析对象为利欧集团湖南泵业有限公司提供的 700QZ-70J 一体化预制泵站模型，筒体尺寸为Φ4200XH8850mm，泵站采用铸钢筒体和防淤泥堆积底座设计，内置两台轴流泵，此外泵站内还包括：提篮格栅、压力管道等设备，其结构示意图如图 1-1 所示。

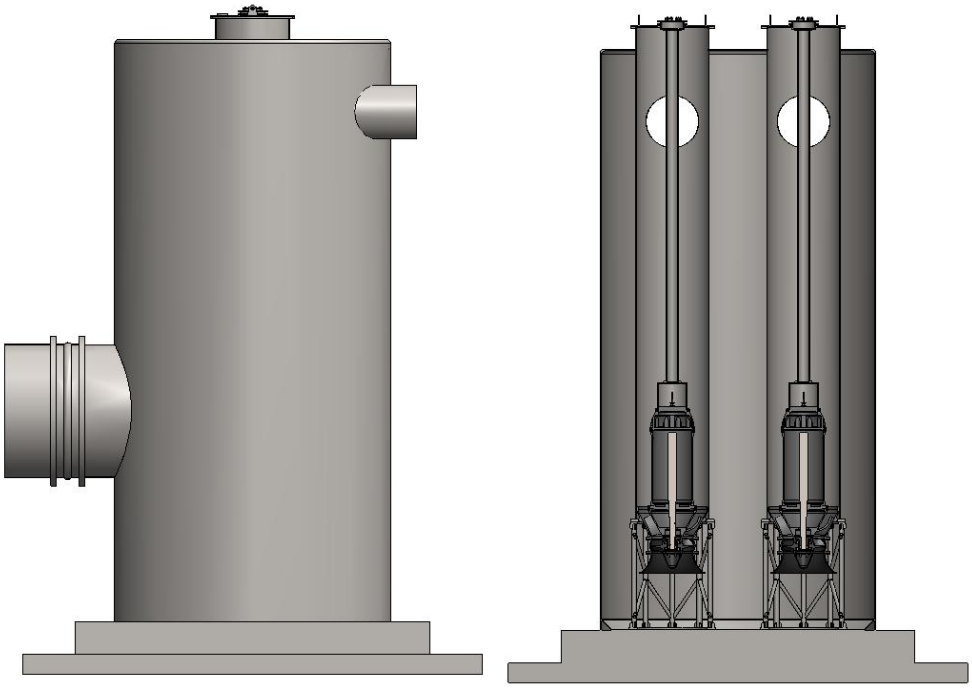

图 1-1 泵站结构

1.2 一体化预制泵站 CFD 分析过程

一体化预制泵站内的流态好坏决定泵的入流条件，从而影响泵机组运行的稳定性，因此需要对筒体内部流场进行 CFD 分析，判别筒体底部形状设计好坏。

一体化预制泵站 CFD 分析过程主要包括三维模型、网格划分、流场求解及后处理四个阶段，采用国际上运用最广泛的 ANSYS 对一体化泵站进行 CFD 分析，具体流程如图 1-2 所示。

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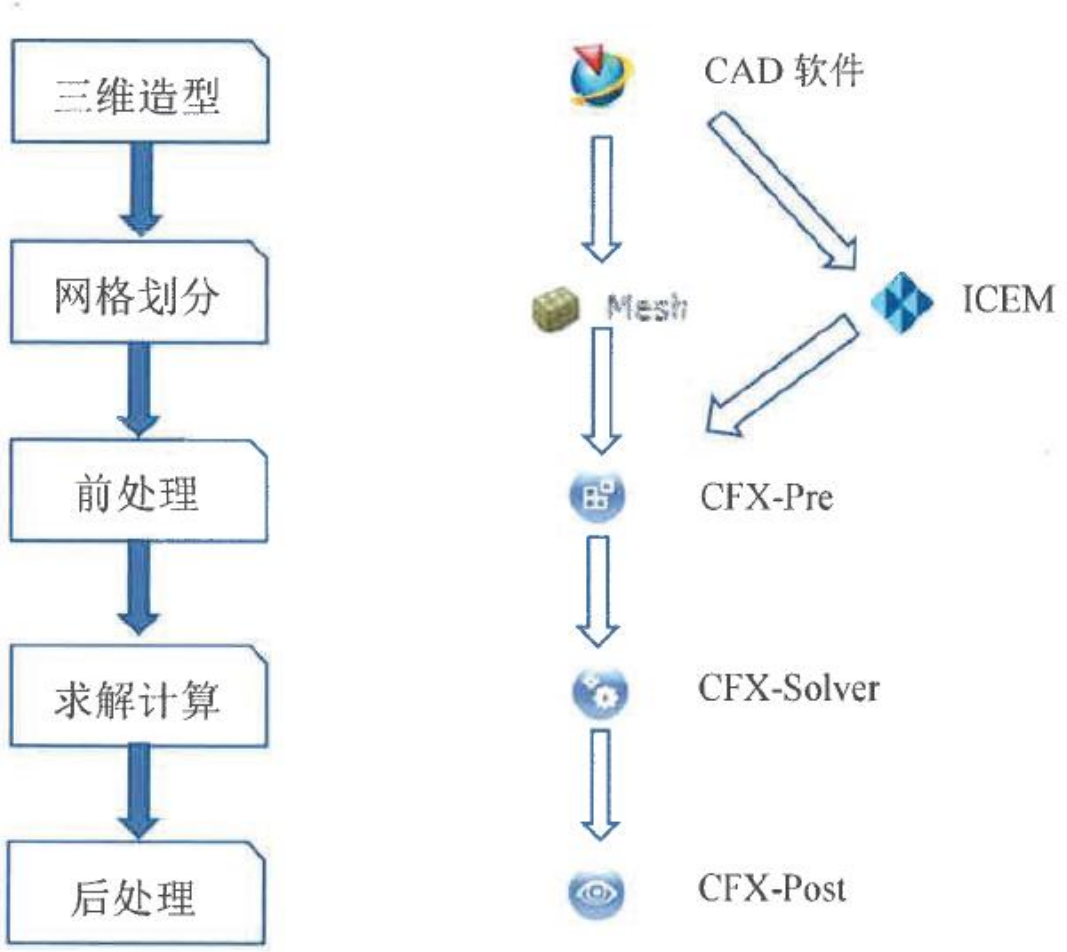

图 1-2 CFD 计算流程

1.3 控制方程

泵站内的流体流动遵循质量守恒、能量守恒和动量守恒，这些规律可用想应的控制方程进行描述。CFD 求解即对这些离散化的控制方程进行求解，得出流体域在各点的压力、速度等流动变量。本次分析的泵站内的流动为三维不可压缩湍流流动，不考虑流体换热情况下其直角坐标系下流动控制方程为：

（a）质量守恒（连续）方程：

$$\frac{\partial(\rho u)}{\partial x}+\frac{\partial(\rho v)}{\partial y}+\frac{\partial(\rho w)}{\partial z}=0$$

式中：ρ – 为流体的密度；

u、v、w – 速度的坐标分量。

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（b）动量守恒（N-S）方程：

$$\begin{cases} \dfrac{\partial(\rho u)}{\partial t} + div(\rho u u) = div(\mu grad u) - \dfrac{\partial p}{\partial x} + S_u \\ \dfrac{\partial(\rho v)}{\partial t} + div(\rho v u) = div(\mu grad v) - \dfrac{\partial p}{\partial y} + S_v \\ \dfrac{\partial(\rho w)}{\partial t} + div(\rho w u) = div(\mu grad w) - \dfrac{\partial p}{\partial z} + S_w \end{cases}$$

式中：Su、Sv、Sw—动量守恒方程的广义源项；

u—流体绝对速度矢量；

μ—动力粘度；

t—时间。

对于湍流，如果直接求解三维瞬态的控制方程，需要采用直接模拟方法，但这对计算机的内存和速度要求都很高，很难在实际工程中采用。工程上广泛采用的方法是对瞬态 N-S 方程进行时均化，同时补充反映湍流特性的其他方程，组成封闭方程组再进行求解。

本次分析采用 k-ε 模型对湍流进行求解，该模型是对瞬时的 N-S 方程用重整化群的数学方法推导出来的模型，其精度较高，在流线曲率大、有旋涡和旋转的叶轮机械内部流场中更加适用。其 k、ε 方程如下：

$$\frac{D(\rho k)}{Dt} = \frac{\partial}{\partial x_j}\left[\left(\mu + \frac{\mu_t}{\sigma_k}\right)\frac{\partial k}{\partial x_j}\right] + \tau_{ij}\frac{\partial \overline{u}_i}{\partial x_j} - \rho\varepsilon$$

$$\frac{D(\rho \varepsilon)}{Dt} = \frac{\partial}{\partial x_j}\left[\alpha_\varepsilon\left(\mu + \frac{\mu_t}{\sigma_\varepsilon}\right)\frac{\partial_\varepsilon}{\partial x_j}\right] + C_{\varepsilon I}^{*}\frac{\varepsilon}{k}\tau_{ij}\frac{\partial \overline{u}_i}{\partial x_j} - C_{\varepsilon 2}\rho\frac{\varepsilon^2}{k}$$

其中ρ为流体密度，μ_t是湍流粘度，定义为：

$$\mu_t = \rho C_\mu \frac{k^2}{\varepsilon}$$

式中：$C_{\varepsilon 1}^{*} = C_{\varepsilon 1} - \dfrac{\eta\left(1-\frac{\eta}{\eta_0}\right)}{1+\beta\eta^3}$，$\eta = \dfrac{\left(2E_{ij}\cdot E_{ji}\right)^{0.5}k}{\varepsilon}$，$E_{ij} = \dfrac{1}{2}\left(\dfrac{\partial u_i}{\partial x_j} + \dfrac{\partial u_j}{\partial x_i}\right)$ $\eta_0 = 4.377$，$\beta = 0.012$，$C_\mu = 0.0845$，$\alpha_k = 1.39$，$C_{\varepsilon 1} = 1.42$，$C_{\varepsilon 2} = 1.68$。

