MECHANIKA
CZASOPISMO TECHNICZNE
TECHNICAL TRANSACTIONS
MECHANICS
WYDAWNICTWO POLITECHNIKI KRAKOWSKIEJ
4-M/2011
ZESZYT 7
ROK 108
ISSUE 7
YEAR 108

HASSAN MOMENI*, EDWARD LISOWSKI**

CFD MODELLING AND RAPID PROTOTYPING OF LIQUID JET PUMP

MODELOWANIE CFD ORAZ RAPID PROTOTYPING POMPY STRUMIENIOWEJ

A b s t r a c t

This paper presents using Rapid Prototyping and CFD tools in modeling Liquid Jet Liquid pump. Prototype of LJL pump was made with FDM technology and was prepared to install measurement equipment and to perform experimental tests. Than results of test will be used to validate CFD model of LJL pump in order to design pump with required specification.

Keywords: *LJL pump*, *CFD simulation*, *Rapid Prototyping*

S t r e s z c z e n i e

W artykule przedstawiono metodę modelowania i projektowania pomp strumieniowych z wykorzystaniem narzędzi CFD oraz technologii szybkiego prototypowania. Wykonany w technologii FDM prototyp pompy przygotowano do zainstalowania aparatury pomiarowej i prowadzenia badań doświadczalnych.

Słowa kluczowe: *pompa strumienicowa*, *analiza CFD*, *szybkie prototypowanie*

---

* MSc. Hassan Momeni, Faculty of Mechanical and Marine Engineering, Bergen University College.
** Prof. PhD. Eng. Edward Lisowski, Institute of Applied Informatics, Faculty of Mechanical Engineering, Cracow University of Technology.

1. Introduction

Jet pumps are class of pumping devices that can be used to transport aggressive fluids, rocks and even very fragile goods like food. One of the biggest advantageous of jet pumps is no moving parts and relatively simple structure while disadvantageous is slow efficiency ranging up to 40%. Despite its simplicity jet pumps are not easy object of modeling and more and more work is conducted on that field [1, 2, 3, 4]. It is due to the complex phenomena that occurring in jet pump during operation. Some of the work includes traditional approach of modeling jet pump with using lumped parameters models. There are also conducted work with the use numerical methods like CFD [1, 2].

Presented work shows a new way of modeling jet pump with using numerical methods like CFD as well as Rapid Prototyping technology. Both methods were applied to two stage Liquid Jet Liquid pump with 50mm diameter of pump inlet. Prepared CAD model of LJL pump was printed using FDM technology. Prepared prototype is ready to install measurement equipment and to conducting tests. Simultaneously a CFD model was prepared and some initial simulation conducted. Results of the test might be later used to validate CFD model of the pump and finally to create design for pump with demanded specification.

2. Liquid Jest Liquid pump prototype

Liquid Jet Liquid pump prototype was prepared in Pro/Engineer package, and later on printed with FDM technology at Bergen University College. CAD model of prototype is shown in Fig. 1. The prototype consists of three components: A – with suction port (1), B – with circumferential drive nozzle (see Fig. 2.) of first stage and C with second stage and pump outlet (4).

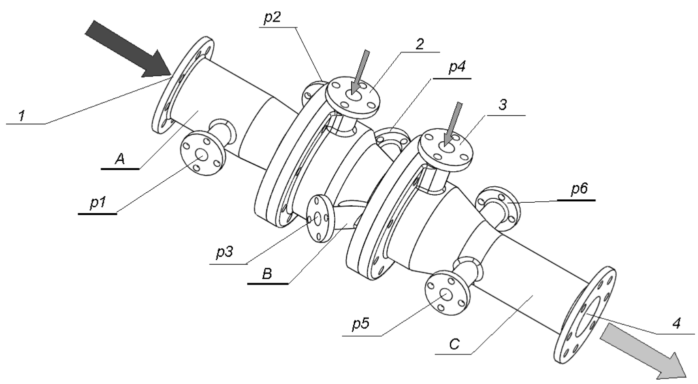

Fig. 1. Two stage LJL pump CAD model: 1- inlet port, 2 – inlet port of stage one motive fluid, 3 – inlet port of stage two of motive fluid, 4 – pump outlet, A, B, C – pump components, p1, p2, p3, p4, p5, p6 – ports for pressure transducers

Rys. 1. Model CAD dwustopniowej pompa strumieniowej: 1 – wlot pompy, 2 – wlot strumienia zasilającego pierwszego stopnia, 3 – wlot strumienia zasilającego drugiego stopnia, 4 – wylot pompy, A,B,C – części pompy, p1, p2, p3, p4, p5, p6 – przyłącza przetworników ciśnienia

All components are connected with the bolted flanges. Model of pump also includes measurement port for pressure transducers marked as: p1, p2, p3, p4, p5, p6.

The cross section of CAD model is presented in Fig. 2. As it can be noticed this is a two stage circumferential nozzle type jet pump.

