DuoTurbo: Mechanical Design

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Context

- Recovering hydraulic energy lost in drinking water networks
- Modular in-line “plug and play” turbine from 5 to 25 kW
- No environmental impact
- Low investment costs

Technical challenges

The hydraulic and electrical concepts of the DuoTurbo prototype have successfully been validated by laboratory tests in 2016. The main issue that is still not entirely resolved, concerns the mechanical concept of the runner bearings. The given operating conditions and requirements make it difficult to find suitable technical solutions.

Operating conditions

- High axial forces > 3 kN possible
- High rotational speed up to 3500 min⁻¹
- Pipeline pressure > 20 bar possible
- Water contaminated with abrasive particles

Requirements

- Low production costs
- Reliability and general lifetime of > 5 years
- Minimum maintenance
- High efficiency

Tested mechanical concepts

The accomplishment of the given requirements is crucial for the realization of an industrial DuoTurbo turbine. Therefore, different mechanical solutions have been analyzed, designed and tested.

Version 0.1

Concept: Water lubricated radial (1.1) and axial (1.2) ceramic ball bearings with high corrosion resistance.

Conclusion: Successful for hydraulic and electrical laboratory tests (2016). Enlarged viscous friction and uncertain long time behaviour of submerged ceramic bearings.

Version 0.2

Concept: Water lubricated axial ceramic ball bearing (2.1) combined with hydrodynamic radial plain bearing (2.2). Reduced mechanical losses and production costs.

Conclusion: Advanced stage of wear of ceramic ball bearings after laboratory tests. Water lubrication insufficient to ensure requested reliability.

Version 0.3

Concept: Hydrodynamic axial and radial plain bearings (3.1), ensuring low wear, low mechanical friction, low maintenance and production costs.

Conclusion: Different bearing materials and shapes tested on a test rig. Hydrodynamic effect too weak to support axial load of turbine runners. Failure during laboratory tests.

Version 0.4

Concept: Axial hydrostatic bearing (4.1) and radial hydrodynamic plain bearing (4.2), ensuring low mechanical friction, low wear and low maintenance costs. Hydrostatic bearing supplied by water pipeline pressure. Requires considerable precision of mechanical assembly.

Conclusion: Functionality of hydrostatic bearing validated on separate test rig. Low efficiency of labyrinth seals caused failure during laboratory tests, due to underestimated axial forces.

Version 0.5

Concept: Encapsulated, grease lubricated angular ball bearings (5.1) guaranteeing requested lifetime and reliability. Tightness ensured by mechanical seal (5.2), typically used for pumps. Considerable maintenance costs due to regular replacement of the seal (1-2 years).


References


Development team of Duo Turbo (CTI Nr. 17197.1 PFEN-IW)

HES-SO Valais/Wallis:

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Industrial partners:
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