FSI simulation of an axially moving flexible cylinder entrained by a supersonic flow

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ABSTRACT

Air jet weaving looms are widely used to weave fabrics because of the high production speed that can be attained. This is directly linked to the high insertion speed of the yarns. The yarn is accelerated into the reed by a main nozzle and its motion is subsequently supported by underexpanded jets emanating from relay nozzles. The contact with the reed is the only mechanical guidance that the yarn experiences along its path and its motion depends heavily on its interaction with the air flow. The yarn can thus deviate from its envisaged path and cause a failed insertion. Furthermore, the tension in the yarn, induced by the traction of the air, can cause yarn breakage. Failed insertions and broken yarns are undesired as they require the machine to be restarted.

Due to the high speed of the yarn and the mechanical components, optical accessibility to the yarn is very limited. Furthermore, the complex geometry experienced by the air flow makes it hard to assess the influence of adaptations. Fluid-structure interaction (FSI) simulations might assist in understanding the behaviour of the air flow and the yarn. However, the flexibility of the yarn in combination with the high speed flow presents its own challenges.

In this research an attempt is made to simulate the launch of a yarn by a single main nozzle into the atmosphere. To better approximate reality, the yarn is considered to be stored on a drum in front of the nozzle. A two-way fluid-structure interaction simulation is performed using Fluent for the flow side, Abaqus for the structural side and the in-house code Tango for the coupling. Continuum elements or beam elements are used for the structure. The axial motion and large transversal displacement of the yarn pose significant challenges for a single deforming grid in the flow solver. To avoid these complications a Chimera approach, which superimposes several meshes, is opted for.

The FSI simulations show that the yarn can indeed be represented by beam elements. The gain in computational time by switching to beam elements is evaluated and the results from the FSI calculation are compared to experimental results in terms of yarn velocity. Stresses in the yarn are examined to identify high tension regions.