

Fan and Pump Efficiency in Modelica Based on the Euler Number

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In this paper, we report a Modelica implementation of a convenient method to represent fan or pump (mover) performance with improved accuracy. It provides an estimate of variable hydraulic efficiency η_{hyd} when such information is unavailable and the user may have to use a constant η_{hyd} otherwise. It only requires the user to provide one data point of η_{hyd} , flow rate \dot{V} , and pressure rise Δp where the efficiency is at its maximum.

The method then uses a dimensionless modified Euler number Eu and a correlation to estimate the hydraulic efficiency η_{hyd} and the shaft power \dot{W}_{hyd} at off-design conditions. This method is applicable regardless of the type, size, or operational region (stall or nonstall) of the mover. In Figure 1 we overlaid operating points from seven sets of fan data and eighteen sets of pump data to the empirical relation to show that the manufacturer data closely followed the correlation. Figure 2 shows that the computed efficiency closely follows the values from the performance map for the full range of \dot{V} and Δp . The computed power is also accurate for most of the range. Across the sample, the errors of the computed power from interpolated data were within 15% for the range of 20% - 70% of \dot{V}_{max} and 40% - 90% of Δp_{max} , excluding outliers.

This method is valuable and applicable at early stages of design or post-retrofit assessment during which detailed mover performance data are generally not available.

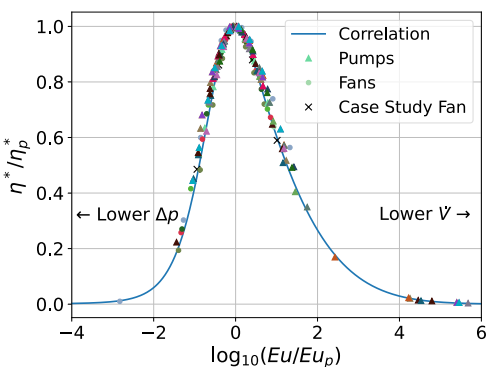


Figure 1. Normalized efficiency curves in dimensionless space and mover performance data. Each colour represents one dataset of seven fan models and eighteen pump models.

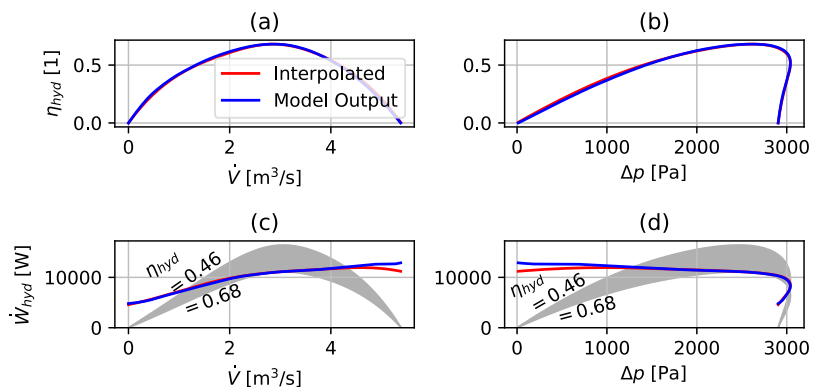


Figure 2. Hydraulic efficiency and power values that were interpolated from the performance map (red lines) and computed by the model (blue lines). The grey shaded area is bounded by the simplified assumption of a constant hydraulic efficiency between $\eta_{hyd} = 0.68$ (peak of this fan) and $\eta_{hyd} = 0.46$ and shown here to visualize the wrong results of this oversimplification.