**Water**
**Resources**
**Engineering**
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# Master's Thesis of Hüseyin Eraydin


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# Investigation on a New Type of a Turbine


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## Renewable Energy Harnessing and Textile Turbine

Today, after considerable R&D effort, renewable resources are now regarded as capable of supplying a significant portion of energy in the long term future. In Germany it is planned to increase the potential energy share from renewable sources up to 12.5% until 2010.
As an alternative to renewable and clean energy harnessing from freely flowing water, namely 'Textile Turbine' has been designed. It has been seen that, by changing the shape of a water wheel and by using so called 'Textile Bags' instead of wheel paddles a number of goals of an environmentally friendly energy converter could be achieved.

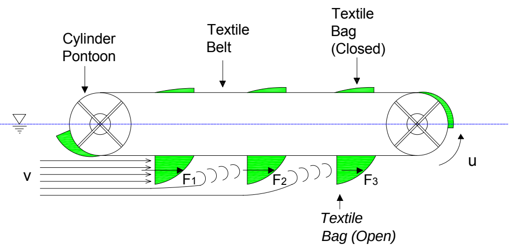


Figure 1. A textile turbine and the flow field around

## Theoretical Investigations

In order to estimate power production and performance of a textile turbine, theoretical investigations have been done. Momentum and drag coefficient -concepts driven from an undershot water wheel give a theoretical basic for such a turbine. More important than the momentum approach, the drag coefficient concept gives a better understanding of the system. According to the momentum method, the maximum power is achieved when the wheel velocity is half of the stream velocity. However, the drag coefficient method says that the wheel velocity is one third of the stream velocity at maximum.

$$P_{har,max} = \frac{1}{2} \cdot P_{kin,flow} \qquad \frac{P_{har,max}}{P_{kin,flow}} = 0.148 \cdot c_D$$

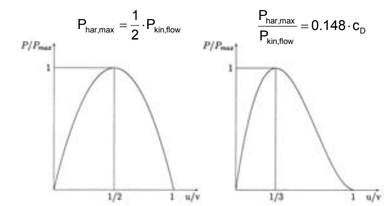


Figure 2. Comparison of the momentum and the drag coefficient methods

## Laboratory Experiments

Working principles of the textile turbine can be explained in a better way by the drag coefficient method. That is why the main concentration for this master thesis was on the possible drag coefficient measurements on the scaled models of the textile bags in the IWS laboratory.

1. Drag coefficient measurement for one textile bag with parabolic opening.

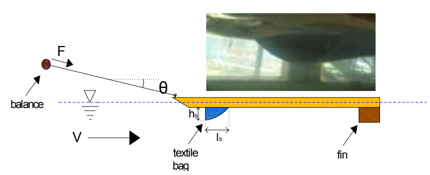


Figure 3. Experimental setup with one textile bag

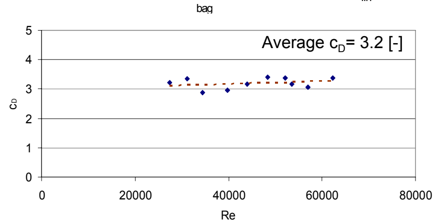


Figure 4. Drag coefficient versus Reynolds number and its trend line

2. Drag coefficient measurement for two identical textile bags with parabolic openings.

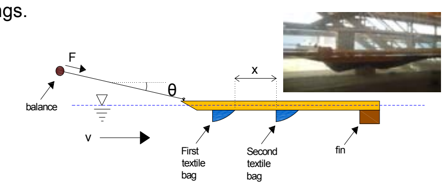


Figure 5. Experimental setup with two textile bags

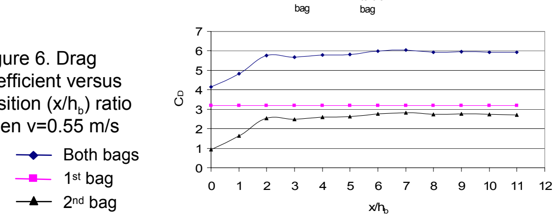


Figure 6. Drag coefficient versus position ($x/h_b$) ratio when v=0.55 m/s

## Construction of a Power Formula for a Textile Turbine

All of the textile bags immersed in water resist to flow with one combined drag coefficient. Laboratory experiments show that this coefficient depends on the distance between the textile bags and the velocity of the stream. The first textile bag has a constant drag coefficient ($c_D$) of 3.2. The second bags' contribution will be less than the first one's by a so called reduction factor (RF). The third bag contributes to total drag less than the second one by again RF and so on..

Total drag coefficient with n bags immersed in water at the same time:

$$c_{tot} = c_D \cdot \left[\frac{1-(1-RF)^n}{RF}\right] \quad \text{(Eraydin)}$$

Maximum theoretical power:

$$P_{max} = 0.074 \cdot c_{tot} \cdot \rho \cdot A_{\perp} \cdot v^3$$

Coefficient of performance:

$$CP(\%) = 14.8 \cdot c_{tot}$$

## Estimation of Maximum Power for the Designed Prototype

A prototype has been designed by the investor. After the construction, it was installed on a channel for power measurement and optimization. Because of seasonal and structural problems, realization of possible optimization by power measurement could not be accomplished during this master thesis. However, the laboratory experiments and the constructed formulas can be used for an example case for the estimation of power and performance.

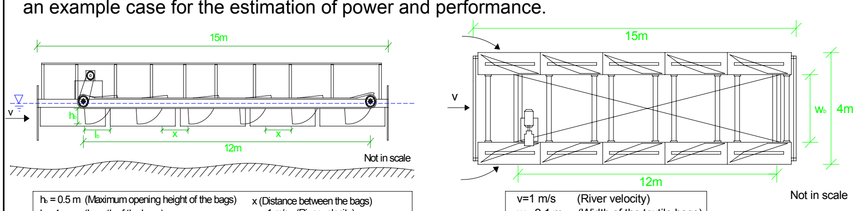


Figure 7. Side and top views of the designed prototype for an example calculation

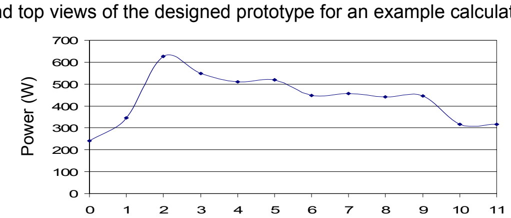


Figure 8. Power versus position ($x/h_b$) ratio for an example calculation with v=1 m/s

Max. Theoretical Coefficient of Performance: CP= 170 %