Research on purpose of determining the optimal configuration of blades for improving the energy efficiency of direct flow hydro turbine

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Introduction

Scientific research work is related to improving the energy efficiency of hydro turbine by changing the stream flow to hydro wheel. Hydropower plants use energy of water flow as the source of energy. Hydro turbine is the hydro engine that turn coming flow energy to mechanical energy.

Today, the whole world pays great attention to water flow energy as the effective source of energy. Investigated hydro turbine for small hydroelectric power station does not require a dam. Instead, it works in scheme as a part of the water given to head tube, after flowing through hydro turbine again dumped into the river. This direct flow hydro turbine size is small, so to construct it need less material accordingly it cost cheaper [1,2,3].

The increasing of energy efficiency of hydro turbine is directly related to the configuration of the blades. Research the optimal version of the attack angle on guide vane and hydro wheel blades with the purpose of improving efficiency of low head hydro turbine.

Methodology

The method of investigation is a computational experiment. The COMSOL Multiphysics application package examines the change in velocity and distribution of pressure of water through the guide vanes and the turbine blades [4].

Showed internal construction of 3D model of hydro turbine in Figure 1.

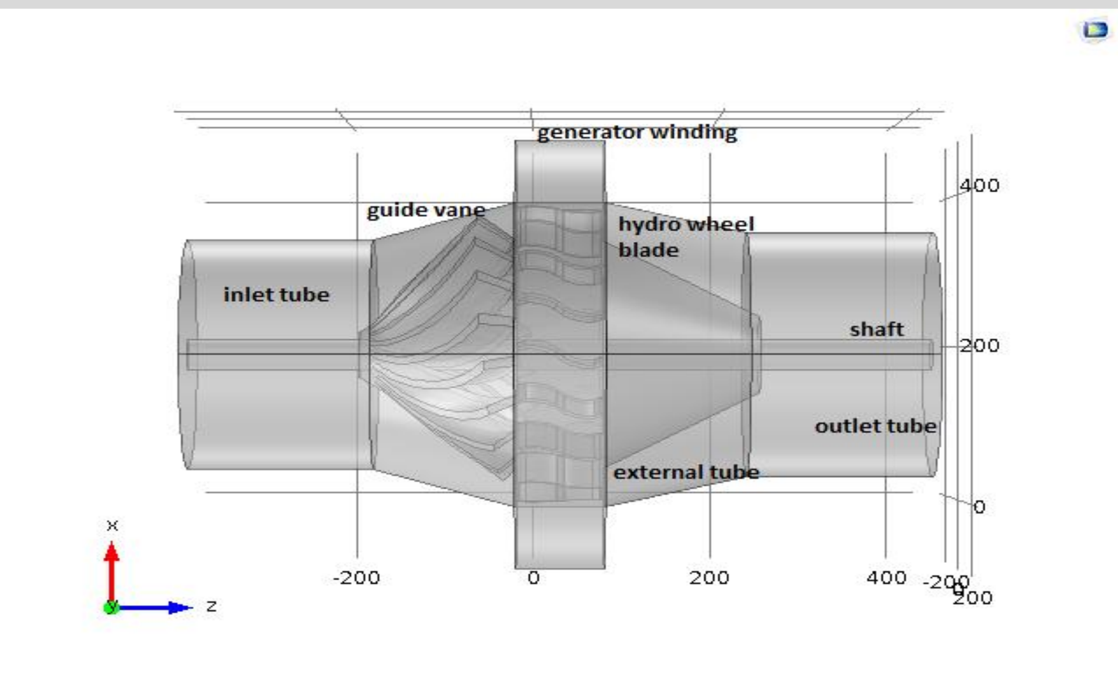

Fig. 1. Internal construction of hydro turbine

To take as more energy is needed to turn as more the hydro wheel. Therefore, there is a guide vane with the aim to regulate impact and direction of water flow to the hydro wheel blades. When water flow through hydro turbine passing through guide vane and hit blades with pressure, and they rotate [5]. Guide vane and hydro wheel of the hydro turbine is showed in Figure 2.

