Modeling the Equipment Shape of the Technological Flow of the Waste Water Treatment Station

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Abstract: *In order to choose the optimal shape of a device, in our case, of a centrifugal pump from the technological flow of a sewage treatment plant, we must find the optimal geometry of it that leads us to an energy efficiency, implicitly the operational cost. For this, we considered two pumps, one normal centrifuge and another with retractable rotor. After normal operating, it can be concluded that retractable rotor pumps have an 80% efficiency compared to normal 77%. Therefore, efficient running costs are lower for retractable rotor pumps, making them even more productive.*

Keywords: *Pump, optimal shape, flow, sewage treatment plant, energy, efficiency, cost.*

1. Introduction

There are 122 energy consumers in the Constanţa-Nord wastewater treatment plant, most of them from the mechanical stage. The intake pumps have an installed power of 20,626% of the total installed power and an energy consumption of 14,317%. The difference in consumption is due to the fact that during operation, many equipment have interruptions for various maintenance reasons, or some have a discontinuous flow. In the process of waste water treatment in the station, the highest installed power is on equipment, 61.399% and the consumed energy is 64.826% [1],[2]. The biggest consumers are: turbochargers, centrifugal intake pumps and centrifuges.
Analysing these consumptions, we propose as a variant: optimization of the geometry of the rotor of the centrifugal intake pumps by modeling the flow in the program ANSYS FLUENT v.13.0.
We propose to analyse the flow optimization through a centrifugal pump other than the one existing on the technological flow in a city wastewater treatment plant, given the high energy consumption on the inlet centrifugal pump group.

In this context, there is an acute need for an efficient energy consumption analysis of equipment and processes (Table 1) in order to optimize it [3], [4].

Table 1: Equipment distribution on processes

Stage/Power/Energy	Equipment consumption quota	
	$P_{installed}/P_{installed\ total}$	$E_{installed}/E_{installed\ total}$
Mechanical stage P=768.83 [kW] E=4132112 [kWh]	25.372	20.815
Biological stage P=1924.68 [kW] E=13704521.4 [kWh]	63.516	69.035
The sludge treatment stage P=325.86 [kW] E=2012168 [kWh]	10.754	10.136
TOTAL P=301937 [kW] E=19848771.8 [kWh]	99.642	9.986

2. Method and research

We offer two types of pumps for analysis: Grundfos with normal rotor for wastewater [4] and FLYGT rotor [4] wastewater pump with automatic rotor lifting when encountering large aspiration obstacles. This FLYGT rotor design is the ideal solution for pumps in terms of lasting efficiency. At the same time, this means low energy consumption and therefore low operating costs [5]. Grundfos pumps are heavier and bulkier than FLYGT pumps if we want to have the same flow. FLYGT multi-blade rotary pumps are designed for optimum hydraulic efficiency.

2.1 Method

The method used is the finite volume method.

2.2 Model used for pump rotor modeling

The model is the turbulent k-ω RANS (Reynolds-Medie-Navier-Stokes) model.

2.3. Analysed fluid

Analysed fluid is urban network wastewater.

2.4. Initial hypothesis

We choose the same constructive form for both pumps and make mesh geometries. We make the discrepancies of the domains: for the Grundfos pump - the number of finite elements of meshing 142952 tetrahedra with 28551 nodes (Fig.1), for the FLYGT pump, the number of finite elements: 113854 tetrahedra with 24328 nodes (Fig.2).