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2.三维造型与网格划分

采用商业三维软件 SolidWorks 对泵站过流区域进行三维造型，如图 2-1 所示，对水泵依次进行编号。

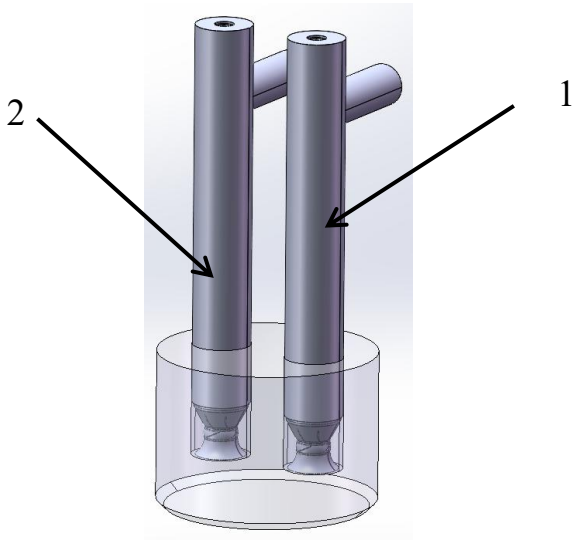

图 2-1 一体化泵站水体三维模型

泵站内的流体为连续流动的，而直接求解连续的流体域难度较大，因此，目前的 CFD 技术需借助网格划分将连续流体域离散化，并求解离散化的方程组，可大大减小数值计算难度并提高求解的精度。从计算的稳定性来说，结构化网格比非结构化网格要好，带来的插值误差等各方面较小。但是，从模型的保形性角度，非结构化网格比结构化网格好的多，能以比较小的网格量做出保形性效果好的网格。由于泵站内流动区域较为复杂，为了有更好的适应性，本文采用的非结构化网格。

如图 2-2 所示，在 ANSYS 中对整个水体进行四面体非结构网格划分，并对泵出水管道叶轮区域进行局部加密。理论上，网格的数量会对计算精度和速度造成一些影响。网格数量的增加会提高计算准确度，但考虑到计算时间及计算成本，网格数也不宜过多，因此有必要进行网格无关性检查。表 2-1 为计算域的网格无关性检查。

根据网格疏密程度划分三套网格方案，比较泵站进出口的流动损失(m)，结果表明疏网格方案会导致计算结果产生一定的偏差，而中密型网格

密网格计算偏差为 1.2%，综合考虑后，选择中密型网格方案，其网格总数为 3496782。

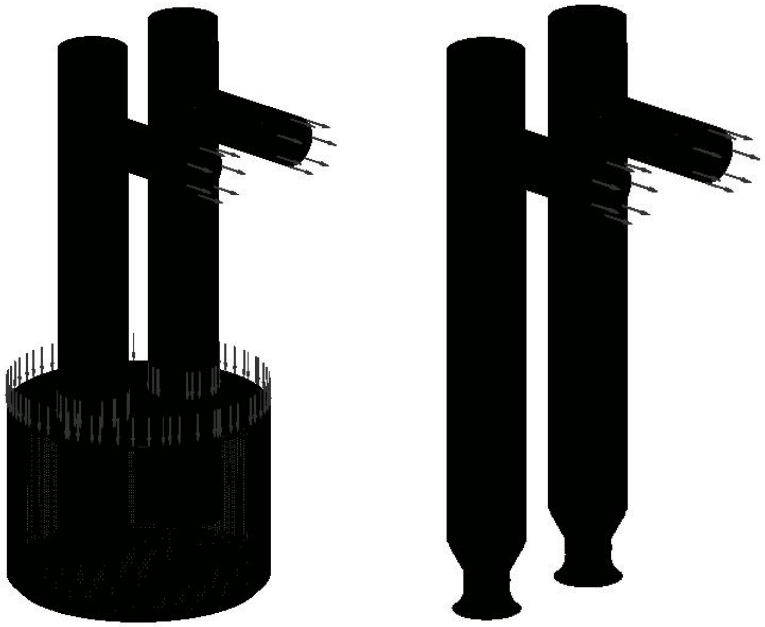

图 2-2 网格划分

表 2-1 网格无关性检查

疏密程度	网格数量	流动损失(m)
疏	1639648	0.53
中	3496782	0.66
密	5697138	0.65

3.边界条件

采用商用软件 ANSYS CFX 对一体化泵站内部流动进行 CFD 分析，针对泵站内部流动特点和对计算收敛性的影响，根据流量将泵站进口设置为恒定的压力进口，出口设置成质量流，叶轮与静止部件间的交界面设置为 Stage(Mixing-Plane)，其余固体壁面均设为光滑无滑移壁面条件。

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4.计算求解

对泵站两种开机情况(开一台和两台全开)分别进行计算求解，对比流场分布，最终给出建议。两种开机情况的计算域如图 4-1 所示。

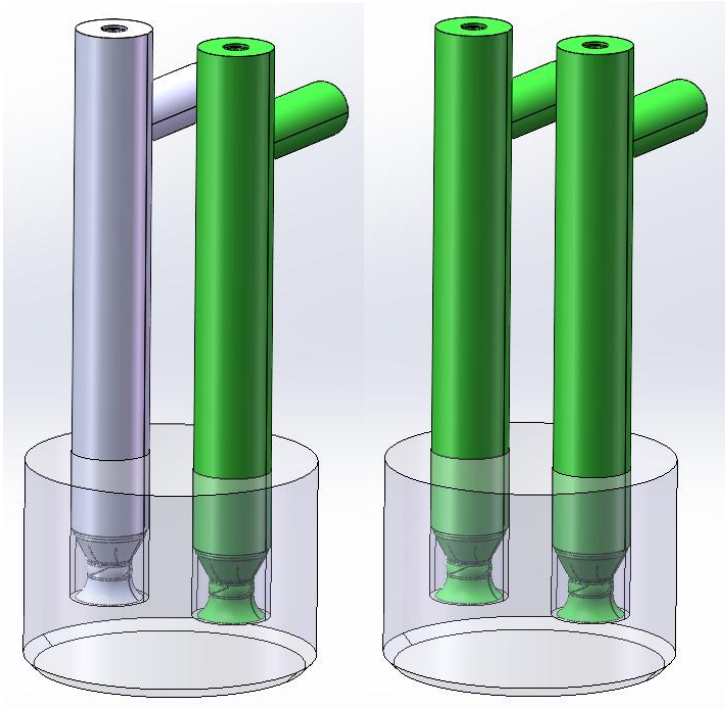

图 4-1 两种开机情况组合

5.流场显示

5.1 筒体三维流场分布

如图 5-1 所示为泵站在两种启动状态下筒体内部三维流线及速度矢量分布，可以看出水流从进口液面向下运动至泵入口后均匀进入泵内，泵进口入流未出现明显的不良现象，泵吸入口和筒体底座流速较密，说明该处流速较大对底部具有很强的抽吸作用。对比发现 2 台泵同时开启时，筒体内流动几乎呈对称分布，泵的入流条件很好。

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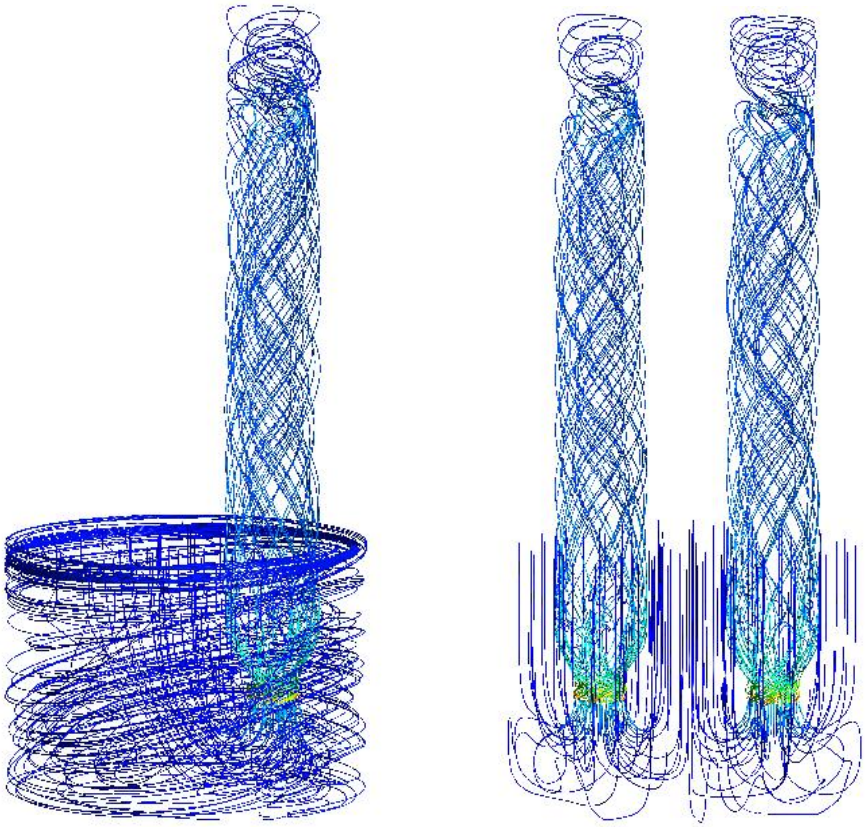

图 5-1 两种开机情况筒体和泵内部三维流动

5.2 筒体内部局部流态

为了更仔细的查看筒体底部流场，在水泵中心横截面查看其速度流线分布，如图 5-2 所示，单台泵启动运行时，筒体内介质会产生旋流，在泵入口处有较大预旋；两台泵同时启动时，筒体内部流态较好，整个流动的对称度很好，介质基本沿轴向进入泵，进口预旋很小。

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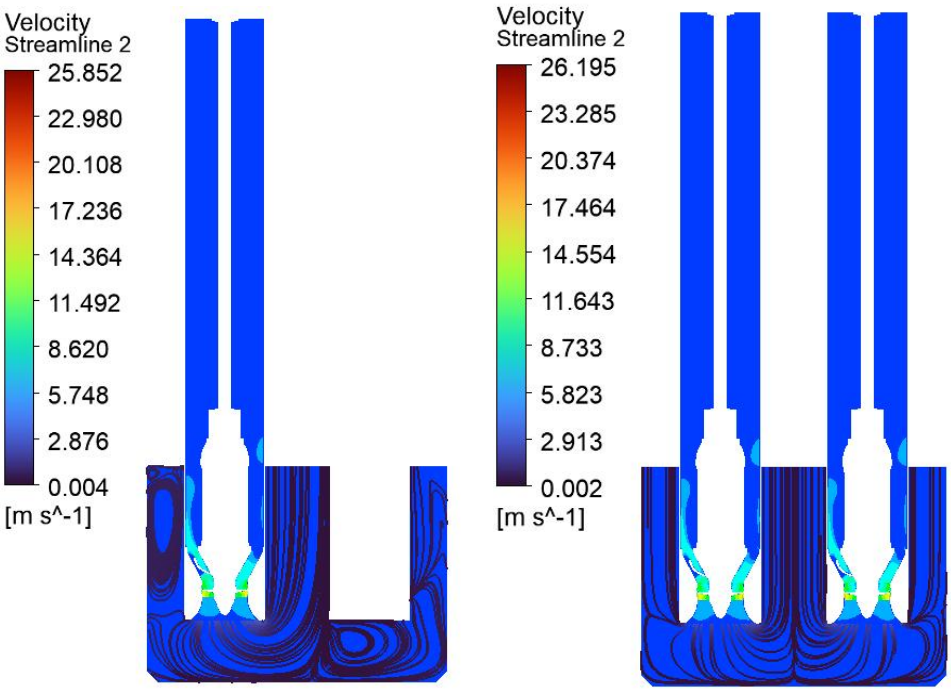