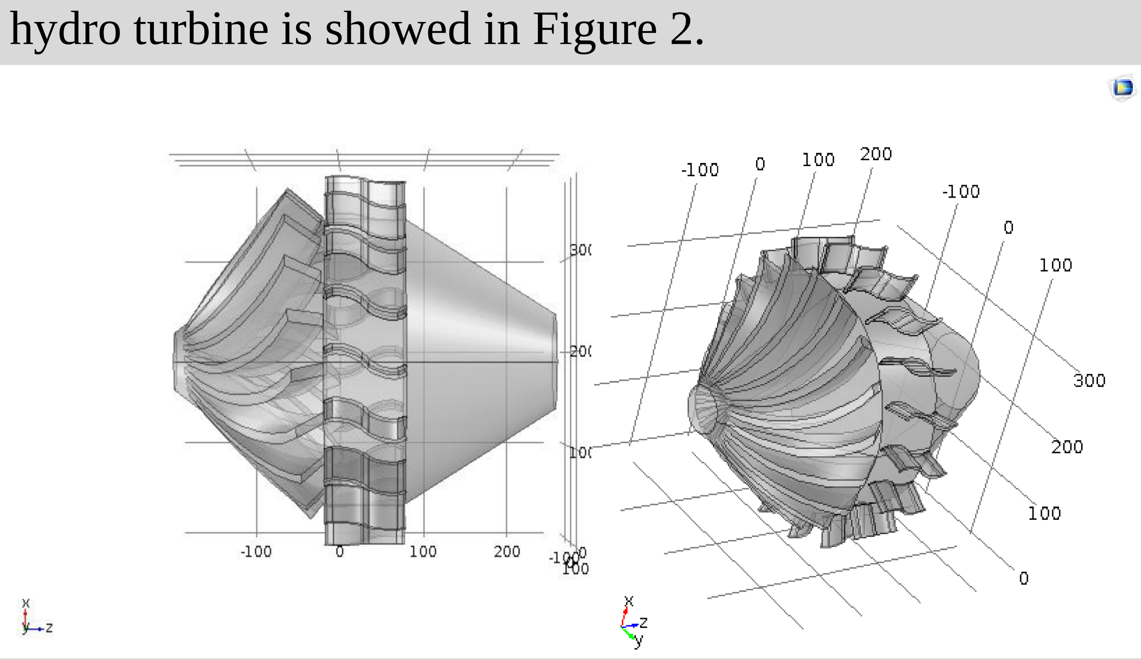

Fig. 2. Guide vane and hydro wheel

Distribution of flow velocity and pressure was calculated with using Reynolds Averaged Navier Stokes (RANS) method to Navier-Stokes equation for incompressible fluid [6]. Task was calculated in Turbulent Flow, k-ω interface of COMSOL Multiphysics. It gives better results for considering internal flows and it takes into account wall functions.

The numerical calculation were obtained by changing the attack angle of the two blades of guide vane and two blades of hydro wheel for shaping the two dimensions. Three different angles were obtained to show the improving in energy efficiency and to compare.

Defining optimal attack angle

Attack angle is an angle between flow direction and chord line of blade. Scheme of attack angle of the guide vane blade and attack angle of the hydro wheel blade illustrated in Figure 3. Arrow is showed water flow direction.

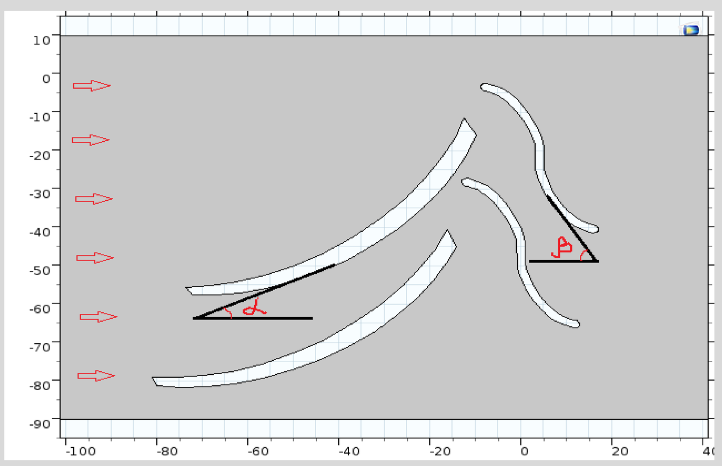

Fig. 3. Attack angle

Results of velocity changing and pressure distribution along blade in 10 second with initial velocity 10 m/s, changing attack angle demonstrated in Figure 4.

