33rd HEXAG Meeting

WORK IN PROGRESS (IMPROMPTU)
Domestic air source heat pump model informed by field data

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Outline

- DECC's *Future of Heating* strategy envisages a dramatic increase in UK domestic heat pump use in the coming years
- Considerable field data starting to emerge from domestic heat pump trials[1,2,3]
- Most of these results show disappointing UK performances – we need to find out why and fix it
- A new model is proposed which can be easily parameterised using manufacturer's rated performance data
- Model tests based on a very small sample of the field data[1,2,3] look good
- More evaluation is ongoing – the results will help to determine remedies to our disappointing heat pump results

1. Getting warmer – a field trial of heat pumps (Energy Saving Trust)
2. The heat is on – heat pump field trials phase 2 (Energy Saving Trust)
3. Lowe, R., Department of Energy and Climate Change. (2016). *Renewable Heat Premium Payment Scheme: Heat Pump Monitoring, 2013-2015*. [data collection]. UK Data Service. SN: 7955, http://dx.doi.org/10.5255/UKDA-SN-7955-1.

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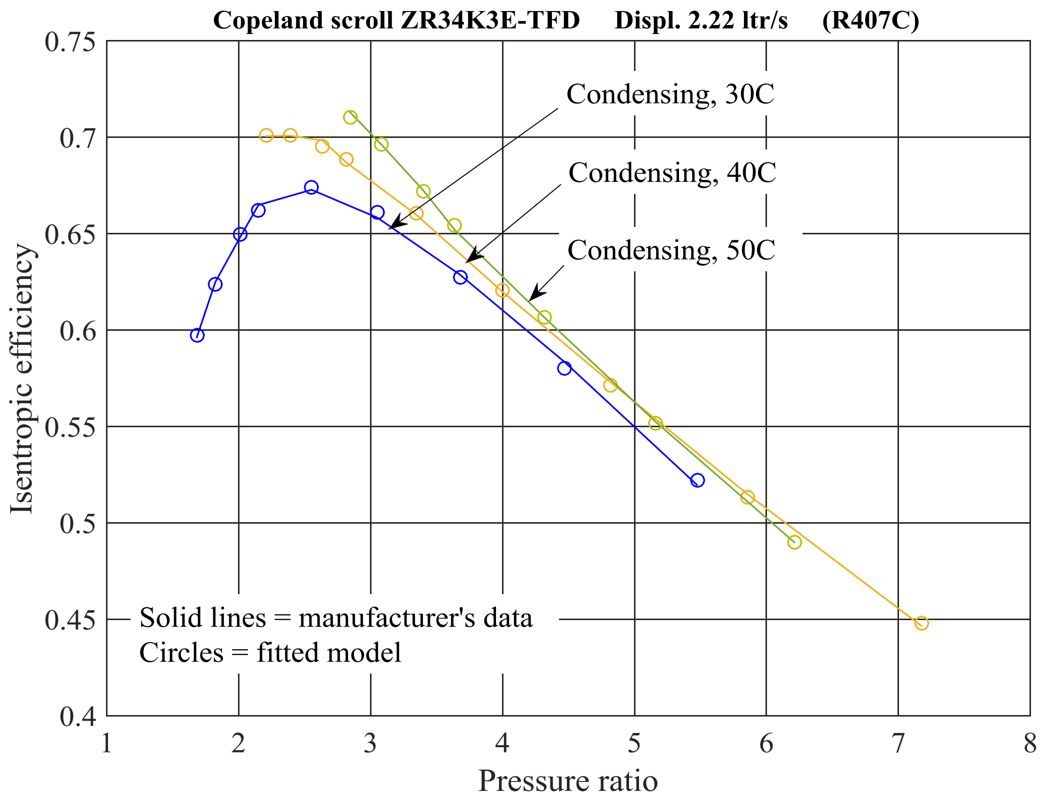
New isentropic efficiency model



$$\eta_{\text{isen}} = \frac{a\exp\left(-b\left(R-c\right)\right)}{1+\exp\left(-d\left(R-c\right)\right)}$$

= 4 parameters ($a \ldots d$) – one less than the more common 4^{th}-order polynomial model

Model interpretation

$$T_{\mathrm{e}} = T_{\mathrm{ao}} - \Delta T_{\mathrm{e}}$$

$$T_{\mathrm{c}} = T_{\mathrm{htgsys}} + \Delta T_{\mathrm{c}}$$

$$R = P_{\mathrm{c}} / P_{\mathrm{e}} \quad (P_{\mathrm{c}} = \mathrm{f}(T_{\mathrm{c}}); P_{\mathrm{e}} = \mathrm{f}(T_{\mathrm{e}}) \text{ from refrigerant properties})$$

$$W_{\mathrm{isen}} = \frac{n}{n-1} P_{\mathrm{e}} v_{\mathrm{reo}} \left(R^{\frac{n-1}{n}} - 1 \right) \quad (v_{\mathrm{reo}}, n \text{ from refrigerant properties})$$

