International Journal of Applied Sciences and Smart Technologies

Volume 5, Issue 2, pages 355–364

p-ISSN 2655-8564, e-ISSN 2685-9432

Analysis of Spiral Pump Discharge Based on Simulation of Fluid Flow in Hoses

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(Received 02-11-2023; Revised 05-11-2023; Accepted 16-11-2023)

Abstract

One of the uses renewable energy is the use of a spiral pump with a water wheel as the driving force. Spiral pumps are classified as environmentally friendly technology because they do not require electricity or fuel. The spiral pump consists of two main parts, namely the water wheel and the hose that is wrapped around both sides of the water wheel. The aim of this research is to analyze the water discharge of a spiral pump based on fluid flow simulation in the hose. This research utilizes advances in computational fluid dynamic (CFD) simulation methods using software. The determination method proposed in this research has been applied to a waterwheel model with a diameter of 1.2 m and a width of 0.6 m. For hoses, diameters of ½, ¾, 1, 1½, and 2 inches are determined, while the river flow speed is 0.9 m/s. For a hose diameter of 2 inches, the initial flow velocity in the hose is 0.38 m/s and the final velocity at the hose outlet is 0.452 m/s. The largest pump discharge was obtained at a hose diameter of 2.0 inches, namely 0.00183 m^3/s.

Keywords: spiral pump, water discharge, fluid flow, CFD

1 Introduction

Water is a basic need for living creatures, so the water supply is something that must always be available so that the survival of living creatures is to be maintained. However, during the dry season, farmers in rural areas struggle to obtain sufficient water for irrigating their fields. Although rivers are the primary source of water, the location of these water bodies, which are typically far from the rice fields and situated at a lower altitude, poses a significant challenge.

To extract water from rivers, power is required and most farmers utilise mechanical pumps as the power source for this task. However, the community's limited financial resources are an obstacle for people who want to use mechanical pumps because electricity or fuel is needed to operate the pump.

Therefore, renewable energy is needed that will not burden the community in terms of funding. In several places, renewable energy has been applied using solar panels as a source of electricity to operate mechanical pumps, but it is not yet efficient because the costs of purchasing, operating and maintaining solar panels are still relatively large.

Another use of renewable energy is the use of a spiral pump which was first made by H. A Wirtz in 1746 [1]. At that time, he used horsepower to drive the pump. The discovery was buried for about 240 years. Then it was picked up again and developed by Peter Morgan as an environmentally friendly technology with a water wheel replacing horse power as a pump driver. The use of spiral pumps can help the community, especially in the agricultural sector because spiral pumps do not require electricity and fuel.

The spiral pump comprises two primary components, namely the water wheel and the hose, which is coiled around the water wheel on both sides. The capacity of the spiral pump will be greatly influenced by the flow of fluid in the hose [2,3]. In this regard, it is unfortunate that no researcher has yet focused on the phenomenon of fluid flow in hoses and how it affects the capacity of spiral pumps. A search of literature shows that the researchers immediately built a model of spiral pump and then tested it in a river or in their laboratory [4-8]. Therefore, the relationship between the fluid flow in the hose and the water discharge of the spiral pump is still not clear [9-11]. Therefore, it is necessary to conduct research on the fluid flow in the hose of the spiral pump. This research aims to simulate fluid flow in a spiral pump hose and analyze the water discharge of a spiral pump based on fluid flow simulations in the hoses.

2 Methods

Figure 1 shows a flow diagram regarding outlining the capacity analysis of spiral pump through computer simulations proposed in this research. The model was created

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using computer aided design (CAD) software, while simulation utilized Computational Fluid Dynamics (CFD) software.