（a）开一台泵　　（b）开两台泵

图 5-2 水泵中心横截面流场分布

图 5-3 为每台水泵中心线纵剖面的速度流线图。图（a）为单台泵启动运行时水泵中心线纵剖面的速度流线图，（b）~（c）为两台泵启动运行时水泵中心线纵剖面的速度流线图。单台泵启动运行时，纵剖面筒体内相对较为混乱，泵进口流态呈不对称状态；两台泵同时运行时，筒体内部流态较好，整个流动的对称度很好，介质基本沿轴向进入泵，泵进口处流线顺畅，基本没有预旋。

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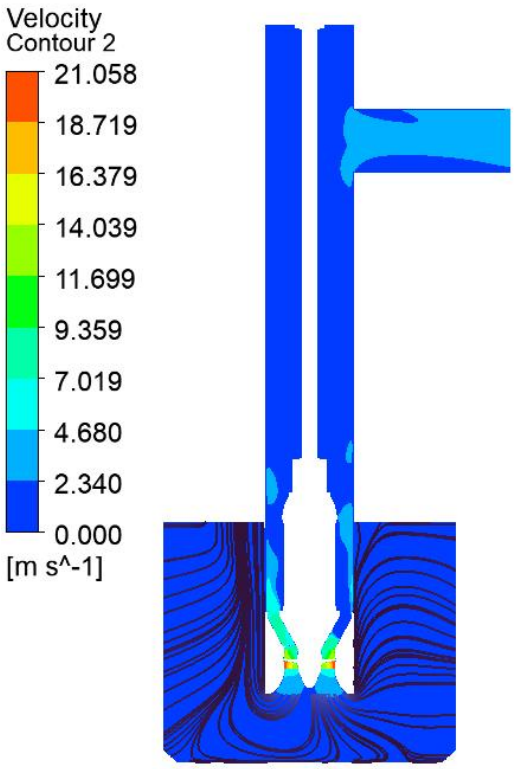
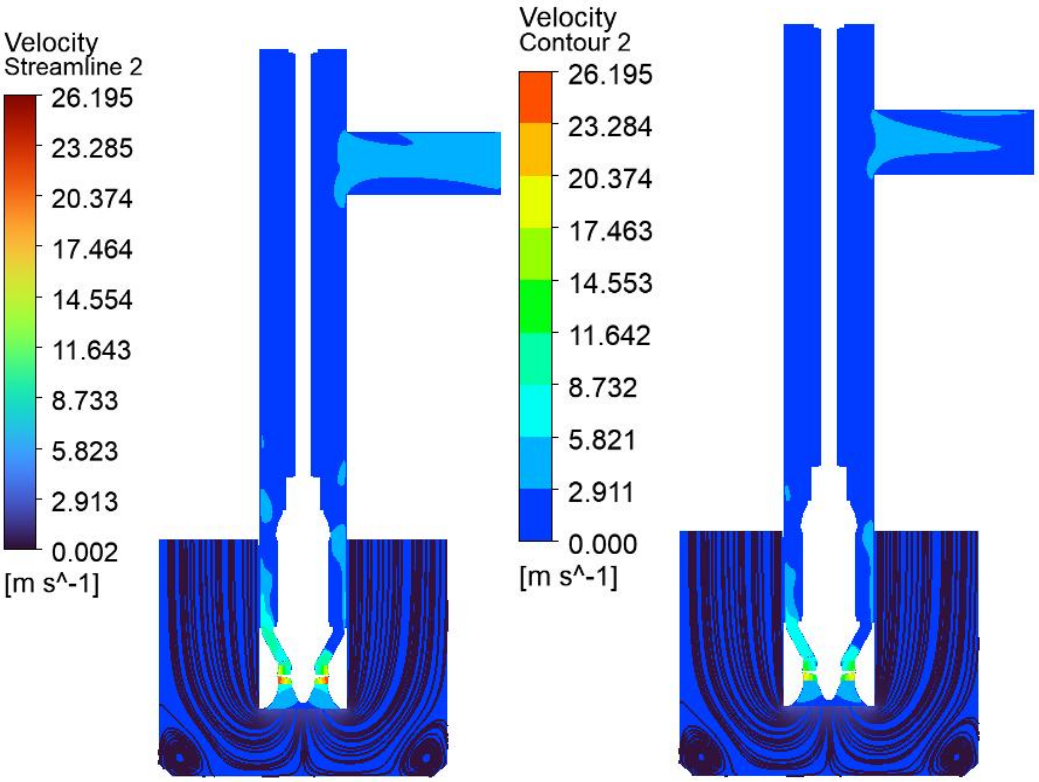


（a）



（b）　　（c）

图 5-3 水泵中心纵截面流场分布

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6 结论

一体化预制泵站在两台泵同时启动运行时，筒体内部流态较好，整体呈对称状态，泵进口入流条件很好，未出现明显的不良流动现象。

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900QZ-160 CFD 水力性能分析报告

1. 设计参数

900QZ-160 设计参数如下表所示。

表 1.1 设计参数

流量(m³/s)	扬程(m)	转速(rpm)	轴功率(kW)	效率(%)
3.02	2	490	80.1	74
3.2	1.2		56.6	66.5

设计和计算分析中所采用的常数和抽送介质基本物理属性见下表。

表 1.2 常数和介质属性

重力加速度 g	介质密度	动力粘度
9.81 m/s²	997 Kg/m³	8.899×10-4 Pa·s

2. CFD 计算策略

CFD 计算策略在四个方面制定：1) 计算域；2) 计算网格；3) 边界条件；4) 计算设置。经过反复论证后最终方案如后文所述。

2.1 计算域

在水力模型开发过程中，完整水力模型的计算域涵盖从进口段到出口段的所有过流部件但不包含各种密封间隙和盖板外侧腔内的流动。沿流动方向，计算域依次为喇叭口、叶轮、导叶。下图所示为本次计算最终确定的计算域。

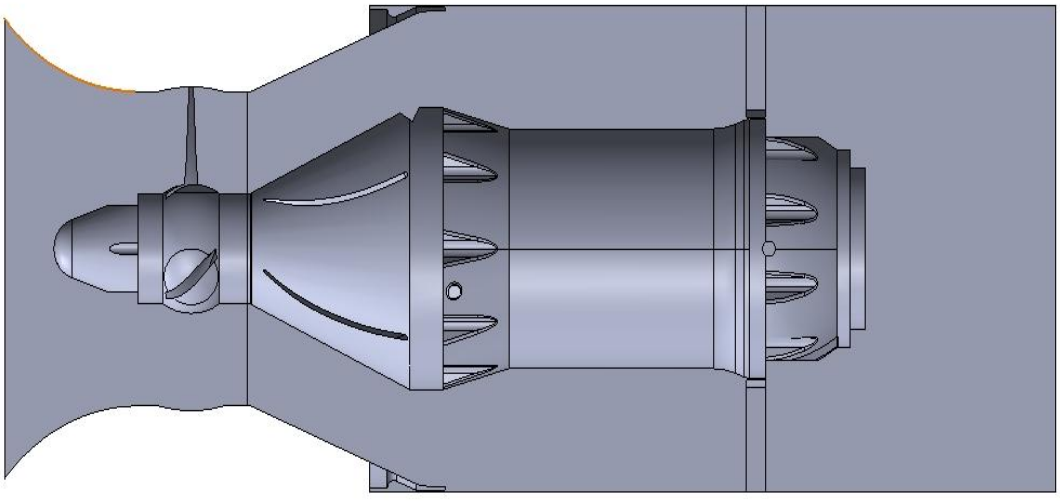

图 2.1 计算域

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2.2 计算网格

计算网格对计算结果有至关重要的影响，需要经过网格无关性验证，恰当的处理近壁区网格密度以满意湍流模型的要求等。

本次计算网格采用贴体网格。其中喇叭口、叶轮和导叶流道网格为六面体为主的混合网格。在叶轮流道内，对近壁区网格进行了特别的加密处理以更好地模拟边界层内的流动和估算水力效率。各部分网格大概数量见下表。

表 2.2 网格数量

位 置	总数量
喇叭口	500000
叶轮	800000
导叶	1200000

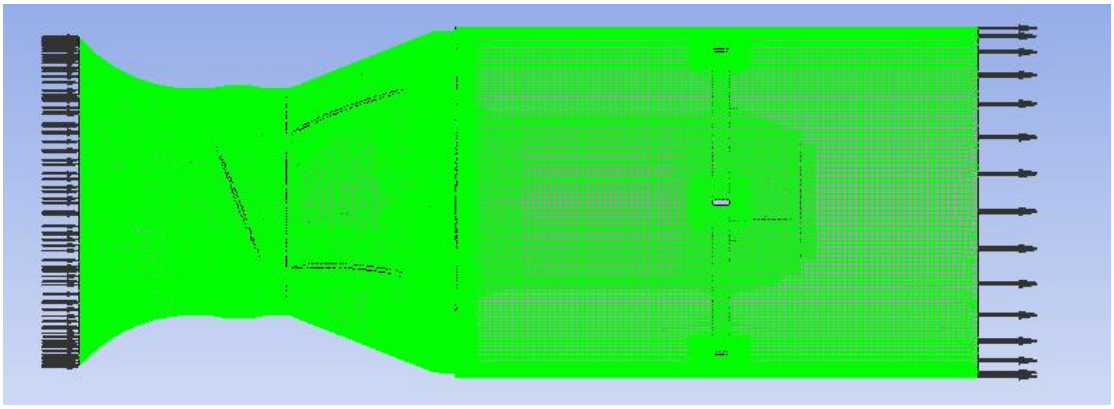

图 2.3 计算网格

2.3 边界条件和计算设置

流体为不可压缩流体，所有过流部件耦合计算，不同部件间的连接关系见下表。

采用无滑移壁面，其他主要边界条件设置见下表。

表 2.4 主要边界条件和计算域耦合算法

项 目	参 数
进口	总压
出口	质量流量
喇叭口和叶轮	Stage Interface (Constant Total Pressure)

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项 目	参 数
叶轮和导叶	Stage Interface (Constant Total Pressure)

计算采用 ANSYS CFX 软件进行，主要计算设置见下表。

表 2.5 主要计算设置

项 目	参 数
分析类型	Steady state
湍流模型	The Baseline (BSL) k-omega Model
壁面函数	Automatic
对流项数值精度	High resolution（2 阶）
湍流项数值精度	High resolution（2 阶）

3. 外特性分析方法

泵的扬程、功率、效率的计算方法为：

扬程 $H=\dfrac{\left(\overline{P_{t\,out}}-\overline{P_{t\,in}}\right)}{\rho g}$

式中，$\overline{P_{t\,out}}$，$\overline{P_{t\,in}}$ 分别为泵进出口质量加权平均总压，按下式求得：

$$\overline{P_t}=\frac{\int_A p_t\rho\boldsymbol{v}\cdot\boldsymbol{n}dA}{\dot{m}}$$