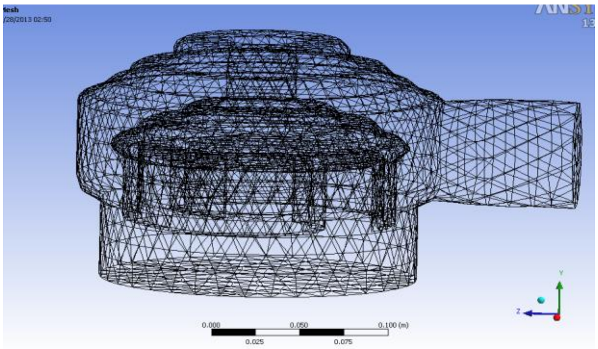

Fig. 1. Grundfos pump range discrepancy

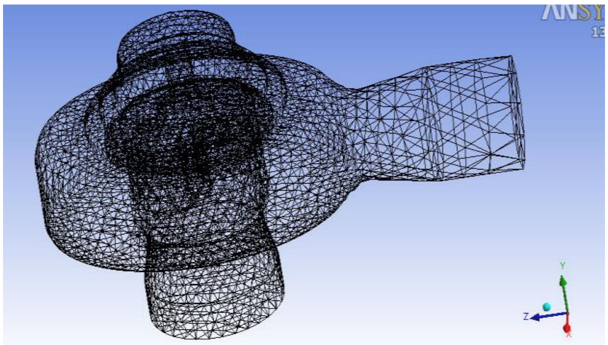

Fig. 2. FLYGT pump range discrepancy

3. Research results

At the Constanta-Nord wastewater treatment plant, there is the intake pump station, where 5 centrifugal FLYGT pumps, T type CP3400 (4 in operation, 1 in stand-by), with a capacity of 0.5 ... 0.6 [m^3 / s] each. We chose the pump capacity of 0.5 [m^3 / s] for flow modeling. We determine the velocity distribution (Figures 3, 4, 5, 6) and total pressures (Figures 7, 8, 9, 10).