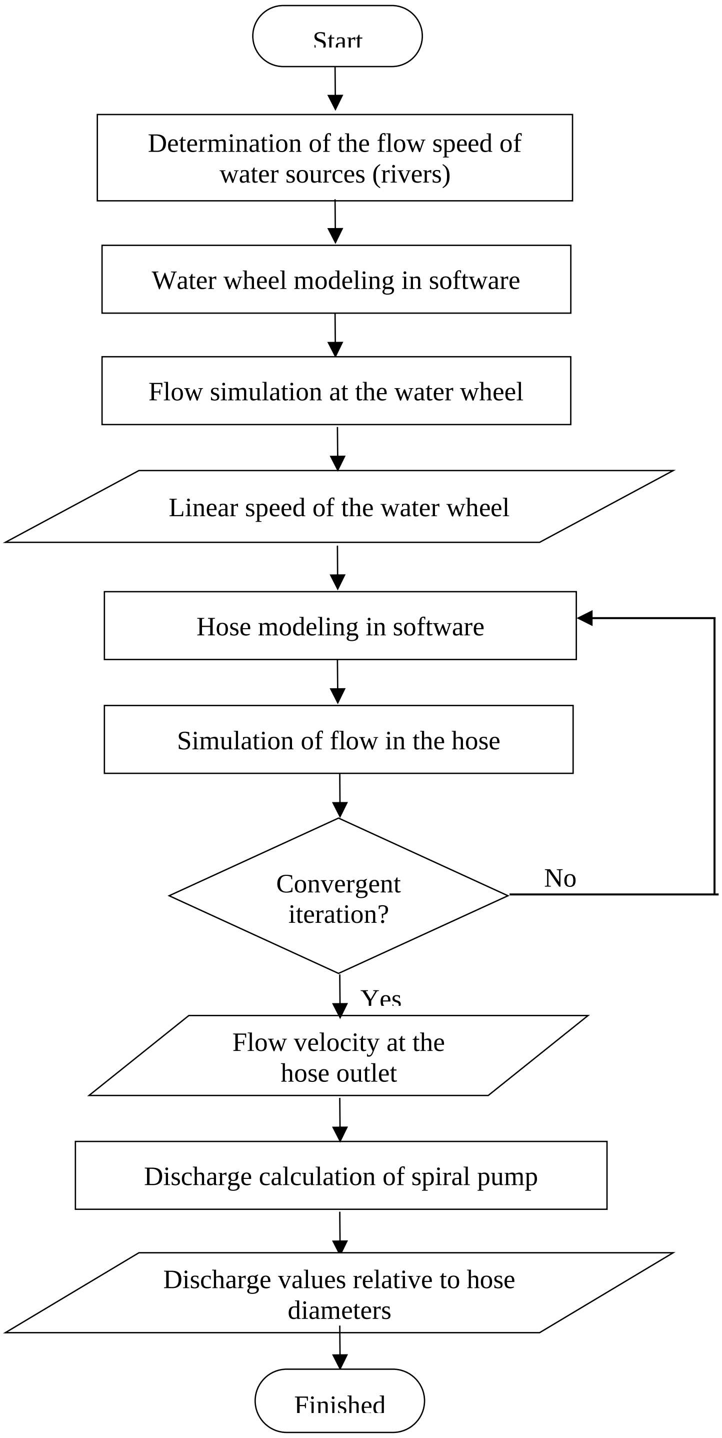

Figure 1. Flow diagram of spiral pump discharge determination

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Two simulations were conducted in this study; the first modelling fluid flow in a waterwheel, and the second is simulation fluid flow in a hose. The first simulation has two parts. The first produces the angular speed values of the water wheel, while the second produces the linear speed values of the water wheel. Next, the linier speeds are used as the initial flow velocity values in the hose during the second simulation.

The outcome of second simulation is the final flow velocity at the hose outlet corresponding to different hose diameter values. In the end, by using these simulation results, the water discharge values of the spiral pump can be determined.

3 Results and Discussions

3.1 Flow simulation at the water wheel

Figure 2 shows the results of water wheel modeling using CAD software. The diameter of the water wheel is 1.2 meters which has been adjusted to the depth of the river. The width of the wheel is 0.6 meters, while the mass of the wheel is 28.85 kg. For the wheel shaft, ASTM A36 steel is used. Steel alloy material for the wheel disc and wheel frame, while aluminum alloy is used for the pinwheel blade.