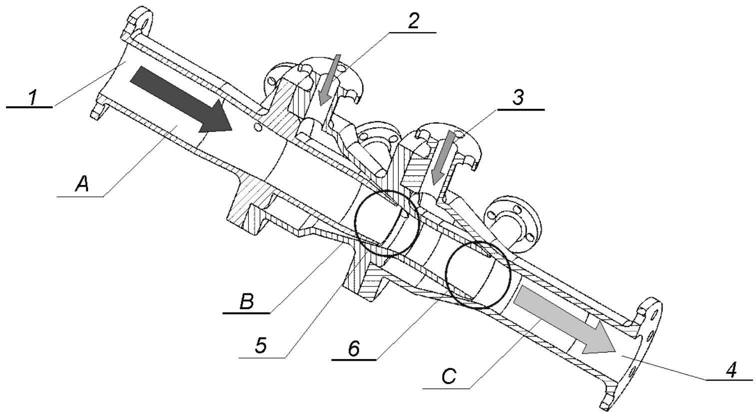

Fig. 2. Cross section of LJL pump: 1– inlet port, 2 – inlet port of stage one motive fluid, 3 – inlet port of stage two of motive fluid, 4 – pump outlet, 5 – nozzle of stage one, 6 – nozzle of stage two, A, B, C – pump components.
Rys. 2. Przekrój przez model pompy: 1 – wlot pompy, 2 – wlot strumienia zasilającego pierwszego stopnia, 3 – wlot strumienia zasilającego drugiego stopnia, 4 – wylot pompy, 5 – dysza stopnia pierwszego, 6 – dysza stopnia drugiego, A, B, C – części pompy, p1, p2, p3, p4, p5, p6 – przyłącza przetworników ciśnienia

Prepared CAD model was next printed using FDM technology and the prototype is presented in Fig. 3.

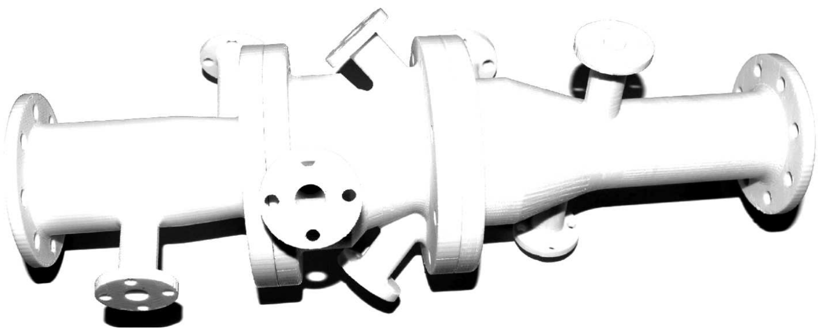

Fig. 3. Two stage LJL pump prototype
Rys. 3. Prototyp dwustopniowej pompy strumienicowej

3. CFD simulation

CAD model of prepared prototype was also used to prepare CFD model of the pump. CFD model was prepared using ANSYS CFX package. Grid for model is presented in Fig. 4. The CFD model is a copy of prototype even with ports for pressure transducers. The discrete model was prepared with the use of hybrid grid (tetrahedral and prism layers close to the walls).

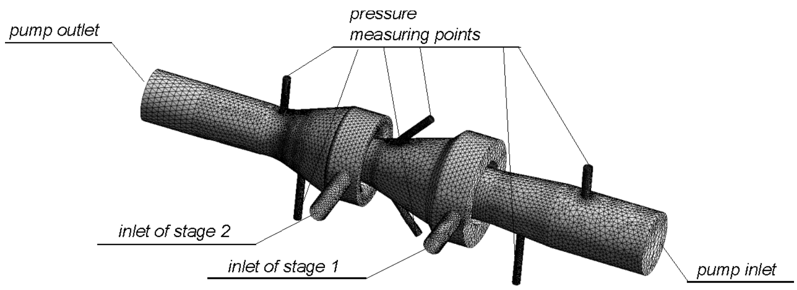

Fig. 4. Hybrid grid of jet pump
Rys. 4. Hybrydowa siatka modelu pompy

CFD simulation was performed in ANSYS CFX code. It was conducted for steady state conditions, with water as a medium, standard wall conditions, k-ε turbulence model and without heat transfer with environment and between driven and drive streams. CFD simulations was conducted for various operating conditions: with various flow rate and with operating only first stage or both simultaneously. Performed CFD simulations allowed to capture flow phenomena inside pump during operation. Also allowed to observe the flow of primary and secondary fluid inside the pump what is shown in Fig. 5.

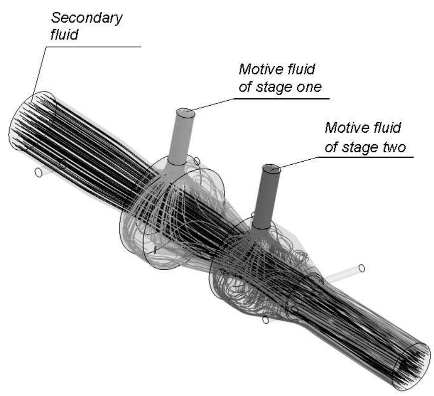

Fig. 5. Pathlines for motive fluids and secondary fluid (in case both stages operate)
Rys. 5. Linie prądu strumieni zasilających oraz strumienia cieczy zasysanej

Vectors of fluids velocity is presented on below picture. This corresponds to the case when both stages operates and both are supplied with fluid with flow rate 50 l/min.

