Fan Efficiency based on Euler Method (Progress Update)

IBPSA Modelica Working Group

Coordination Meeting

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Overview

- Status: Under review & revision
  - IBPSA issue #1645 “Fan efficiency with Euler number”
  - IBPSA PR #1646 “fan efficiency euler”
- Highlights

  $\eta = \eta_{hyd}\, \eta_{mot}$
  - Variable hydraulic efficiency η_{hyd} estimated by Euler number
  - Variable motor efficiency η_{mot} estimated by DOE generic curves
  - Preconfigured fan/pump models

Highlights
Hydraulic efficiency η_{hyd}

$$\frac{\eta}{\eta_p} = f\left(\frac{Eu}{Eu_p}\right)$$

- Sub p: peak, i.e. where $\eta = \eta_{max}$

$$Eu = \frac{\Delta p \cdot D^4}{\rho \cdot \dot{V}}$$

$$\frac{Eu}{Eu_p} = \frac{\Delta p}{\dot{V}^2} \cdot \frac{\dot{V}_p^2}{\Delta p_p}$$

User input needed:

$\eta_p, \Delta p_p, \dot{V}_p$

* η is hydraulic efficiency
* Eu is modified Euler number

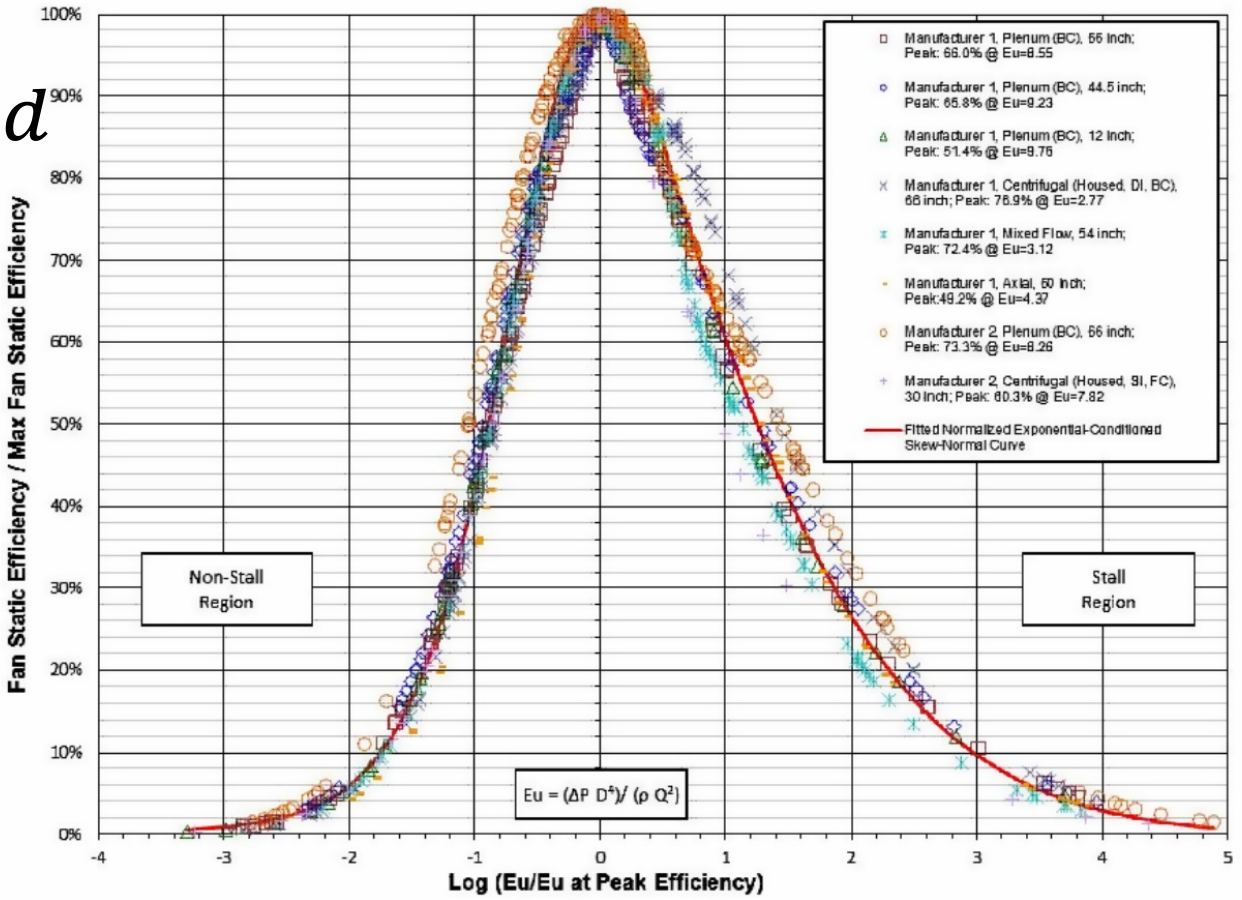


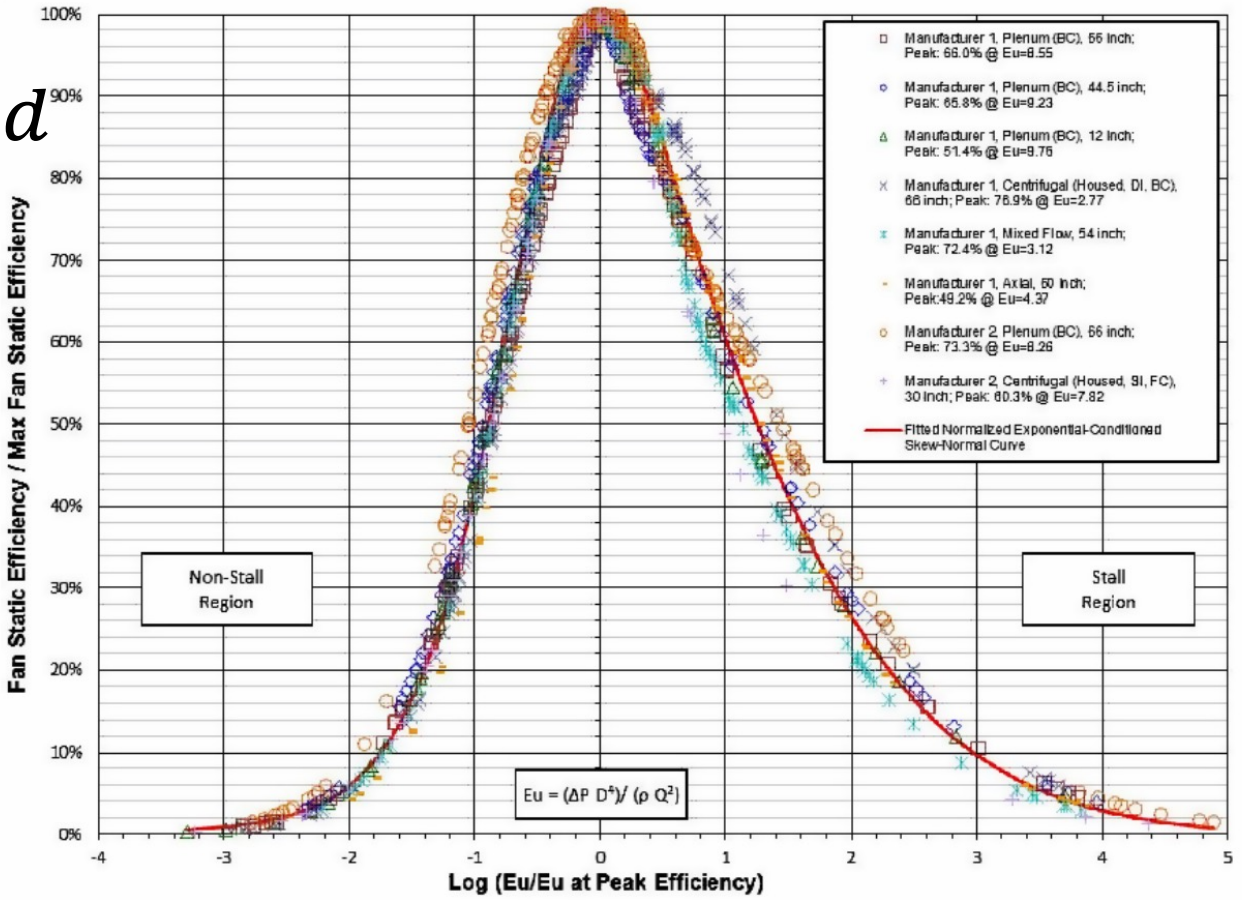
Figure 16.17: Normalized Efficiency Curves for Eight Fans in Dimensionless Space *(BC = backward curved, FC = forward curved; SI = single inlet, DI = double inlet)*

