# Fluctuating Impact Force in Discrete Region of Hydroentangling Waterjets

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In this study, we compute and discuss the impact force of waterjets which break up in the so-called 1st wind-induced breakup mode (see Figure 1) consisting of three different regions: ***i*** - a long and continuous portion, ***ii*** - a discrete portion (a stream of high-speed drops with diameters comparable with the jet diameter), and ***iii*** - a spray region.

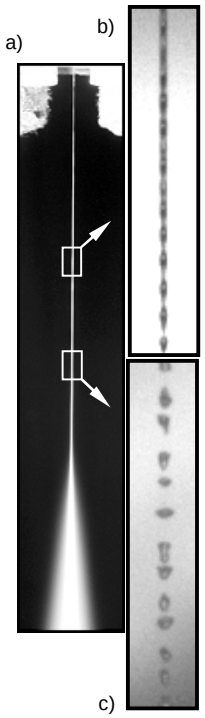


Figure 1: a) A constricted waterjet at a pressue of 137 bar, b) continuous region, and c) discrete (drop stream) region.

Waterjets that break up in the 1st wind-induced breakup regime have long breakup lengths. After the primary breakup, droplets with diameters greater than that of the jet are formed. Considering the continuous portion of a jet as a cylindrical column of water with a diameter of 100μm, we calculate its impact force to be $F_{imp} = p/4\, d_j^{\,2}\, r\, U^{\,2} = 0.21N$ , after a 90-degree deflection, for a velocity of $\boldsymbol{U}$=165m/s.

Conducting an experiment to measure impact force of drops in the abovementioned speed and size range is quite demanding. We, therefore, performed a CFD simulation of the discrete region having a droplet size of 190 microns. The periodicity of the collisions allowed us to simplify the computation by considering only the 1st, 2nd, and 3rd drops. Figure 2 shows a sequence of the different moments during the impact for the first two droplets. A large drop spread on the surface can be seen which ends up in a splash far from the axis.

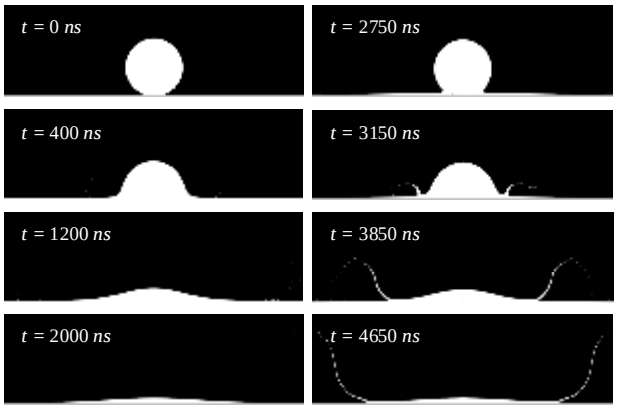


Figure 2: Different moments of time during the impaction of the 1st (picture to the left), and 2nd (picture to the right), drops.

The resulting impact forces are presented in Figure 3 for the 1st, 2nd, and 3rd drops. It can be seen that discrete waterjet can produce an impact force of about 3.5 - 4 times greater than that of the continuous jet.

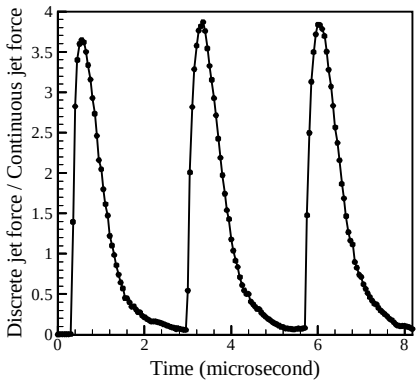


Figure 3: Impact force of the 1st, 2nd, and 3rd drop normalized by the impact force of the continuous jet, $\boldsymbol{F_{imp}}$.

By using the discrete jets (by properly adjusting the nozzle-web stand-off distance) a higher degree of randomization may be achieved which can potentially help reducing jet streaks. Additionally, a pulsating steady-state jet may be more effective in fiber splitting.

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