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FAST COMPUTATION OF A SMOOTH YARN'S VELOCITY IN A MAIN NOZZLE

Delcour L.*[1], Peeters J.[2], Degroote J.[1,3] and Vierendeels J.[1,3]

[1]Ghent University, Faculty of Engineering and Architecture, Department of Flow, Heat and Combustion Mechanics, Sint-Pietersnieuwstraat 41, B-9000 Ghent Belgium, https://www.ugent.be/ea/floheacom/en, lucas.delcour@ugent.be
[2]Picanol NV, Steverlyncklaan 15, 8900 Ieper Belgium, http://www.picanol.be/en, info@picanol.be
[3]Flanders Make, Belgium

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Air jet weaving looms are well-known for their high insertion rates. The attainable insertion rate is directly dependent on the yarn velocity, which is mainly imposed by the main nozzle. The complex flow patterns arising in those nozzles make it difficult to predict how a change in geometry or supply pressure will affect the yarn velocity.

In this paper a computational fluid dynamics (CFD) model is coupled with a simplified structural model to calculate the axial velocity of a smooth yarn as it is launched by the main nozzle. The force on the yarn is obtained by using a Reynolds-Averaged Navier-Stokes (RANS) model and a no-slip boundary condition, without any experimental tuning. The results are compared to experiments in which the yarn velocity is obtained from high speed footage. By using a smooth yarn the influence of yarn hairiness is omitted and uncertainty on the yarn diameter is reduced.

In the flow model the yarn is modeled as a rigid cylinder centered on the axis, allowed to move in the axial direction by a moving wall boundary condition. In the structural model the inertial force required to accelerate a stationary piece of yarn to the current yarn velocity, the inertial force associated to an increase or decrease of the yarn velocity and the force exerted by the air flow on the yarn (obtained from the flow simulation) are considered. Calculations are performed on a single nozzle geometry and the sensitivity with respect to simplifications and numerical parameters is investigated.

From the results it can be concluded that a reasonable estimate for the velocity of a smooth yarn can be obtained without the use of force coefficients and with relatively limited computational resources. The shocks appearing inside the main nozzle do not have to be accurately resolved if one is only interested in the axial motion of the yarn. The acceleration of the yarn tends to take longer in the simulations compared to the experiments. This is most likely caused by the fact that the yarn is considered inelastic in the simulations and that the yarn is not stretched at the start of the experiment.