其中，$\dot{m}=\int_A\rho\boldsymbol{v}\cdot\boldsymbol{n}dA$

功率 $P=P_P+P_{vis}$

等式右边依次为压力对叶轮所做功率和粘性力对叶轮所做功率，按下式求得：

$P=M\cdot\omega$

式中，M 为压力或粘性力对叶轮回转轴的力矩，ω为叶轮旋转角速度。

效率 $\eta=\dfrac{\rho gQH}{P}\times100\%$

式中，Q 为通过泵的流量。

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4 CFD 性能预测

4.1 外特性结果

参照 3 节分析方法从 CFD 计算结果中提取计算模型的外特性，见下表及下图所示。

表 4.1 设计参数

流量(m³/s)	扬程(m)	转速(rpm)	轴功率(kW)	效率(%)
3.02	2	490	80.1	74
3.2	1.2		56.6	66.5

表 4.2 CFD 计算参数

流量(m³/s)	扬程(m)	轴功率(Kw)	水力效率(%)
2.80	2.41	116.3	56.8
3.02	1.64	96.5	50.1
3.20	0.86	78.0	34.6
3.30	0.38	66.8	18.2

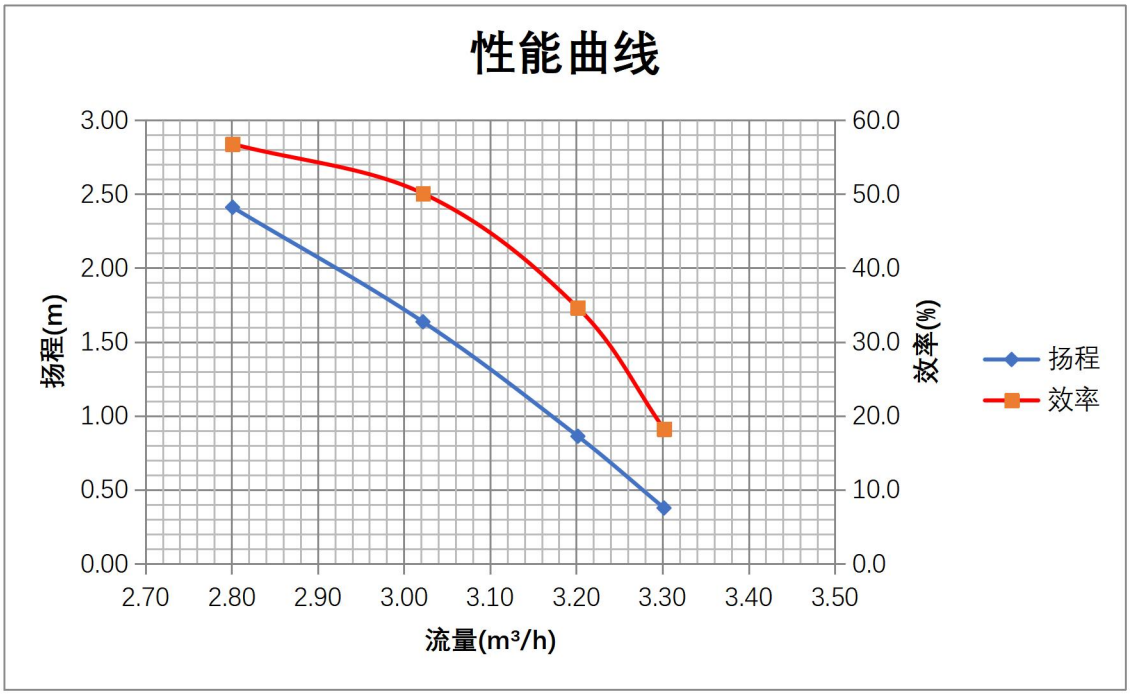

图 4.3 流量-扬程/效率曲线

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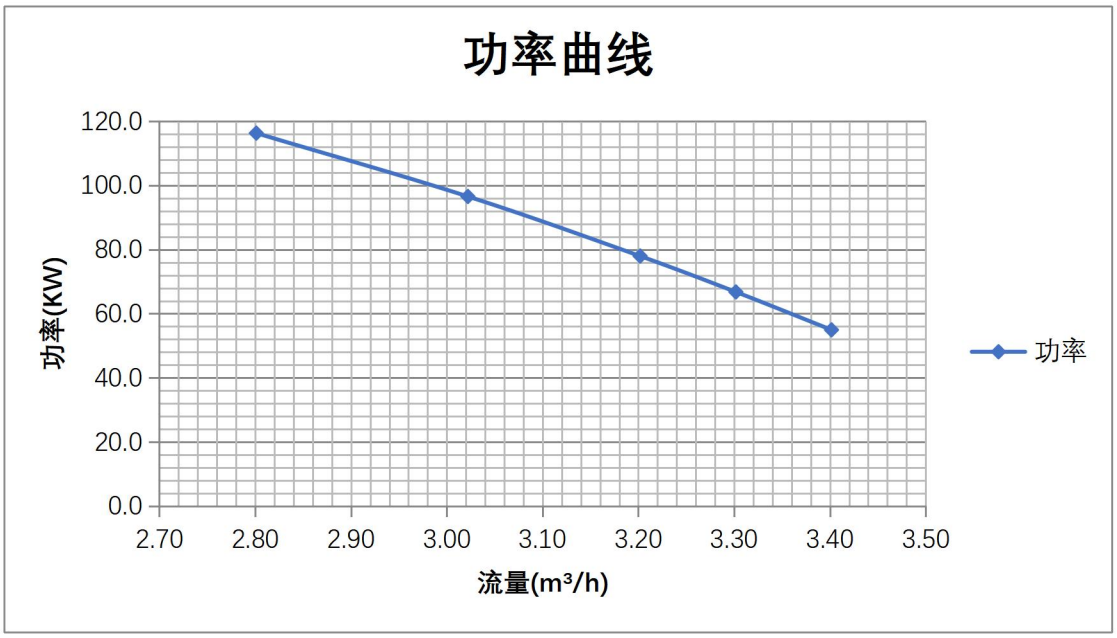

图 4.4 流量-功率曲线

从上图和上表中可以看到，计算模型外特性参数不满足设计要求。

4.2 原因分析

对水力模型分析后发现，扬程、效率、轴功率和设计参数都偏差比较大，在流量 3.2m³ /s 时，扬程偏差了 28.3%，这个比例还是非常大的，问题可能是出现在了分析的水力模型上，水力模型加了很多的死水区(如下图 4.5 所示)，这些区域的水无法提供有效功，但是却会消化有限功，从而导致了扬程下降很多的情况。

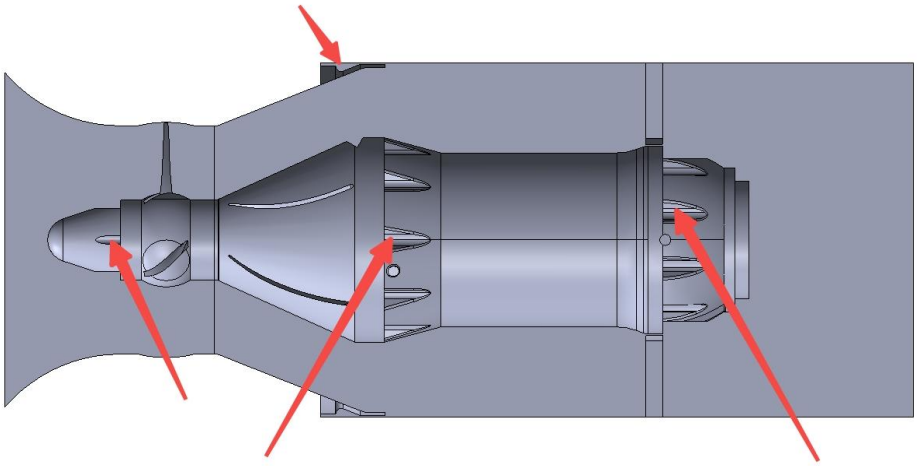

图 4.5 首次分析水力模型死水区

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4.3 对比分析

扬程和效率低下的原因，可能是因为首次分析的水力模型死水区域过多，通过减少死水区域再分析一次，进行一下对比。水力模型如图 4.6 所示。

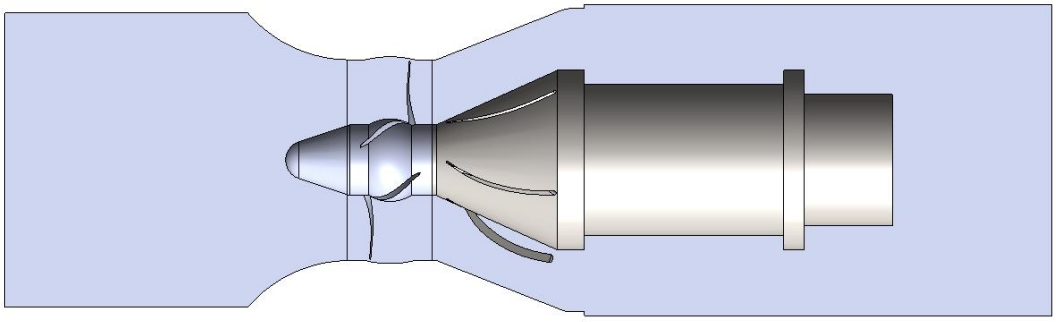

图 4.6 第二次分析水力模型无死水区

计算结果如下表 4.7。

表 4.7 第二次分析结果

流量(m³/s)	扬程(m)	轴功率(Kw)	水力效率(%)
2.80	2.91	108.2	73.6
3.02	2.09	88.3	69.9
3.20	1.23	69.7	55.3
3.30	0.68	58.0	37.7
3.40	0.12	45.7	8.6

表 4.8 第一次分析结果

流量(m³/s)	扬程(m)	轴功率(Kw)	水力效率(%)
2.80	2.41	116.3	56.8
3.02	1.64	96.5	50.1
3.20	0.86	78.0	34.6
3.30	0.38	66.8	18.2

两次分析结果对比后可以得出，再去掉水力模型的死水区域后，CFD 计算出来的结果和设计参数基本一致，同时也验证了第一次分析扬程差距比较大的原因，是因为分析模型中的死水区域，所带来的损失造成的。