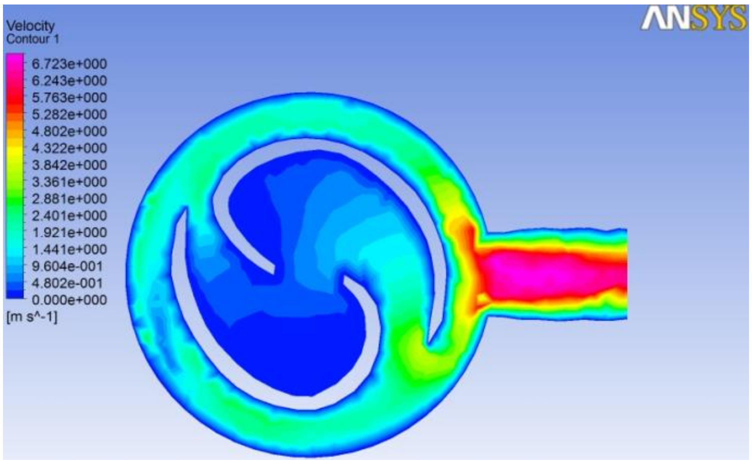

Fig. 3. Velocities distribution (horizontal component) for the Grundfos pump

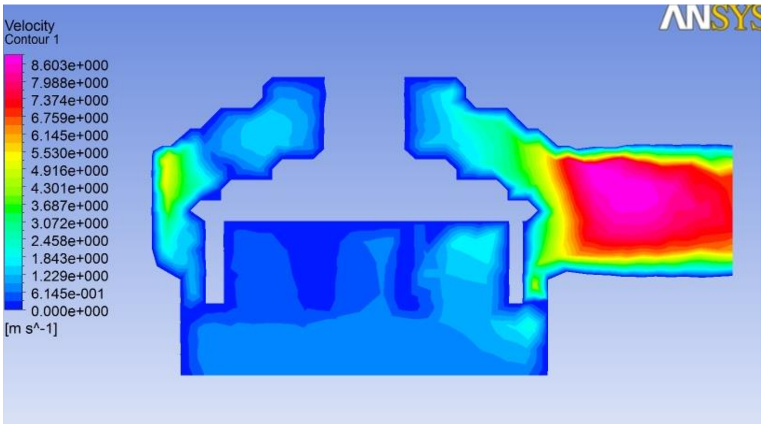

Fig. 4. Velocities distribution (vertical component) for the Grundfos pump

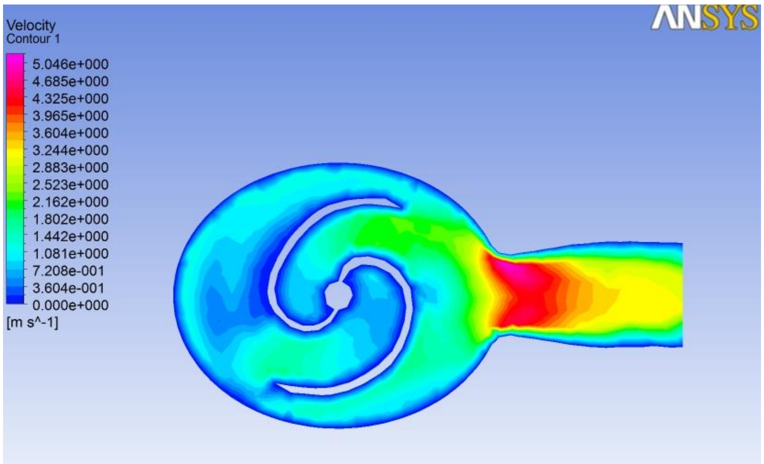

Fig. 5. Velocities distribution (horizontal component) for the FLYGT pump

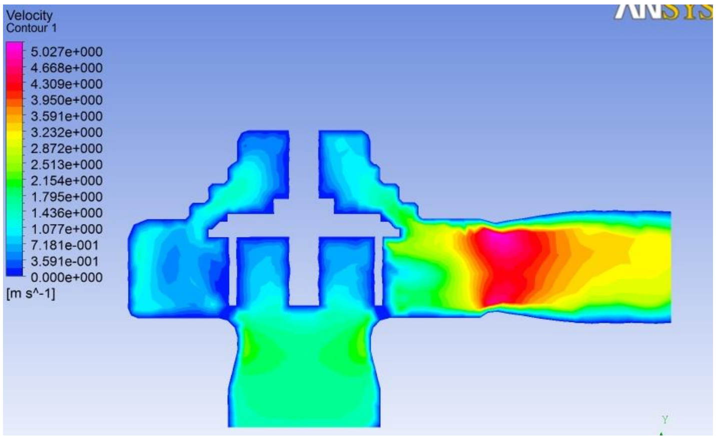

Fig. 6. Velocities distribution (vertical component) for the FLYGT pump

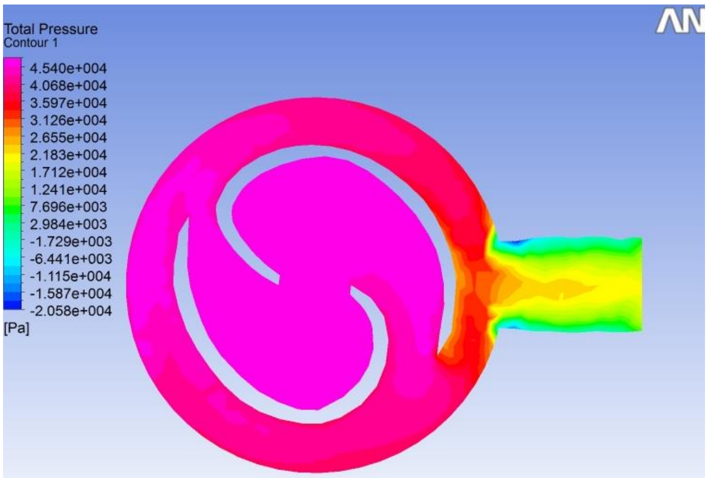

Fig. 7. Total pressure distribution (horizontal component) for the Grundfos pump

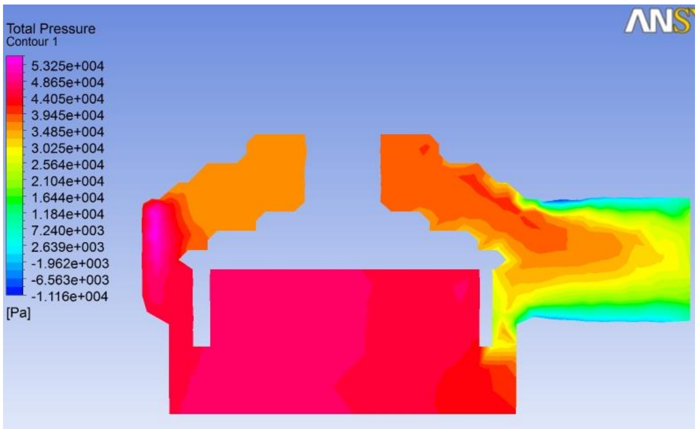

Fig. 8. Total pressure distribution (vertical component) for the Grundfos pump

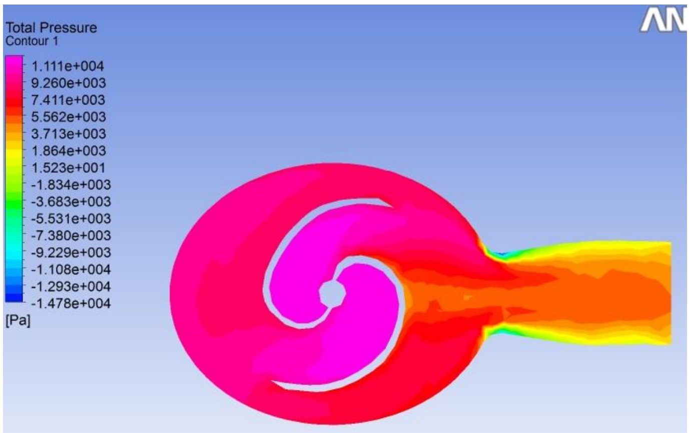

Fig. 9. Total pressure distribution (horizontal component) for the FLYGT pump

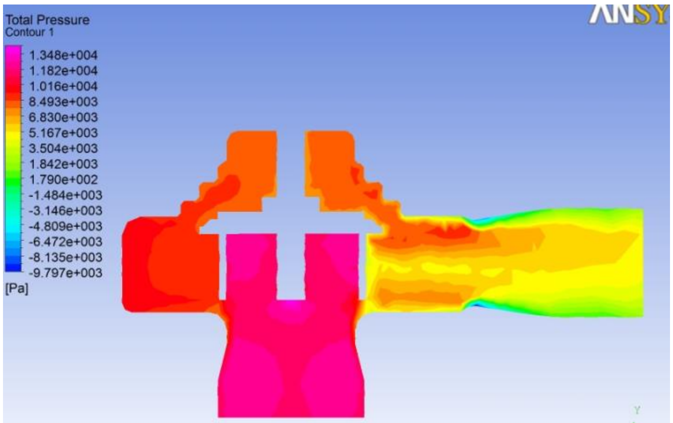

Fig. 10. Total pressure distribution (vertical component) for the FLYGT pump

Analyzing the current and speed potential functions, we choose the optimum form for the two rotors (Fig. 11, Fig. 12), in order to make energy consumption more efficient, so the operational cost [1], [4], [5], [6]. The optimal shape of the rotor is that of the FLYGT pump geometry.

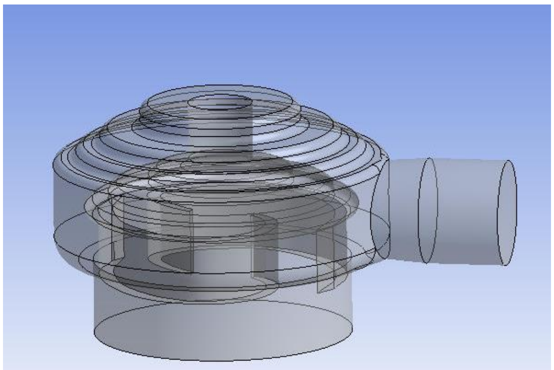

Fig. 11. The geometry of Grundfos rotor

For FLYGT pumps, both the housing and the rotor configuration allow self-cleaning of the pump. This reduces the pump stop times. Also, maintenance teams are no longer required to unlock / clean up.

Based on the ANSYS programming environment, pump load losses are determined, resulting in loss of yield. Finally, the yield of each variant is determined.

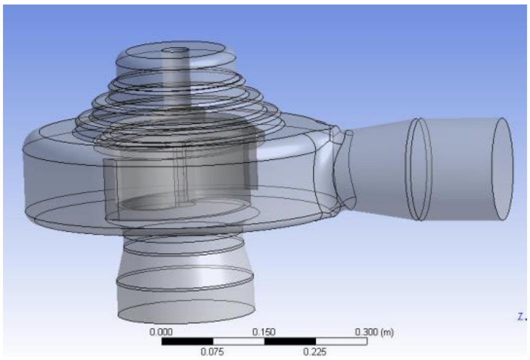

Fig. 12. The geometry of FLYGT rotor

