State of the art & current research on Turgo impulse turbines

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Overview

• Introduction
• Performance envelope
• Design layout
• State of the art
• Current research
The Turgo impulse turbine was invented by Eric Crewdson, Managing Director of Gilkes, in 1919 and a patent was awarded in 1920. A paper was presented in 1922 at the Institution of Civil Engineers: *Design and Performance of a New Impulse Water-Turbine* (Crewdson, 1922).

**Drawing of the 1920 Crewdson Turgo design showing the inlet plane and cut section with the jet trace on the inlet wheel plane shaded**

**Elevation and plan view showing the 1920 Crewdson design of the Turgo machine**
Introduction

The 150HP (at full load) turbine used in the initial tests was tested using a 65kW continuous current compound-wound interpole generator, set up for 220V at 725-750rpm.

A similar turbine of the same capacity was later tested by Dr A. H. Gibson of Manchester University showing a maximum efficiency of 83.5% under a head of 200 feet, producing 106HP, at 640rpm (Crewdson, 1922).
Performance envelope

**TURGO TURBINE**

- Head Range: up to 300m
- Power Output: up to 10MW
Turgo impulse turbine design layout

Typical arrangement of a Gilkes twin jet Turgo Impulse turbine
State of the art

• Turgo impulse turbine design was developed to provide a simple impulse type machine with a higher specific speed than a Pelton by inclining the jet to the runner face.

• The first Turgo turbine was installed in 1919. Since then Gilkes have supplied over 900 Turgo turbines producing a total of 300 MW to over 80 countries. Many of the original units are still in operation today.
Current research

Generic Multiphase CFD Analysis

CFD analysis of a jet impacting a cup: Setup

Cup exit angle-15deg  Jet angle-0deg  Jet Velocity 20m/s
Current research

CFD analysis of a jet impacting a cup: Results

Isosurfaces at water VF 0.5
Current research

CFD analysis of a jet impacting a cup: Results

Water and Air Volume Fraction Contours
Current research

CFD analysis of a jet impacting a cup: Results

Water velocity streamlines
Full Steady State Analysis of A jet impacting a Cup

CFD analysis of a jet impacting a cup: Results

Pressure on Cup
Current research

CFD analysis of a jet impacting a cup: Results comparison

Final Force comparison

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<th>Jet angle (deg)</th>
<th>Theoretical Force (N)</th>
<th>x (N)</th>
<th>y (N)</th>
<th>z (N)</th>
<th>mod (N)</th>
<th>No.</th>
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Current research

Analysis of a jet impacting 3 cups in a rotating domain: Animation
Current research

Analysis of a jet impacting 3 cups in a rotating domain: Torque curves

![Torque curves graph](image)
**Current research**

**Turgo CFD Analysis**

**Initial Domain Creation**

The initial domain was created using a single blade and rotational symmetry around the hub to create the full geometry.

Multifluid geometry is then drawn around the runner section and the runner geometry is subtracted from this giving the fluid domain around the runner which will be rotating relative to the jet.
Current research

Mesh Generation

For the initial analysis, tetrahedral meshing was used. Face sizing was applied to the front of each blade and to the hub and outer ring. Edge sizing was applied to the jet inlet.

Min element size: 1e-3m
Max element size: 8e-3m
Growth Rate: 1.2
Inflation layers: 3
Transition ratio: 0.2
Growth rate: 1.2
Face Sizing element size: 2 e-3 m
Edge Sizing element size: 2e-3 m
Interface element size: 2.5e-3 m
Current research

Simulation setup - Calculation using inbuilt functions

The calculated Torque data on the inside of the first blade and the outside of the second blade was extracted from the simulation using an inbuilt torque function applied to the Named Selections created for the two regions shown below.

This function is then plotted as a Monitor Point while the simulation runs, allowing the calculated torque at each timestep to be exported.
Current research

Initial results
Current research

Power calculation - Torque on 1 blade

![Graph showing torque on front and back of blade with phase difference]
Power calculation: Torque on all blades

The total torque curve is shifted by the single blade passage phase (360/22) for the whole range of total torque values and summed to give the total torque acting on the turbine shaft.

Note: Blades 8-12 also exert a small torque, but have been removed from the graph for clarity.
Current research

Refined tetrahedral mesh

Axial cut section showing the refined tetrahedral mesh element sizing around the blades

Tangential cut showing refined tetrahedral mesh inflation layers and element sizing from LE to TE
Tetrahedral mesh study: Results comparison

Current research
Current research

Results comparison - Refined mesh - more developed jet
• Conclusions
• Thank you