Documentation

Matlab Codes

ExpanderModel.mat

1. Model name:

ExpanderModel.mat

2. Model description:

ExpanderModel.mat is a matlab function developed for the simulation of volumetric expanders. Three modelling paradigms are currently implemented to simulate the expander, i.e.

- CstEff: a "constant efficiency" model into which constant values for both the isentropic efficiency and the filling factor are provided by the user, i.e.

  - $\varepsilon_{is} = \frac{\dot{W}_{exp,mec}}{\dot{m}_{exp}\ (h_{su} - h_{ex,is})} = \bar{\varepsilon}_{is}$
  - $FF = \frac{\dot{V}_{exp}}{\dot{V}_{th}} = \overline{FF}$

  Heat losses to the ambience are also included by means of a global AU_{loss} coefficients i.e.

  - $\dot{Q}_{loss} = AU_{loss}(T_{su} - T_{amb})$
  - $\dot{m}_{exp}(h_{su} - h_{ex}) = \dot{W}_{exp} + \dot{Q}_{loss}$

- PolEff: a "polynomial efficiency" model into which quadratic polynomial regressions are used to evaluate both the volumetric efficiency (i.e. the filling factor) and the isentropic efficiency, i.e.

  - $\varepsilon_{vol} = \sum_{i=0}^{2}\sum_{j=0}^{2}\sum_{k=0}^{2} a_{ijk} N_{pp}^{j} \left(\frac{P_{ex}}{P_{su}}\right)^{i} {\rho_{su}}^{k}$
  - $FF = \sum_{i=0}^{2}\sum_{j=0}^{2}\sum_{k=0}^{2} a_{ijk} N_{pp}^{j} \left(\frac{P_{ex}}{P_{su}}\right)^{i} {\rho_{su}}^{k}$

  Heat losses to the ambience are also included by means of a global AU_{loss} coefficients as in the CstEff model.

- SemiEmp: a "semi-empirical" model implementing physics-based equations as proposed by Lemort et al. in [1]. This model decomposes the evolution of the fluid into a series of 6 consecutives steps and a detailed description of the modelling scheme can be found in [1].[1]

[1] [1] V. Lemort, S. Quoilin, C. Cuevas, and J. Lebrun, "Testing and modeling a scroll expander integrated into an Organic Rankine Cycle," *Appl. Therm. Eng.*, vol. 29, no. 14–15, pp. 3094–3102, 2009.

3. Model inputs:

The model inputs are the following ones:

- P_su (Pa) : inlet pressure of the pump;
- P_ex (Pa) : outlet pressure of the pump;
- h_su (J/kg) : inlet enthalpy of the pump;
- fluid (-) : fluid name;
- N_exp (rpm) : pump rotational speed;
- T_amb (K) : ambient temperature;
- param : a structure variable that contains the model parameters (see next section);

4. Model parameters:

Depending of the type of model chosen by the user, *param* will need to include the following variables:

- if param.modelType = 'CstEff':
  - param.V_s (m^3) : machine displacement volume;
  - param.V (m^3) : machine volume;
  - param.epsilon_is (-): isentropic efficiency;
  - param.FF (-): filling factor (volumetric efficiency);
  - param.AU (W/K) : global heat losses coefficient;

- if param.modelType = 'PolEff':
  - param.V_s (m^3), machine displacement volume;
  - param.V (m^3) : machine volume;
  - param.N_pp_nom, pump nominal shaft speed;
  - param.coeffPol_is (-), polynomial coefficients for epsilon_is;
  - param.coeffPol_ff (-), polynomial coefficients for FF;
  - param.AU (W/K) : global heat losses coefficient;

- if param.modelType = 'SemiEmp':
  - param.V_s (m^3), machine displacement volume;
  - param.V (m^3) : machine volume;
  - param.alpha (-), proportional losses coefficient;
  - param.W_dot_loss_0 (W), constant losses term;
  - param.C_loss (Nm), losses torque;
  - param.r_v_in (-), built-in volumetric ration;
  - param.A_leak0 (m^2), nozzle cross section area for the leakage;
  - param.d_su (m), nozzle diameter for supply pressure drop;

- param.AU_su_n (W/K), global heat transfer coefficient for supply heat transfer;
- param.AU_ex_n (W/K), global heat transfer coefficient for exhaust heat transfer;
- param.AU_amb (W/K), global heat transfer coefficient for ambient heat losses;
- param.M_dot_n (kg/s), nominal mass flow rate;

5. Model outputs:

The outputs are two structure variables, namely *out* and *TS*, and they contain the following sub-variables:

- **out** (structure variable with all the relevant model outputs). At minimum, **out** will include
  - T_ex (K): outlet temperature of the expander;
  - h_ex (J/kg): outlet temperature of the expander;
  - M (kg) : mass of fluid inside the component;
  - M_dot (kg/s) : fluid mass flow rate;
  - W_dot (W) : net mechanical power;
  - Q_dot_amb (W) : heat losses;
  - epsilon_is (-) : expander isentropic efficiency;
  - FF (-) : filling factor;
  - time (sec) : the simulation time
  - flag (-): the model flag (>0 if the model run correctly, <0 if not)

  In the case of the SemiEmp model, **out** will also include all the intrinsic variables of the model;

- **TS** (structure variable only used to plot the Ts diagram)
  - T (K) : vector of the fluid temperatures
  - s (J/kg.K) : vector of the fluid entropies

6. External function requirements:

The user must install CoolProp (http://www.coolprop.org/) to run ExpanderModel.

7. Matlab version:

This code has been developed under Matlab R2015a

8. Contact:

For any further information, please contact one of the main developers of ORCmKit:

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