Concept & hydraulic design of a counter-rotating micro-turbine

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Context
- Energy recovery in drinking water networks
- Modular in-line "water to wire" generating unit from 5 to 25 kW
- No environmental impact
- Low investment for final customer

Concept
- Two axial counter-rotating runners per stage
- Compact permanent magnet synchronous generator straflo-design
- Individual runner speed regulation for best efficiency
- Multi-stage concept for a wide power range

Hydraulic Design
1. Rated specific hydraulic energy $E$:
   \[ E = \frac{p_f - p_i}{\rho} + \frac{c_i^2 - c_f^2}{2} + g(Z_i - Z_f) \]

2. Runner angular momentum balance yields Euler equation for the specific hydraulic energy conversion:
   \[ \eta_t \cdot E = U_f C_{u_f} - U_i C_{u_i} \]

3. Velocity triangles at both the inlet and outlet runner blades yield the relative flow angle $\beta$.

4. Blade camber-line and shape are defined as a function of $\beta$.

Requirements
- Mass flow: 9 kg/s
- Pressure drop: 2.4 bar
- Rotational speed: 2500 rpm
- Hydraulic efficiency: 90.2 %
- Mechanical power: 1.728 W

CFD Simulations
- ANSYS CFX numerical flow simulations are performed to achieve optimized performance of the micro-turbine

Simulation Results
- Total Pressure: 2.35 bar
- Mechanical power: 1.908 W
- Hydraulic power: 2.115 W
- Torque 1st runner: 3.54 Nm
- Torque 2nd runner: 3.75 Nm

Perspectives
- Multi-stage configuration investigations with numerical flow simulations
- Fabrication of the straflo-prototype until October 2015
- Experimental tests of the straflo-prototype on the hydraulic test rig till end of 2015

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