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5 内流场特性

本节基于（速度）框架对泵内流场特性进行了多角度的展示。

5.2 速度分布

5.2.1 空间流线

下图 5.1 展示了在流量 3.2m³/s 时，首次分析叶轮和导叶内的流体的空间流线，表示了流体的空间运动轨迹。

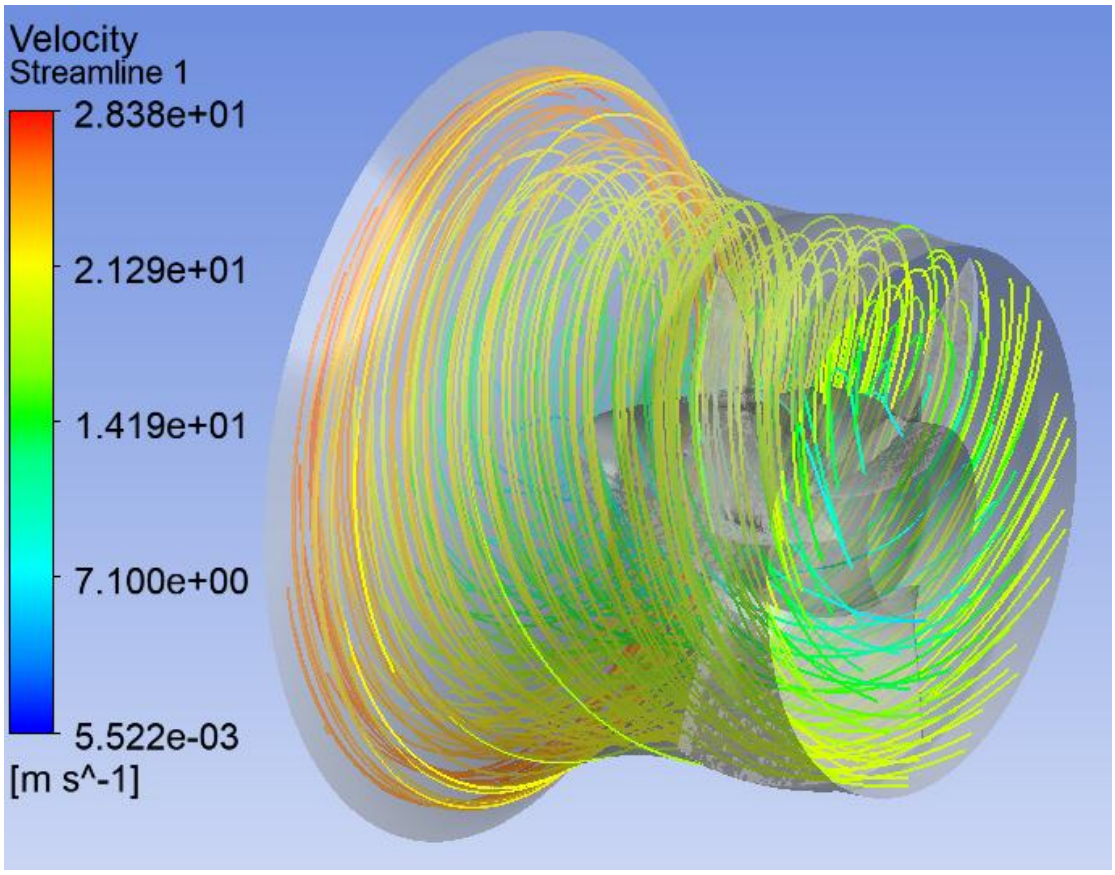

图 5.1（a）第一次分析叶轮流线图

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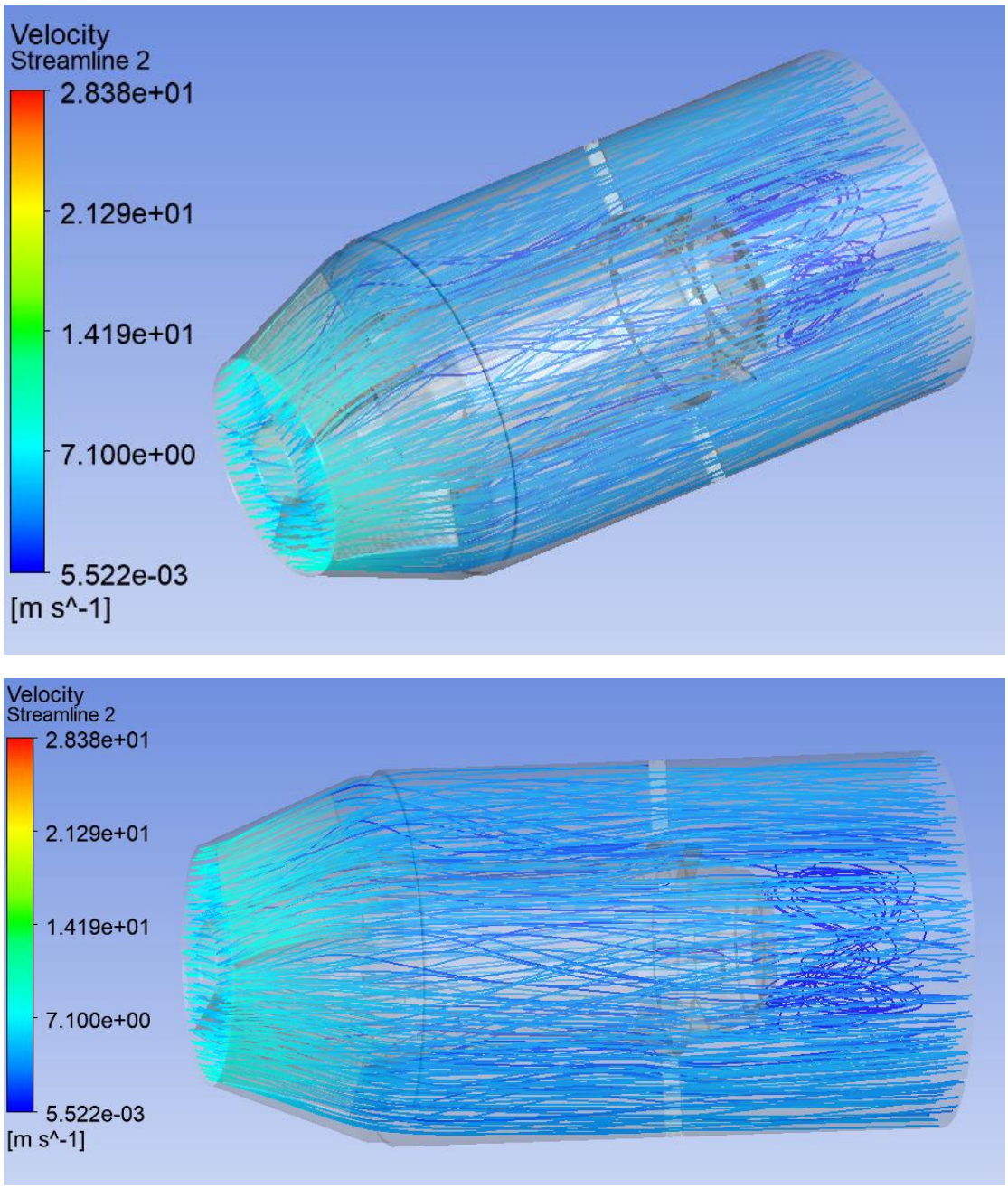

图 5.2（b）第一次分析导叶流线图

结论：明显可以看出来，导叶尾部有明显的漩涡，从而造成了扬程和效率下降。

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下图 5.2 展示了在流量 3.2m³/s 时，第二次分析叶轮和导叶内的流体的空间流线，表示了流体的空间运动轨迹。

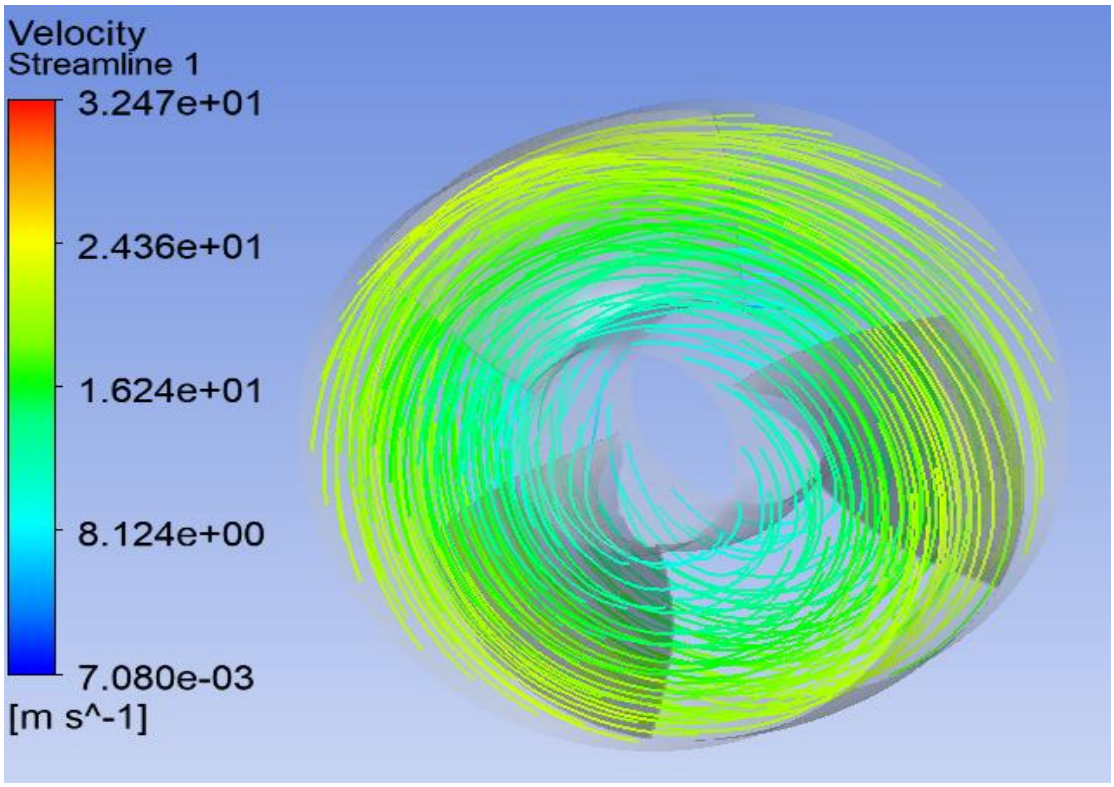
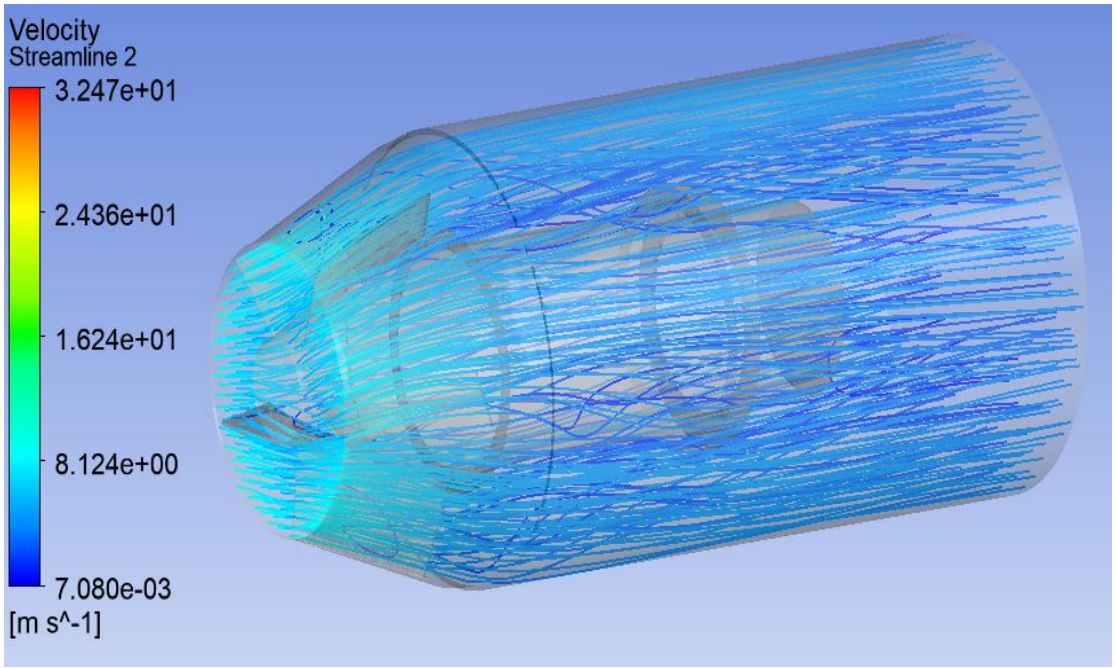