EnergyPlus v9.4 Engineering Reference.
https://energyplus.net/sites/all/modules/custom/nrel_custom/pdfs/pdfs_v9.4.0/EngineeringReference.pdf

Highlights
Hydraulic efficiency η_{hyd}

- Estimate of η_{hyd} under any operating condition
- Ongoing work:
  - Replace correlation function with polynomials

    (by Filip Jorissen @Mathadon)
  - Replace CombiTable2Ds blocks which require external C code



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Fu et al., Fan and Pump Efficiency in Modelica based on the Euler Number, 2022 American Modelica Conference, Dallas TX USA

EnergyPlus v9.4 Engineering Reference. https://energyplus.net/sites/all/modules/custom/nrel_custom/pdfs/pdfs_v9.4.0/EngineeringReference.pdf

Highlights
Motor efficiency η_{mot}

- Estimate of η_{mot} based on motor part load

$$y_{mot} = \dot{W}_{hyd}/\dot{W}_{nom}$$

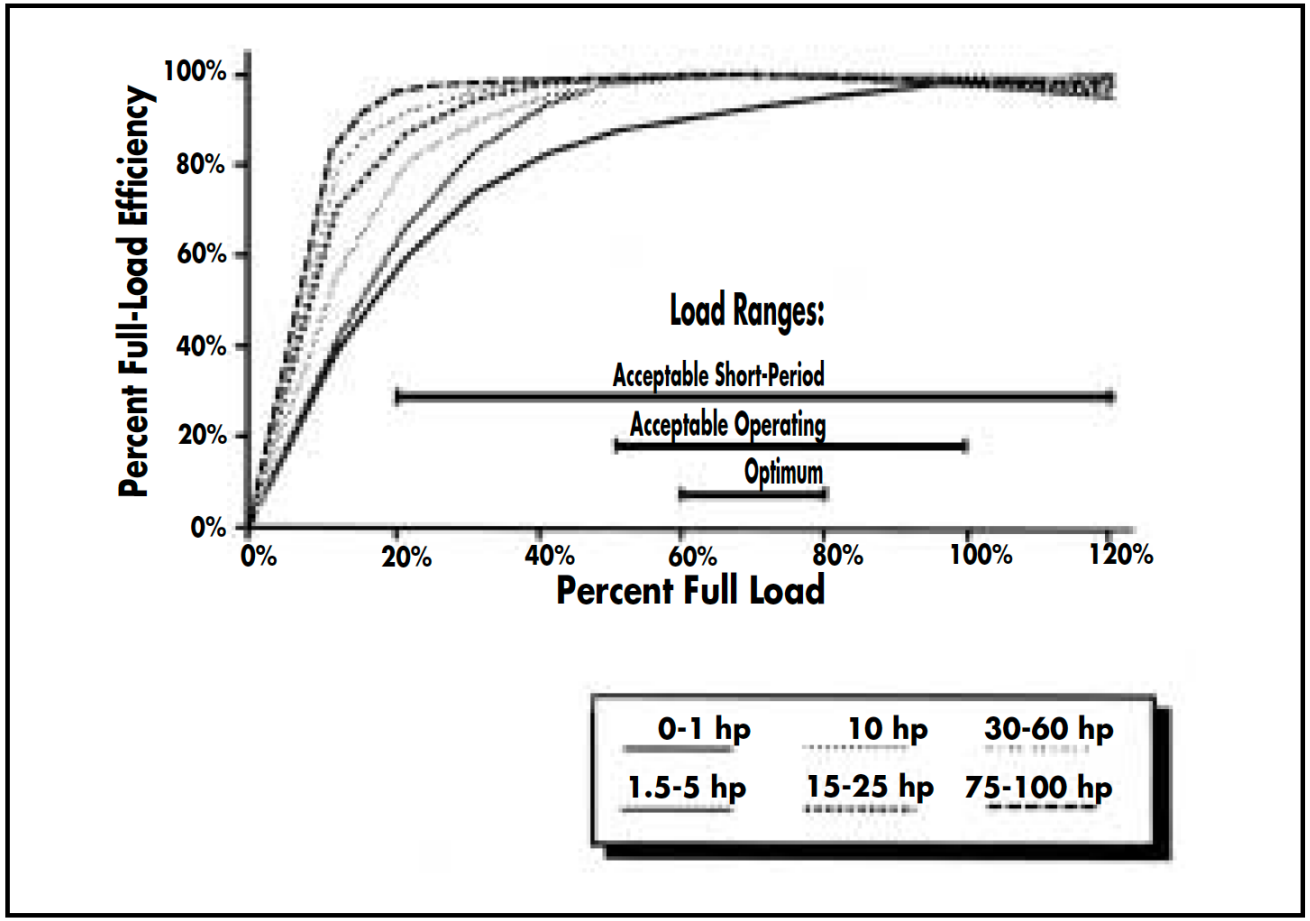

Figure 1 Motor Part-Load Efficiency (as a Function of % Full-Load Efficiency)

Determining Electric Motor Load and Efficiency
https://www.energy.gov/sites/prod/files/2014/04/f15/10097517.pdf

Highlights
Preconfigured Fan/Pump Models

- Model parameters auto-populated with nominal values.
- No more manual dummy pressure curves! (Buildings issue #1884)