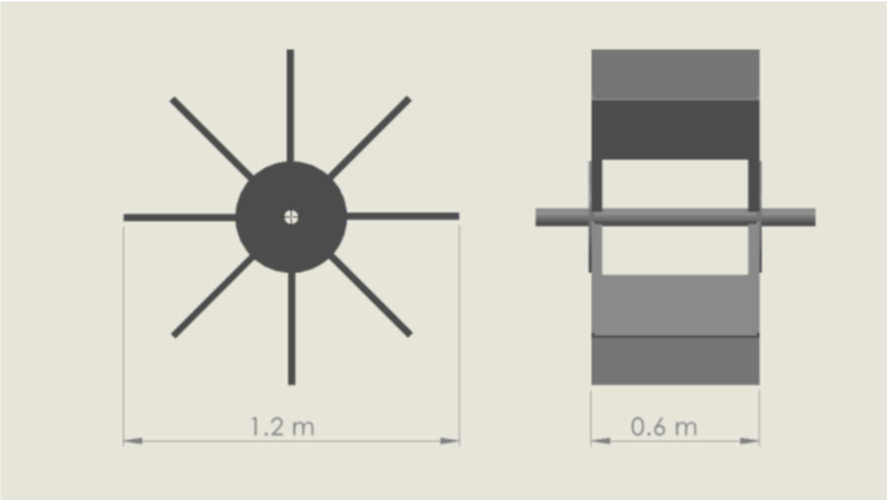

Figure 2. Water wheel model

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The first simulation is a flow simulation on the wheel. Figure 3 explains the simulation results in the form of flow velocity values on the wheel blades at a certain time.

Next, Figure 4 shows the values of flow velocity at the wheel blade versus time. The linear speed of the water wheel increased from 0 to 1.2 seconds, then at 1.2 seconds, the linear speed of the water wheel stabilized at a value of 0.38 m/s. So, based on Figure 4 it can be seen that the linear speed of the water wheel is 0.38 m/s. This speed value is applied as the initial flow velocity in the hose.