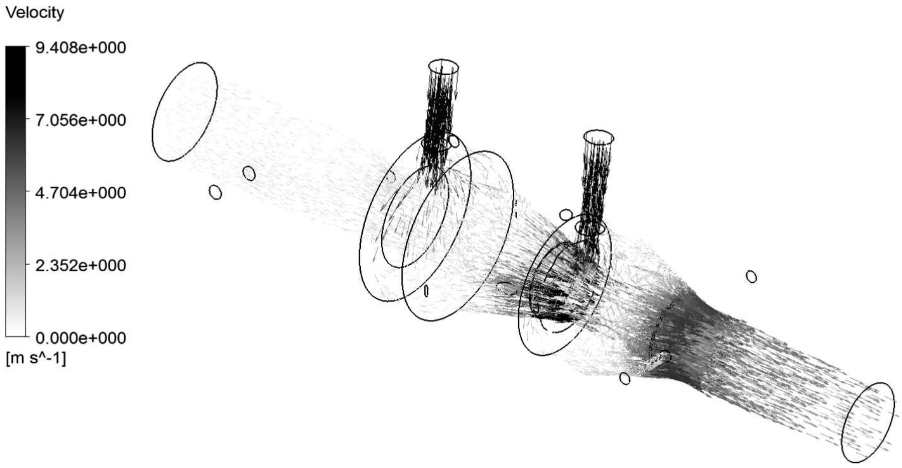

Fig. 6. Velocity vectors for motive fluids and secondary fluid (in case both stages operate)
Rys. 6. Wektory prędkości dla strumieni głównych obu stopni oraz strumienia cieczy zasysanej

CFD model was prepared in the way allowing to record pressure at area where pressure transducers will be installed. Fig. 7 presents distribution of static pressure while Table 1 shows pressure values for selected operating conditions.

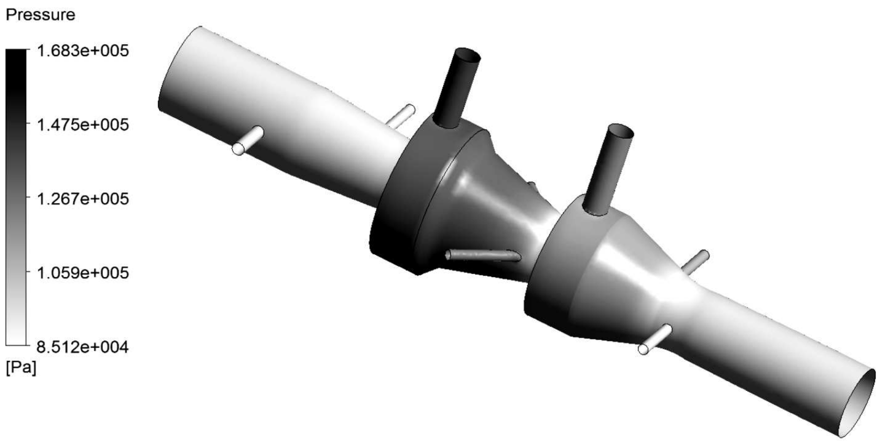

Fig. 7. Pressure distributions
Rys. 7. Rozkład ciśnienia statycznego

Table 1

Pressure values in measuring points

Flow rate [l/min]				Pressure [Pa]			
Stage one	Stage two	P1	P2	P3	P4	P5	P6
50	50	99 452.3	99 158.5	128 700	126 482	115 077	98 446.7
25	25	99 870.1	99 801.9	107 316	106 877	99 662.5	103 918
25	0	99 833.3	99 744.6	107 185	106 725	100 106	99 828.4

4. Condusions

This paper presents modeling of LJL pump with the use of CFD tools and Rapid Prototyping technology. CFD simulation conducted in Ansys CFX code was aimed at obtaining information about pressure and velocity distribution during pump operation. The prototype that was printed with the use of FDM technology will be used to validate CFD model. Experimental test on printed prototype might be used for validating CFD model and will show guidelines to design new type of LJL pumps.

References

[1] Narabayashi T., Yamazaki Y., Kobayashi H., Shakouchi T., *Flow Analysis for Single and Multi-Nozzle Jet Pump*, JSME International Journal Series B, Vol. 49, No. 4, 2006, 933-940.

[2] Fan J., Eves J., Thompson H.M., Toropov V.V., Kapur N., Copley D., Mincher A., *Computational fluid dynamic analysis and design optimization of jet pumps*, Computers & Fluids, Elsevier 2010.

[3] Levy A., Jelinek M., Borde I., *Numerical study on the design parameters of a jet ejector for absorption systems*, Applied Energy 72, 2002, 467-478.

[4] Xu L., Deng H., Ma W., *Numerical Analysis for Solid-liquid Two-phase FlowField of Draining-sand Jet Pump*, Proceedings of the IEEE International Conference on Mechatronics and Automation, 2009.