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Compromise Resource-Efficiency Curve for a Centrifugal Pump

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Abstract. This article discusses centrifugal pumps with half-open impellers. One of the two most important parameters of a centrifugal pump is its resource and efficiency. However, often the race for efficiency leads to such constructive solutions that help reduce the pump life and vice versa. The solution of such problems is attributed to multicriteria optimization, one of the methods of which is to build a trade-off curve. In this paper, this curve is constructed using the application of such methods as the LP-Tau search method. The variable parameters in this article are axial clearance and rotor speed.

1. Introduction

The main characteristics of centrifugal pumps, as well as many other mechanisms, include the resource and efficiency. Often, these are two competing parameters: increasing the first, the second has to sacrifice. There is a need to find a compromise solution [1-7], when at the selected value of one parameter, the second is maximum.

Such a task is completely non-trivial, given that many parameters have an impact on these characteristics. To concretize the solution to this problem we will consider the example of a low flow centrifugal pump with a switching valve, which is used in the thermal control system on the ISS.

The resource and efficiency of such a pump, among other parameters, are significantly influenced by the axial clearance [8-12] between the impeller and the housing of the outlet and the frequency of rotation of the pump rotor. Determining the final dependence causes some difficulties, since both criteria are weighty and it is not possible to determine weight coefficients for them. Therefore, it was decided to use LP-Tau search, since this method does not imply an exact definition of the objective function.

It should be noted that the currently existing methods of finding a compromise between resource and efficiency [13-18] are oriented towards small rotational speeds of the pump shaft, which creates large errors in the calculation of the high-speed low-flow pump from them.

2. Getting a compromise curve

The LP-Tau search generates points in a quasi-random manner in the specified interval for two parameters. For the above pump, the axial clearance “a” can vary from 0.5 to 1.5 mm, the rotor speed “n” from 3000 to 8000 rpm (figure 1). Then the field of the generated operating points will be a rectangle.

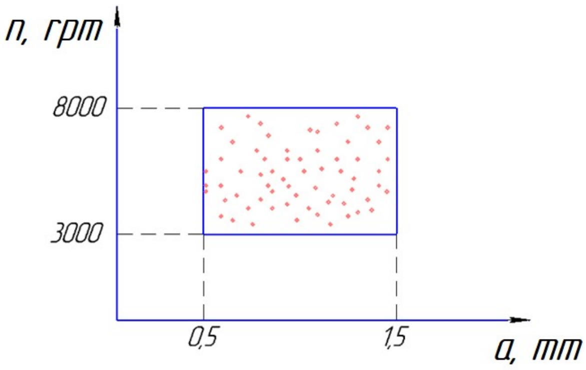

Figure 1. Point generation area.

The calculated points obtained using LP-Tau search are tabulated (table 1).

Table 1. LP-Tau search data points.

Number of point	*a*, mm	*n*, rpm
1	1	5500
2	0.75	6750
3	1.25	4250
4	0.625	6125
5	1.125	3625
6	0.875	4875
7	1.375	7375
8	0.5625	7687.5
9	1.0625	5187.5
10	0.8125	3937.5
11	1.3125	6437.5
12	0.6875	4562.5
13	1.1875	7062.5
14	0.9375	5812.5
15	1.4375	3312.5
16	0.53125	5656.25
17	1.03125	3156.25
18	0.78125	4406.25
19	1.28125	6906.25
20	0.65625	3781.25
21	1.15625	6281.25
22	0.90625	7531.25
23	1.40625	5031.25
24	0.59375	5343.75
25	1.09375	7843.75
26	0.84375	6593.75
27	1.34375	4093.75
28	0.71875	7218.75
29	1.21875	4718.75