$$W_{\mathrm{overall}} = \frac{W_{\mathrm{isen}}}{\eta_{\mathrm{isen}}} + W_{\mathrm{aux}}$$

$$Q_{\mathrm{c,adjusted}} = Q_{\mathrm{htgsys}} \times F_{\mathrm{defrost}}$$

$$F_{\mathrm{defrost}} = \text{defrost discount factor} = \min\left(1, e + f \times T_{\mathrm{ao}}\right)$$

$$CoP = \frac{Q_{\mathrm{c,adjusted}}}{W_{\mathrm{overall}}}$$

INPUTS: $Q_{\mathrm{htgsys}}, T_{\mathrm{htgsys}}, T_{\mathrm{ao}}$ PARS TO BE FITTED: $a \ldots f, W_{\mathrm{aux}}, \Delta T_{\mathrm{e}}, \Delta T_{\mathrm{c}}$ (9)

Parameterisation

Par:	a	b	c	d	ΔT_e	ΔT_c	W_{aux}	e	f
Mean:	0.808	0.151	1.228	3.999	10.025	7.024	0.277	0.877	0.00478
σ**:**	0.055	0.024	0.081	0.002	0.031	0.029	0.041	-	-

- $a \ldots d$, ΔT_e, ΔT_c, W_{aux} fitted using A7/W35 capacity standard in EN 14511:2007
- *e* and *f* (defrost parameters) fitted to detailed experimental data from laboratory heat pump
- Using 10 commercial heat pump suppliers and a total of 12 alternative heating capacities (including the laboratory unit)
- Parameters fitted using a constrained optimisation algorithm

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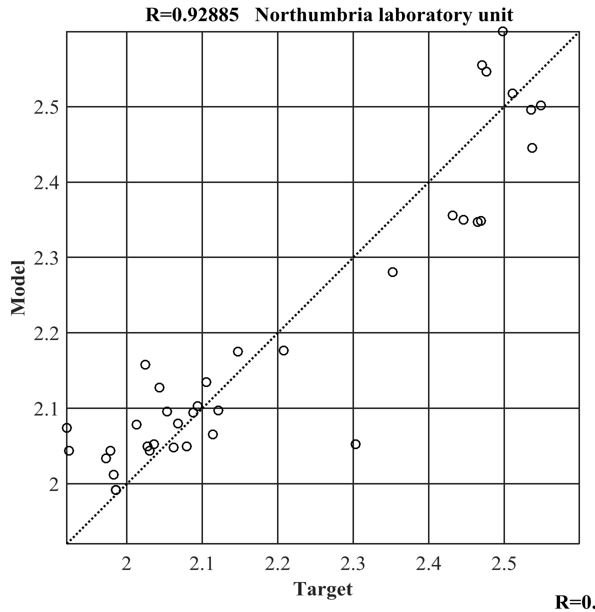
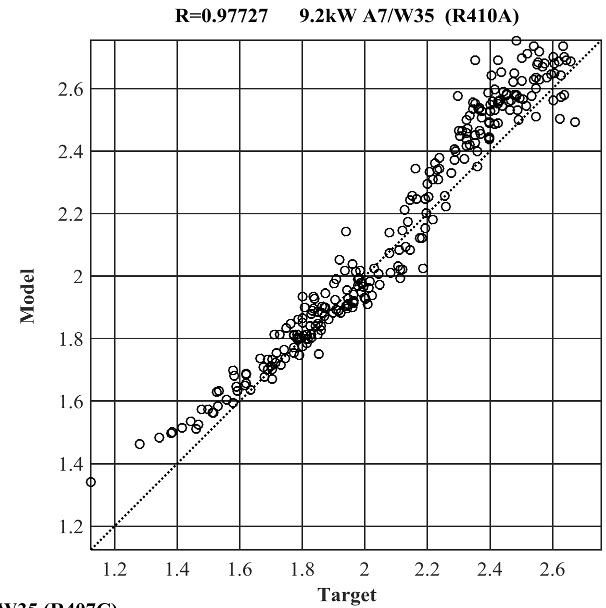
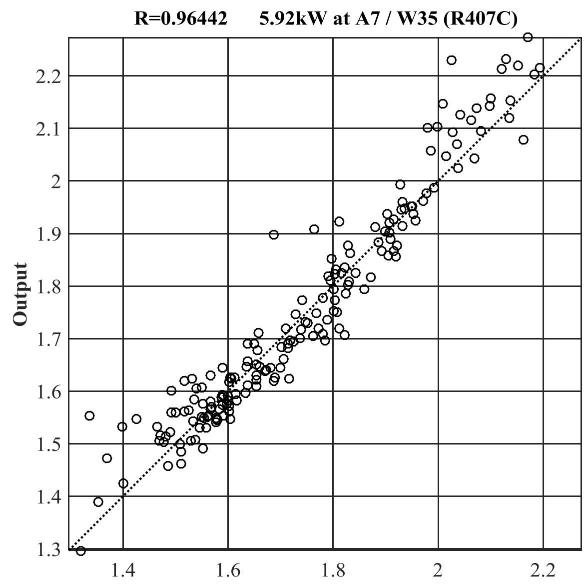
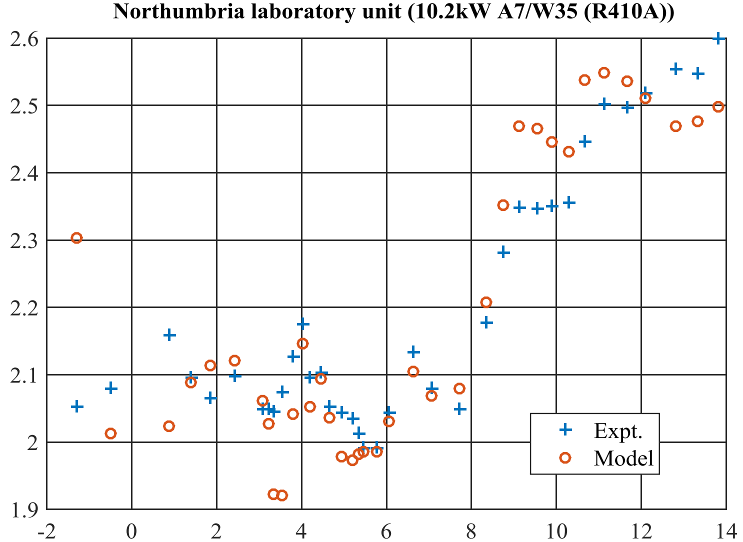
Model tested using data from UK domestic field trials[3]
1: Model on field data regression (*CoP*)