图 5.2（a）第二次分析叶轮流线图



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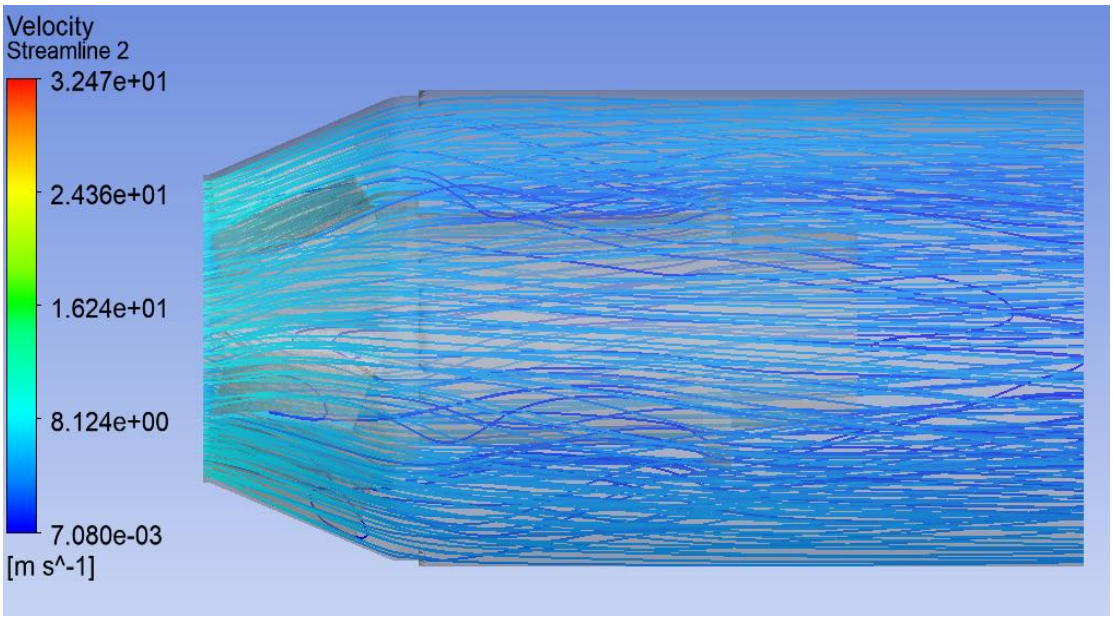

图 5.2（b）第二次分析导叶流线图

结论：第一次分析后导叶尾部有明显的漩涡，第二次分析后导叶尾部的漩涡消失，故扬程和效率都相应的进行了提升。

Technical department

CFD Hydraulic Performance Analysis Report of Pump

900QZ-160

1.Design Specification

900QZ-160 Design parameters are shown in the following table.

Table 1.1 Design data

Flow(m^3/s)	Head(m)	Speed(rpm)	Shaft power(kW)	Efficiency(%)
3.02	2	490	80.1	74
3.2	1.2		56.6	66.5

The constants and basic physical properties of the pumping medium used in the design and calculation analysis are shown in the table below.

Table 1.2 Constants and basic physical properties of pumping medium

Acceleration of gravity g	Medium density	Dynamic viscosity
9.81 m/s^2	997 Kg/m^3	8.899×10-4 Pa·s

2.CFD calculative strategy

CFD calculation strategy is formulated in four aspects:

1) calculation domain; 2) Computing grid; 3) Boundary conditions; 4) Calculate Settings.

After repeated argumentation, the final scheme is as described below.

2.1 Calculation domain

In the hydraulic model development process, the calculation domain of the complete hydraulic model covers all the flow components from the inlet section to the outlet section, excluding the various seal gaps and the flow in the outer cavity of the cover plate. Along the flow direction, the calculation domains are successively the horn, impeller and guide vane. The following figure shows the final calculation domain.

Figure 2.1 Calculation domain

2.2 Calculation of grid

The calculation of grid has a crucial influence on the calculation results, and it is necessary to verify the grid independence and properly deal with the mesh density in the near-wall region to satisfy the requirements of the turbulence model.

This calculation grid adopts body-fitted mesh. The flow channel grid of the horn, impeller and guide vane is a hexahedral hybrid grid. In the impeller channel, the near-wall mesh is specially encrypted to better simulate the flow in the boundary layer and estimate the hydraulic efficiency. The approximate number of grids in each part is shown in the table below.

Table 2.2 Grid quantity

Position	**Total quantity**
Suction cone	500000
Impeller	800000
Guide vane	1200000

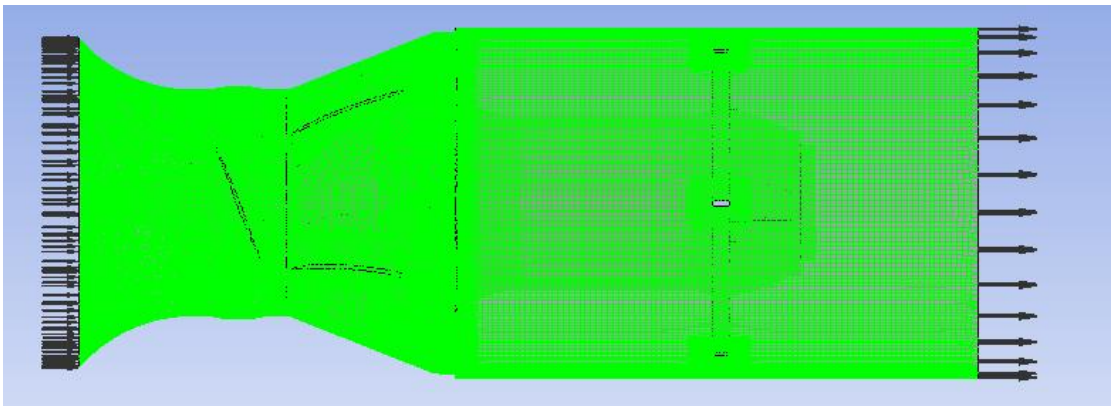

Figure 2.3

Compute Grid

2.3 Boundary conditions and Calculate settings

The fluid is an incompressible fluid, and all the overflow components are couply calculated. The connection relationship between different components is shown in the

following table.

Non-slip walls are used, and other major boundary conditions are set in the table below

Table 2.4 Main boundary conditions and computational domain coupling algorithms

Item	Parameters
Inlet	Total pressure
Outlet	Mass flow rate
Suction horn and impeller	Stage Interface (Constant Total Pressure)
Impeller and guide vane	Stage Interface (Constant Total Pressure)

The calculation is carried out by ANSYS CFX software, and the main calculation Settings are shown in the following table.

Table 2.5 Primary calculation Settings

Item	Parameters
Analysis type	Steady state
Turbulent model	The Baseline (BSL) k-omega Model
Wall function	Automatic
Numerical accuracy of convective term	High resolution (phase 2)
Numerical accuracy of turbulence term	High resolution（phase 2）

3. External characteristic analysis method

The calculation method of the pump's head, power and efficiency is：

Head $H = \dfrac{\left(\overline{P_{t\,out}} - \overline{P_{t\,in}}\right)}{\rho g}$

In formula，$\overline{P_{t\,out}}$，$\overline{P_{t\,in}}$ are the mass weighted average total pressure of the pump inlet and outlet respectively, which can be obtained by the following formula：

$$\overline{P_t} = \frac{\int_A p_t \rho \boldsymbol{v} \cdot \boldsymbol{n} dA}{\dot{m}}$$

Of Which $\dot{m} = \int_A \rho \boldsymbol{v} \cdot \boldsymbol{n} dA$

Power $P = P_P + P_{vis}$

The right side of the equation is the power exerted by pressure on the impeller, and the power exerted by viscous force on the impeller, and power is obtained by pressing the formula below：

$$P = M \cdot \omega$$

In formula，M is the torque of pressure or viscous force on the impeller rotation axis, ω is the impeller rotation angular speed.

Eff $\eta = \frac{\rho g Q H}{P} \times 100\%$

In formula，Q is the flow of the pump。

4 CFD performance prediction

4.1 External property results

To extract the external characteristics of the calculation model from the CFD calculation results, see the following table and the figure below.