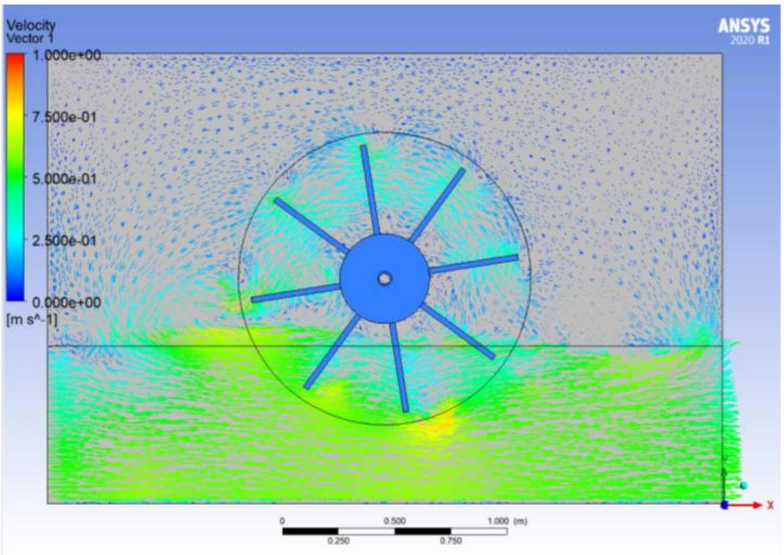

Figure 3. Flow simulation on the wheel

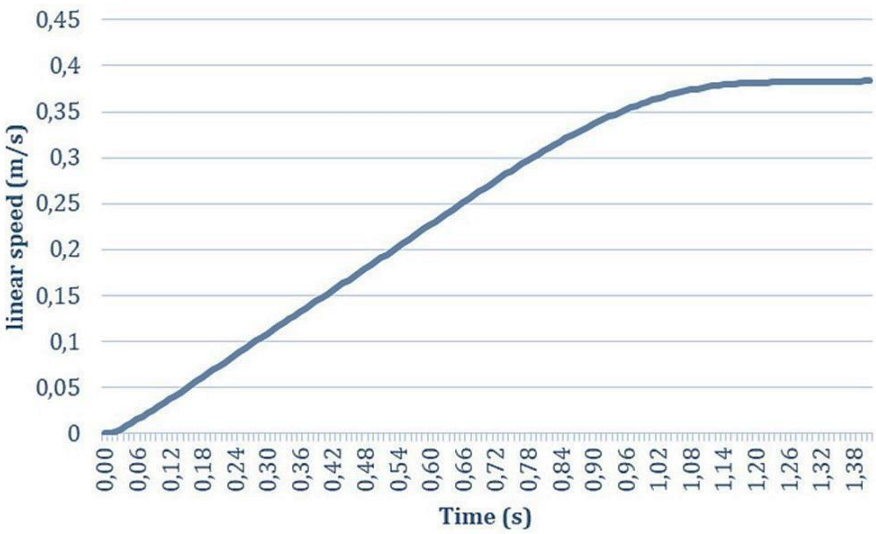

Figure 4. Graph of linear speed of the wheel against time

3.2 Simulation of flow in the hose

Figure 5 displays the results of modeling the hose of spiral pump. In this research, various hose diameter values were used, namely ½, ¾, 1, 1½, and 2 inches. Figure 6 shows the flow velocity value at outlet of ½ inch diameter hose. Based on the simulation results, the maximum velocity of fluid flow at the hose outlet is 0.538 m/s. In the same way, speed values for other hose diameters are obtained.

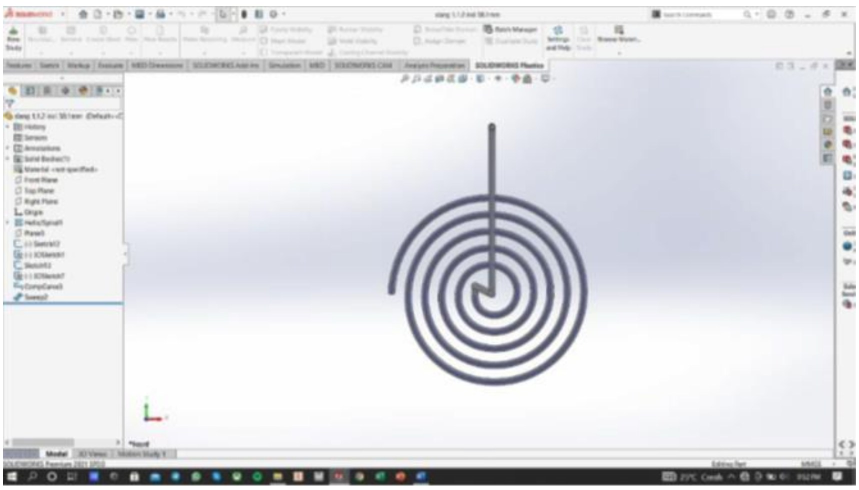

Figure 5. Model of the hose

International Journal of Applied Sciences and Smart Technologies
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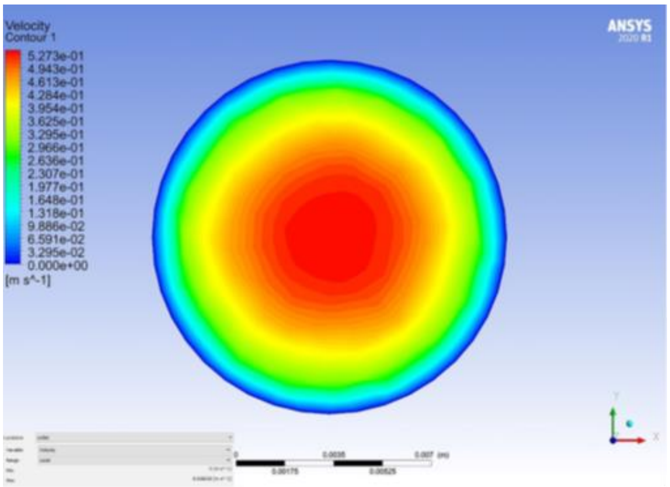