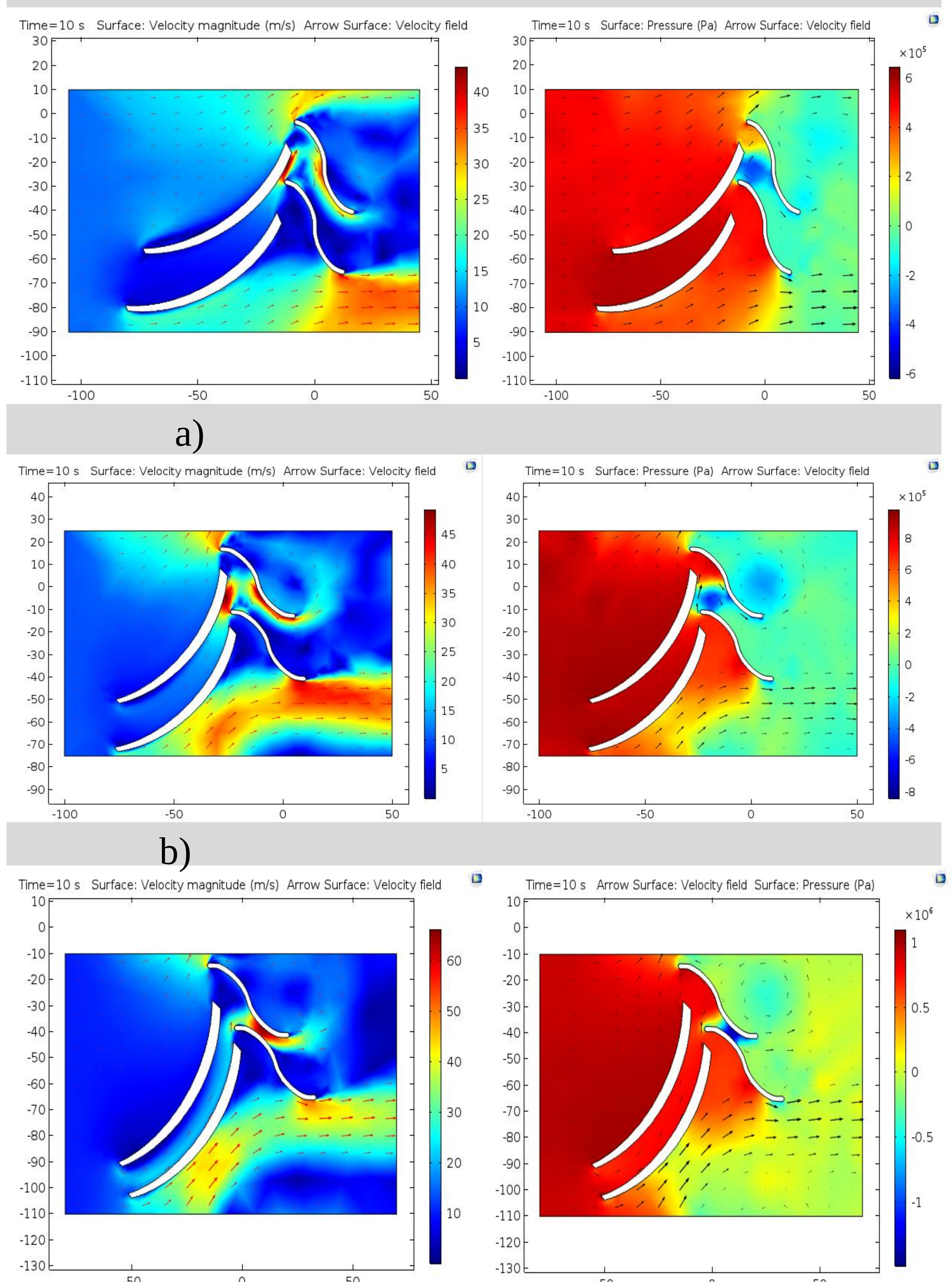

Fig. 4. Distribution of velocity and pressure at different attack angle on guide vane and hydro wheel blades:
a) 30º and 60º, b) 45º and 45º, c) 50º and 40º.

Changing of colour from blue to red showed increasing of velocity and pressure. Arrow is showed water flow direction. In the first case the maximum value of velocity reached to 40 m/s and pressure 600 kPa. Pressure increase in the bottom side of the blade as a result of the appearing lift force [7]. Changing attack angle to 45º maximum value of velocity reached to 45 m/s and maximum value of pressure reached 800 kPa. So we see that attack angle has affect. Changing attack angle to 50 and 40º angle degree maximum value of velocity reached to 60 m/s and pressure reached to 1000 kPa. Changing attack angle affected to previous results.

Defining lift and drag forces

The force component that perpendicular to the flow direction is called lift force. The force component that parallel to the flow direction is called drag force [8].