Table 4.1 Design parameters

Flow (m³/s)	Head (m)	Speed (rpm)	Shaft power (kW)	Eff(%)
3.02	2	490	80.1	74
3.2	1.2		56.6	66.5

Table 4.2 CFD calculation parameters

Flow (m³/s)	Head (m)	Speed (rpm)	Shaft power (kW)
2.80	2.41	116.3	56.8
3.02	1.64	96.5	50.1
3.20	0.86	78.0	34.6
3.30	0.38	66.8	18.2

Performance curve

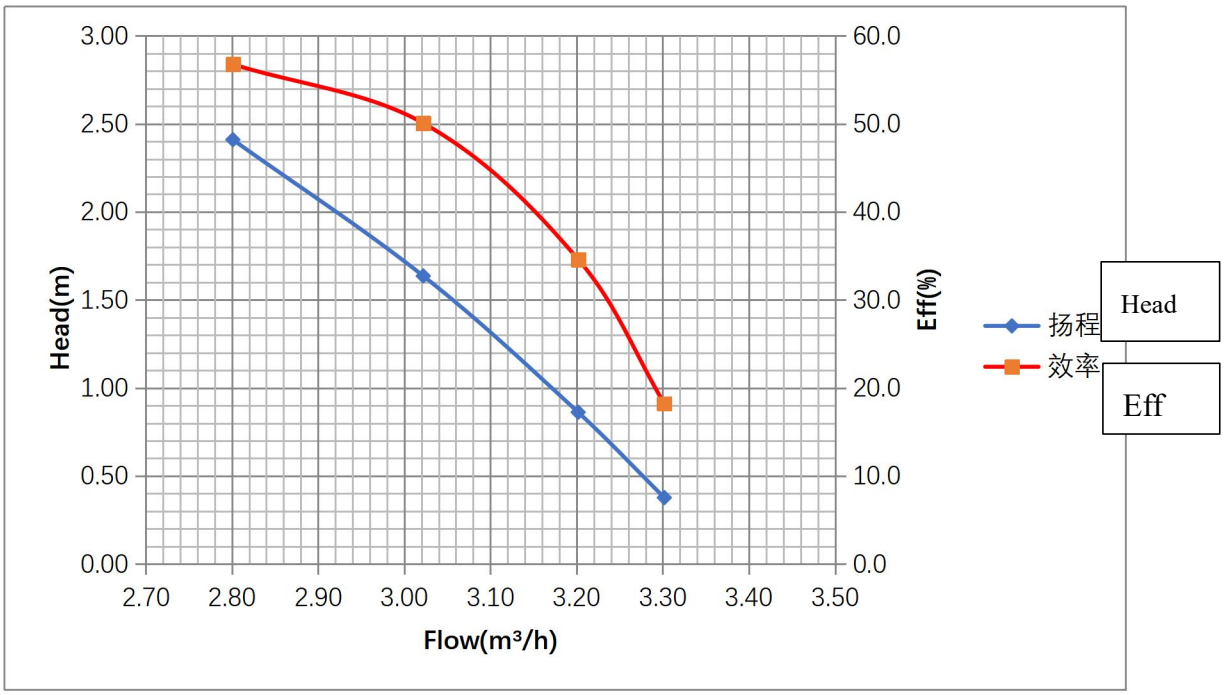

Figure 4.3 Flow rate-head / efficiency curve

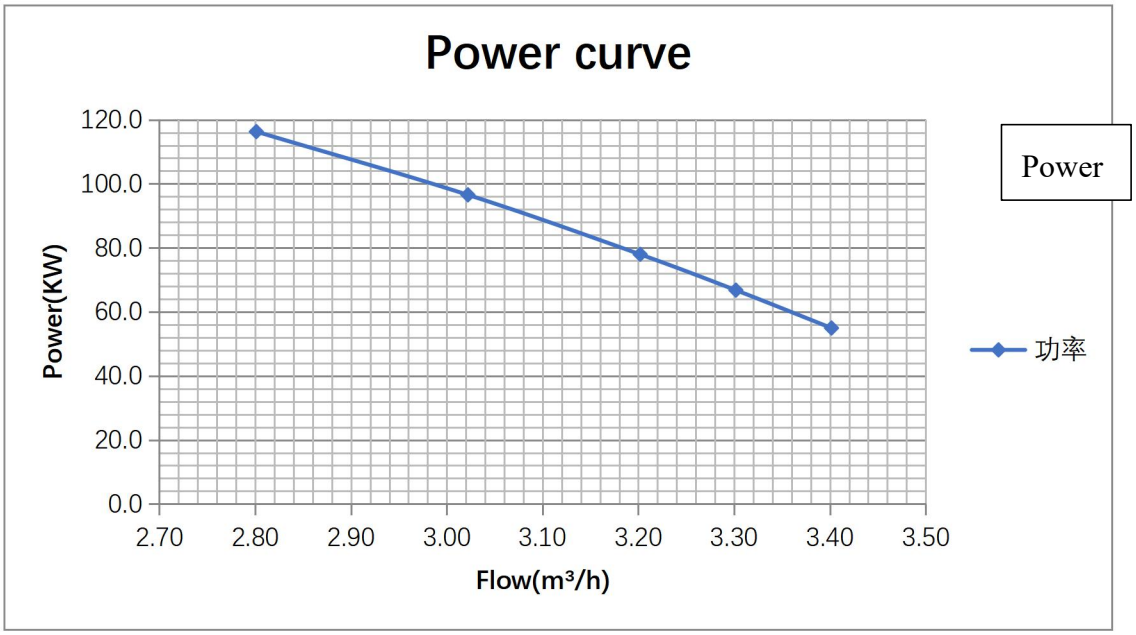

Figure 4.4 Flow-power curve

As can be seen from the above figure and table, the external calculated characteristic parameters of the calculation model do not meet the design requirements.

4.2 Cause analysis

After analysis of hydraulic model, we found that the head, efficiency, shaft power has deviation with design parameters. When flow is 3.2m3/s, head deviation is 28.3%, the problem may be in the analysis of the hydraulic model with a lot of stagnant water zone(as shown in figure 4.5 below). These areas of water cannot provide effective work, because stagnant water will digest finite work, leading to the head down a lot.

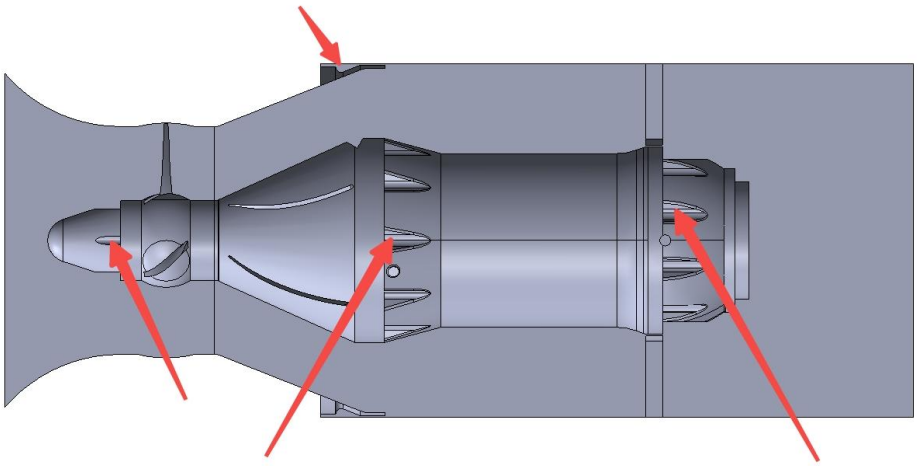

Figure 4.5 First analysis of the hydraulic model（red arrow points are stagnant water zones）

4.3 Comparative analysis

The lower head and lower efficiency above is caused by the stagnant water according to our analysis. After trying to remove the stagnant water, we analyzed it again for a comparison. The hydraulic model is shown in Figure 4.6.

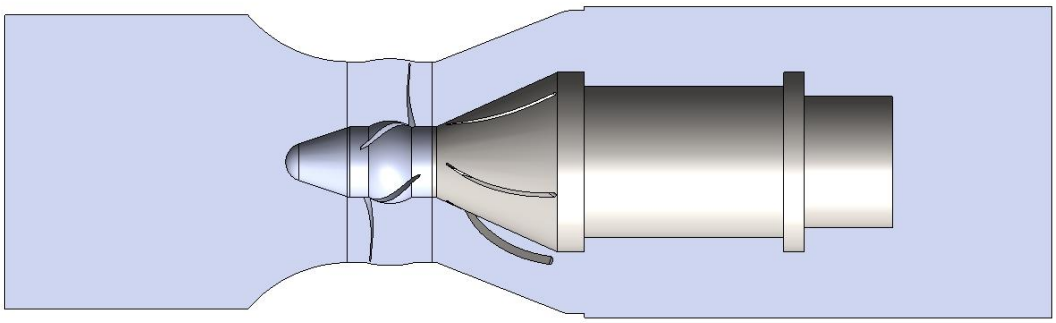

Figure 4.6 Second analysis of the hydraulic model without stagnant zones.

The calculations are shown below in Table 4.7 below.

Table 4.7 Results of the second analysis

Flow (m^3/s)	Head (m)	Speed (rpm)	Shaft power (kW)
2.80	2.91	108.2	73.6
3.02	2.09	88.3	69.9
3.20	1.23	69.7	55.3
3.30	0.68	58.0	37.7
3.40	0.12	45.7	8.6

Table 4.8 Results of the first analysis

Flow (m^3/s)	Head (m)	Speed (rpm)	Shaft power (kW)
2.80	2.41	116.3	56.8
3.02	1.64	96.5	50.1
3.20	0.86	78.0	34.6
3.30	0.38	66.8	18.2

After comparing results of the two analysis, we concluded that after removing the dead water area of the hydraulic model, the results calculated by CFD and the design parameters are basically the same, and the reason for the large head gap in the first analysis is the loss caused by the dead water area in the analysis model.

5 Internal flow field characteristics

Based on (velocity) framework, we show the internal flow field characteristics of the pump from multiple angles.

5.2 The velocity distribution

5.2.1 Space streamline

Figure 5.1 below shows the first analysis of the spatial streamline of the fluid in the impeller and the guide vane at the flow of 3.2m³/ s, which represents the spatial motion trajectory of the fluid.