```
Buildings.Fluid.Movers.SpeedControlled_y pumSpe(
  redeclare final package Medium=Medium,
  per(
    pressure(
      final V_flow=per.pressure.V_flow,
      final dp=per.pressure.dp),
    final hydraulicEfficiency=per.hydraulicEfficiency,
    final motorEfficiency=per.motorEfficiency,
    final motorCooledByFluid=per.motorCooledByFluid,
    final speed_nominal=per.speed_nominal,
    final constantSpeed=per.constantSpeed,
    final speeds=per.speeds,
    final power=per.power),
```

```
al=allowFlowReversal,
e,
,
ca.Fluid.Types.Dynamics.SteadyState) if have_pum and
th prescribed speed (fractional)"
(transformation(extent={{-50,-50},{-30,-30}})));
```

BEFORE

```
288+  Buildings.Fluid.Movers.Preconfigured.SpeedControlled_y pumSpe(
289     redeclare final package Medium=Medium,
290+    final m_flow_nominal=m_flow_nominal,
291+    final dp_nominal=dp_nominal,
292     final allowFlowReversal=allowFlowReversal,
293     addPowerToMedium=false,
294     use_inputFilter=false,
295     energyDynamics=Modelica.Fluid.Types.Dynamics.Ste
296     "Distribution pump with prescribed speed (fracti
297     annotation (Placement(transformation(extent={{-5
```

AFTER

- Thank you!

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