I like your approach, and I use it often to interpret experimental measurements. However, if the parameter that I find is non-physical (i.e., a heat transfer problem where a negative emissivity provides the best fit of the data), then one might question the model. The model at that point becomes a curve fitting exercise, and if one has enough free parameters, then you can fit any data set (even if the model is bad). Extrapolation of such a model beyond the range of the data then is very suspect.

Why do you report such small error (+/- 80) on the flow rates? This appears in 4 places on slide 5. Is that what you determine? I do not know anybody that would justify such a small number.