Lift and drag forces scheme illustrated in Figure 5.

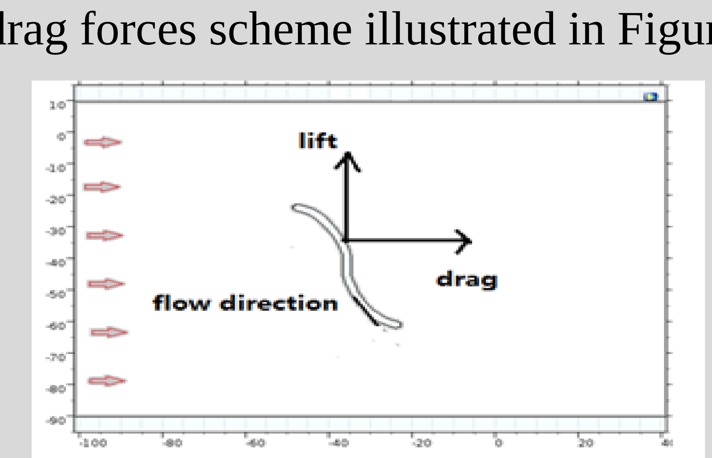

Fig. 5. Scheme of the lift and drag forces

Lift and drag forces at different angle attack on the blade at last time showed in Figure 6. Was chosen as different angle attack as 0º, 15º, 40º, 45º, 60º, 90º.

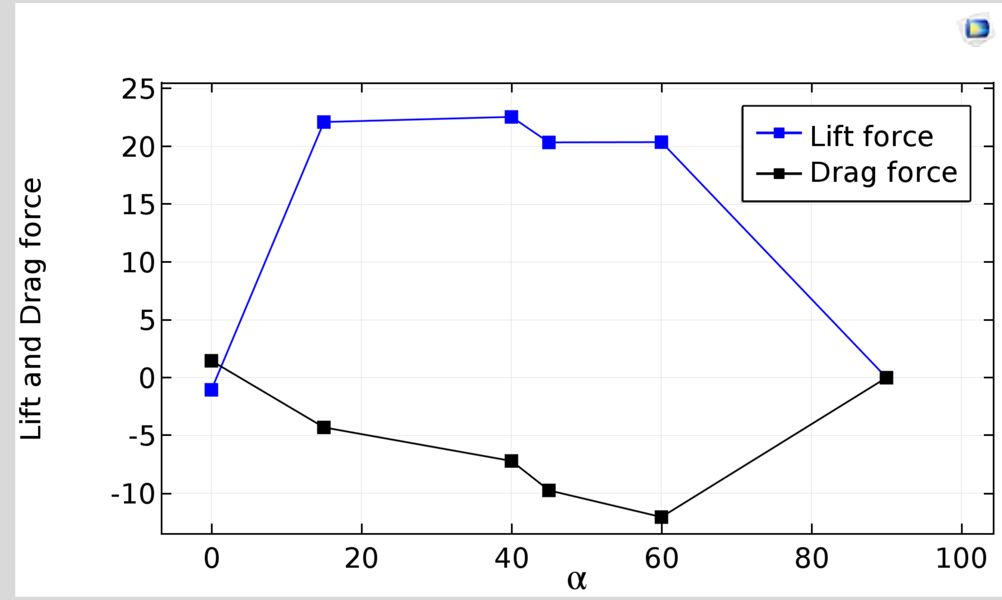

Fig. 6. Lift and drag forces at last time

Lift force increasing from 0 to 40 angle degree, then decreasing. So at 40º angle attack on blade take maximum value of lift force.

Defining lift and drag coefficients

Lift coefficient at different angle attack on the blade in 10 second time showed in Figure 7.