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Number of point	*a*, mm	*n*, rpm
30	0.96875	3468.75
31	1.46875	5968.75
32	0.515625	6984.375
33	1.015625	4484.375
34	0.765625	3234.375
35	1.265625	5734.375
36	0.640625	5109.375
37	1.140625	7609.375
38	0.890625	6359.375
39	1.390625	3859.375
40	0.578125	4171.875
41	1.078125	6671.875
42	0.828125	7921.875
43	1.328125	5421.875
44	0.703125	6046.875
45	1.203125	3546.875
46	0.953125	4796.875
47	1.453125	7296.875
48	0.56875	4328.125
49	1.046875	6828.125
50	0.796875	5578.125
51	1.296875	3078.125
52	0.671875	7453.125
53	1.171875	4953.125
54	0.921875	3703.125
55	1.421875	6203.125
56	0.609375	6515.625
57	1.109375	4015.625
58	0.859375	5265.625
59	1.359375	7765.625
60	0.734375	3390.625
61	1.234375	5890.625
62	0.984375	7140.625
63	1.484375	4640.625
64	0.5078125	6320.125

Each point corresponds to certain values of the resource and efficiency, which can be obtained from the relations in [3]. After calculations, it is possible to construct the distribution of all calculated points in the coordinates $T(\eta)$ (figure 2).

For this distribution, we build a compromise curve for the following reasons: for the same value of one parameter, the point with the highest value of the second is considered to be the “winning”. From this it is clear that the compromise curve must pass through these “winning” points (figure 3).

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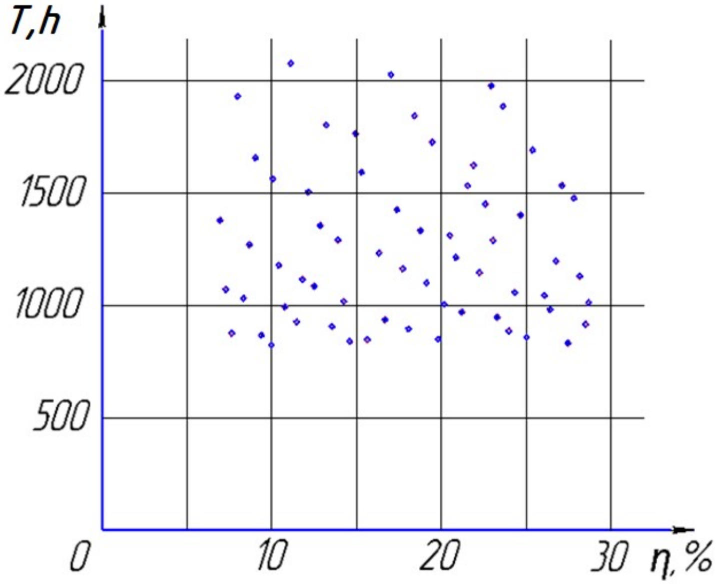

Figure 2. Distribution of calculated points.

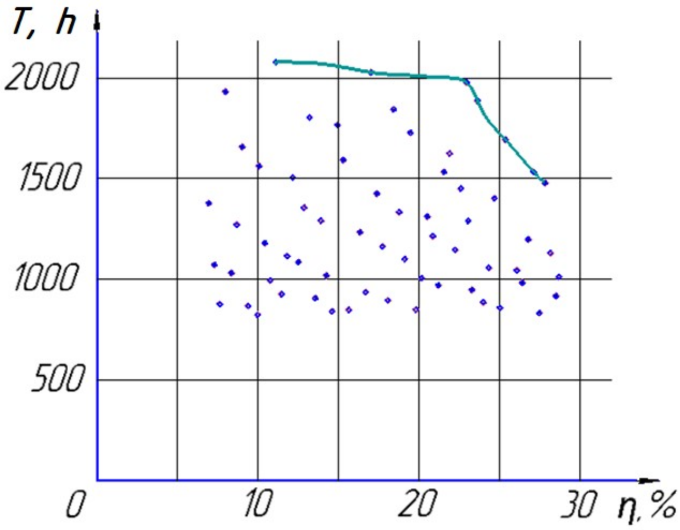

Figure 3. Compromise curve.

3. Conclusion

The use of LP-Tau sequence for finding a compromise between resource and efficiency when varying the rotor speed and axial clearance by an effective method. This is clearly seen from the obtained compromise curve - when considering 64 points of the LP-tau sequence, 7 of them entered the Pareto set and formed a compromise curve. Thus, the above method can be recommended when calculating high-speed centrifugal pumps.

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