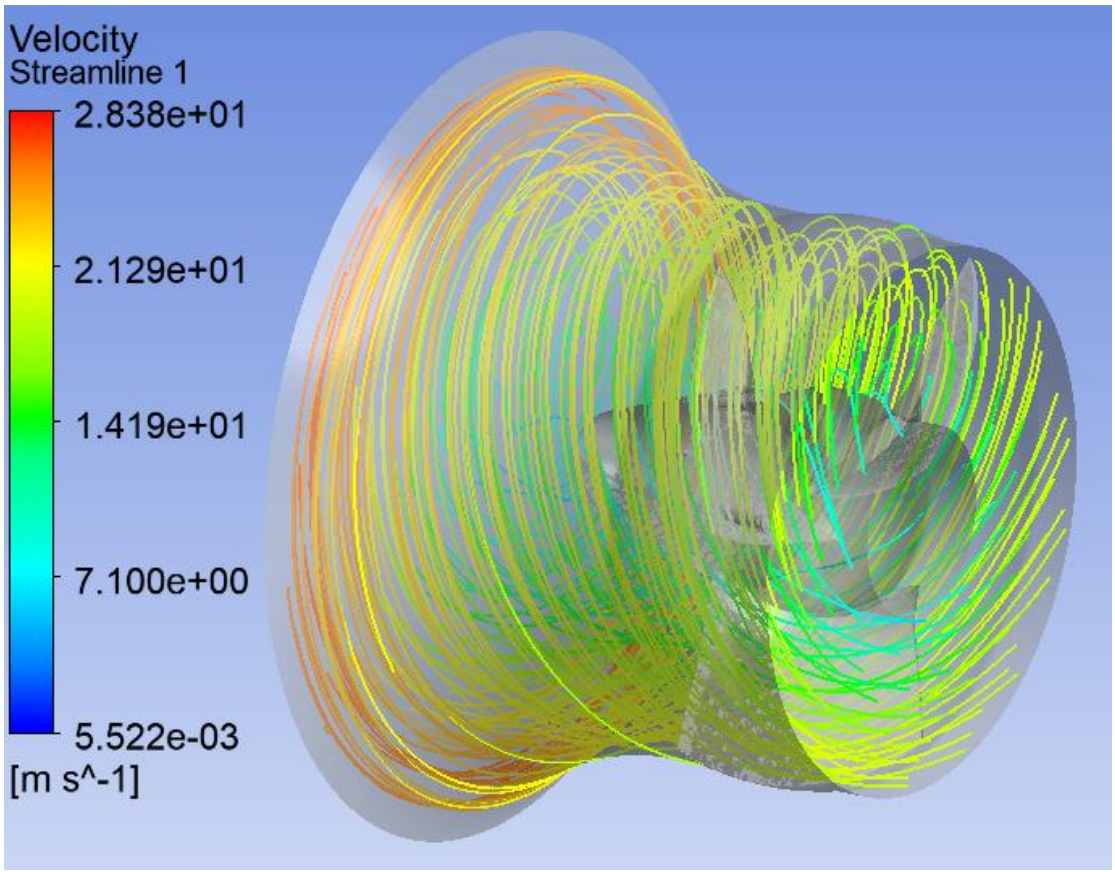

Figure5.1 (a) First analysis of impeller streamline

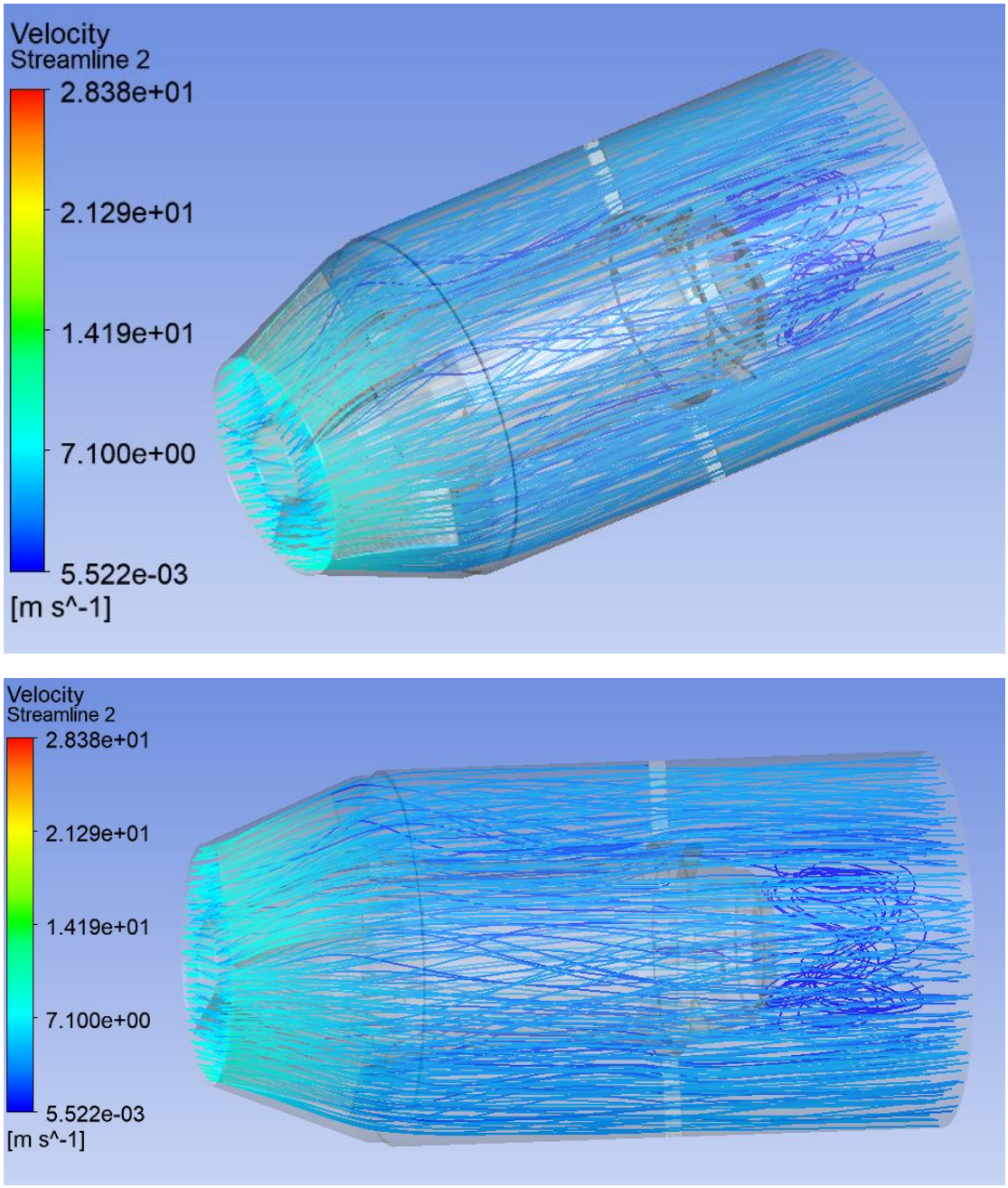

Figure5.2 (b) First analysis of Guide vane streamline

Conclusion: It is obvious that the tail of guide vane has an obvious vortex, resulting in the head and efficiency reduction.

Figure 5.2 below shows spatial streamline of the fluid in the impeller and guide vane at the flow of 3.2m³/ s, which represents the spatial trajectory of the fluid.

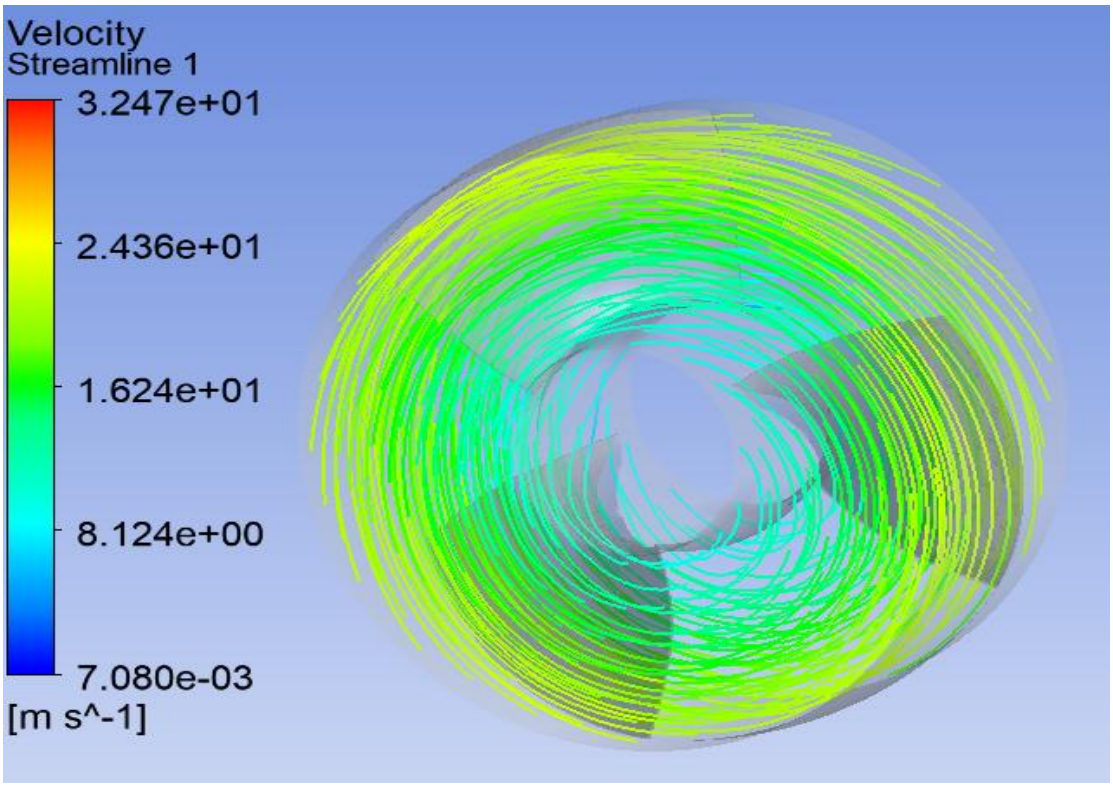

Figure5.2 (a) First analysis of impeller streamline

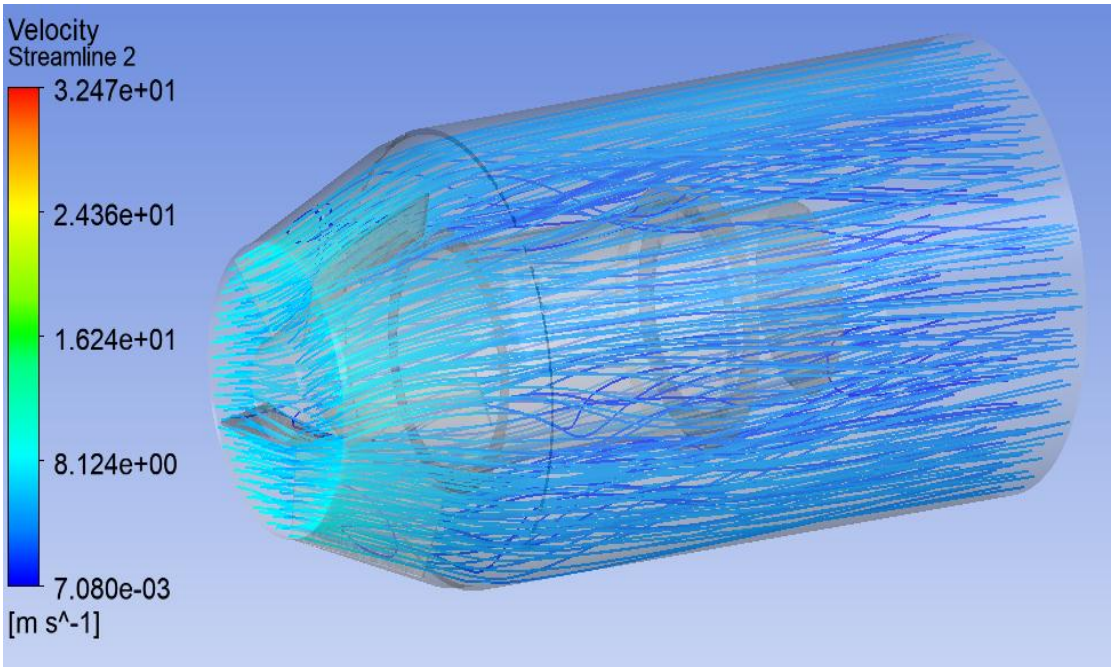

Figure5.2 (b) First analysis of Guide vane streamline

Conclusion: After the second analysis, vortex at the tail of the guide vane disappears so the head and efficiency are improved.