Figure 6. Flow velocity distribution at the hose outlet with a diameter of ½ inch

3.3 Discharge calculation of spiral pump

Discharge of spiral pump can be calculated based on the flow velocity at the hose outlet and the diameter of the hose. Figure 7 explains the distribution of pump discharge values relative to hose diameter. The hose diameter values are 0.5, 0.75, 1.0, 1.5, and 2.0 inch.

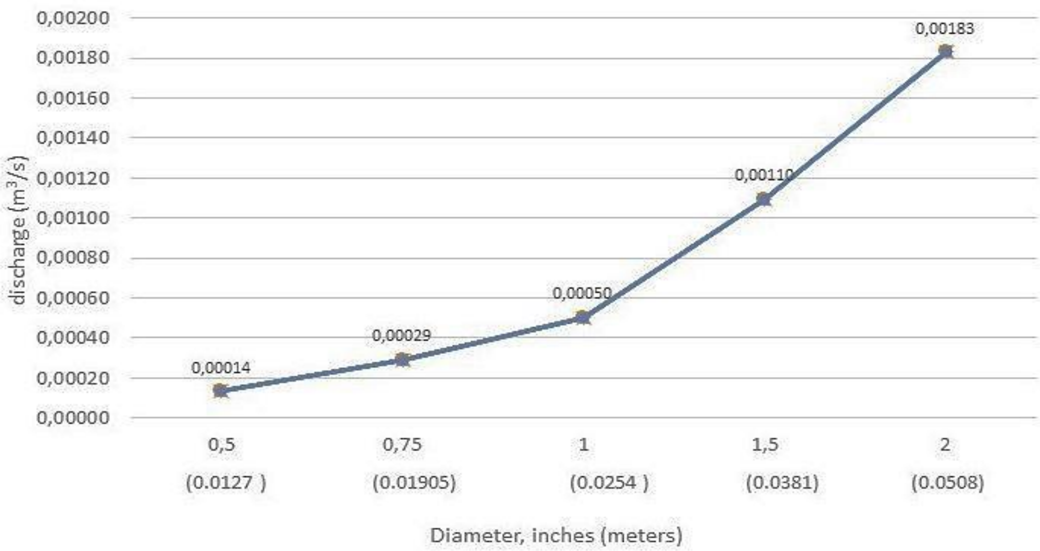

Figure 7. Pump discharge versus hose diameter

Based on Figure 7, it is known that the hose diameter greatly influences the performance of the spiral pump. Specifically, the increase in pump discharge relative to hose diameter follows a parabolic curve. The largest pump discharge was obtained at a hose diameter of 2.0 inches, namely 0.00183 m^3/s.

4 Conclusions

This research produces several conclusions as follows. Determination of the spiral pump discharge based on CFD simulation is carried out through two simulations, namely simulating the flow at the water wheel and simulating the flow in the hose of spiral pump.

The determination method proposed in this research has been applied to a water wheel model with a diameter of 1.2 m and a width of 0.6 m. For hoses, diameters of ½, ¾, 1, 1½, and 2 inches are determined, while the river flow speed is 0.9 m/s.

For a hose diameter of 2 inches, the initial flow velocity in the hose is 0.38 m/s and the final velocity at the hose outlet is 0.452 m/s, while the resulting pump discharge is 0.00183 m/s.

Acknowledgements

This research was funded by Sam Ratulangi University (PNBP Unsrat 2023) through a research scheme of Unsrat (RDUU K2).

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International Journal of Applied Sciences and Smart Technologies

Volume 5, Issue 2, pages 355–364

p-ISSN 2655-8564, e-ISSN 2685-9432

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