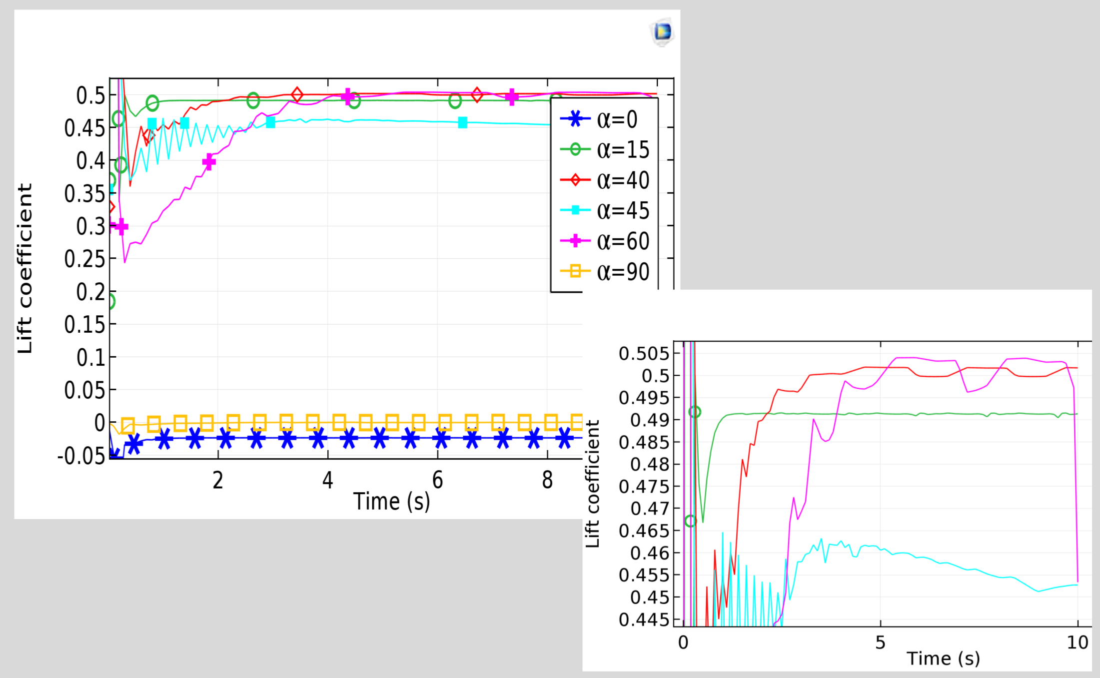

Fig. 7. Lift coefficient in 10 second

Drag coefficient at different angle attack on the blade in 10 second time showed in Figure 8.

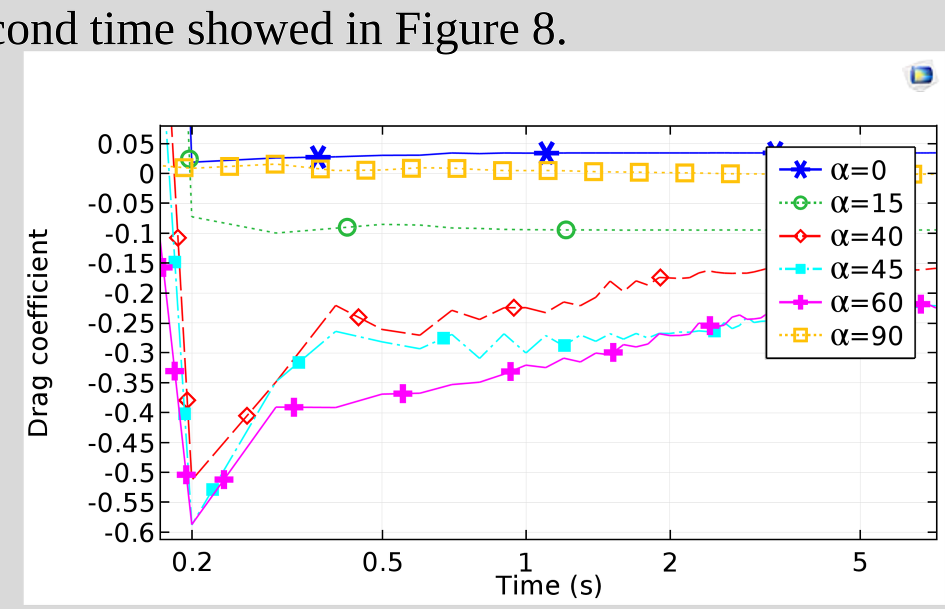

Fig. 8. Drag coefficient in 10 second

Conclusions

Research with the aim of improving efficiency of low head hydro turbine was performed. Three various location of the blades with changing attack angle investigated in COMSOL Multiphysics. Changing of attack angle affected to efficiency. Based on the results of the research, it was determined the optimal configurations of the hydro wheel blades with effective efficiency. As optimal configuration was taken guide vane attack angle as 50º and hydro wheel blade attack angle 40º, where velocity reached to 60m/s and pressure reached to 1000 kPa. Based on the results of the research, where velocity and pressure distribution and where lift force is maximum value it was determined the effective location angle of the hydro turbine blades.

References

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