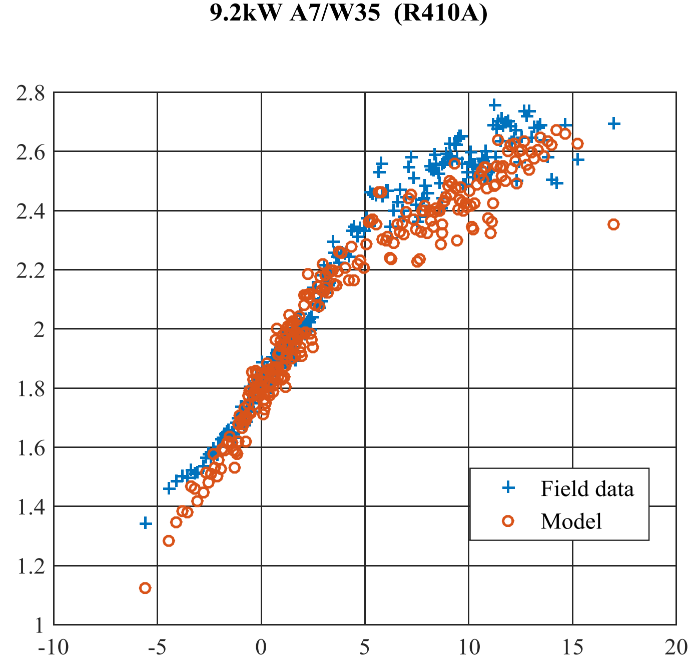


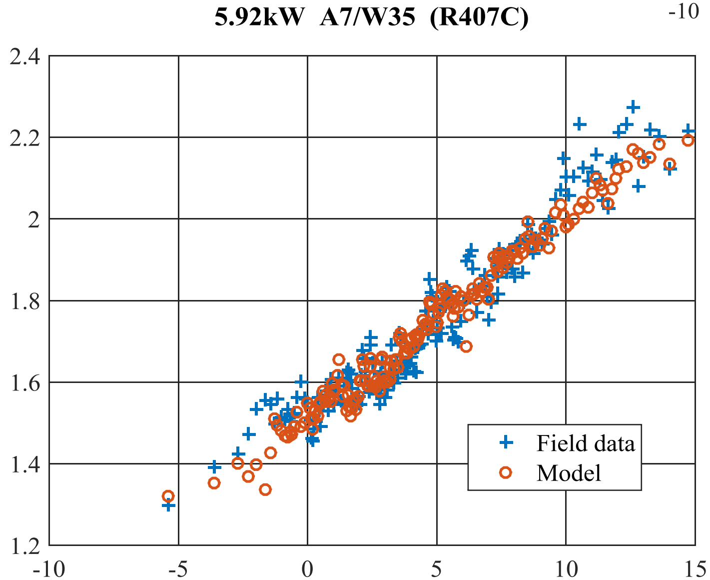




2: *CoP* vs source air temperature (T_{ao})







3: *CoP* vs temperature lift (T_{htgsys} - T_{ao})