The FLYGT pump greatly reduces energy costs. If we compare our existing Grundfos system with the FLYGT pump system and make a comparison for the two alternatives we have used [1], we get (Table 2):

Table 2: Compare Grundfos-FLYGT efficiency

Type of equipment	Alternative 1	Alternative 2
Pump	FLYGT	Grundfos
Efficiency	80 %	77%
Price	273 000	246 000

The yield difference obtained is relatively small, of 3 [%]. There are five pumps of this type, out of which 4 work normally and the fifth is stand-by. The power of the electric motor is 125 [kW]. The average daily running time of these pumps, as provided by SCADA equipment of the SEAU Constanta-North, is as shown in Table 3 and the daily energy consumption is 2775 [kWh / day] [1]:

Table 3: The correlation between average time and energy consumption

Element of analysis	Average running time [hours]	Daily energy consumption [kWh]
Intake Pump 1	3.5	437.5
Intake Pump 2	7	875
Intake Pump 3	8	1000
Intake Pump 4	3.5	437.5
Intake Pump 5	0.2	25

In conclusion, the pump cleaning procedure is costly and justifies the use of the pump in the variant FLYGT [3].

4. Conclusions

The optimal shape of the rotor is that of the FLYGT pump geometry. The FLYGT pump greatly reduces energy costs. In terms of costs, the highest cost in total costs is the running costs. Almost 2/3 of the total costs are operating costs, which implies the importance of minimizing them. Effective running costs are FLYGT pumps.

With regard to operating costs, because the station is equipped with a reserve pump, the blocking of one of the 4 pumps at work will not affect the normal development of the technological process from a qualitative point of view. Once one of the pumps is blocked, it is necessary to intervene the operating team, which implies increasing operating costs. The highest cost of all costs is running costs.

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