About Simulation of Buildings and HVAC Systems

0. **Introduction**

1. HOW TO SIMULATE

Rendez vous de l'ATIC

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0. Introduction

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Simulation may help a lot at all stages of a building life cycle: Design, balancing, commissioning, management, audits and retrofits.

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At design stage:

- Prediction of actual performances to be expected from different technical options
- Satisfactory optimization…

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Balancing and commissioning:

- Correcting and tuning actions
- Performances verifications.

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Management:

- Optimal control
- Fault detection
- Preventive maintenance

Powerful computers are too often “sleeping” or dedicated to too elementary tasks…

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Audit:

- Satisfactory diagnosis
- Identification of most promising retrofit opportunities

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1. How?

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How to simulate?

- "*Causalities*" are for *our* understanding (not for the computer!):
- We like to speak of "Causes" and "Consequences"
- i.e. of "*Inputs*" and "*Outputs*"
- Constant inputs are "*parameters*"

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Simulation must be adapted to:

- objectives
- information looked for

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Make sure that:

- The output variables correspond to what the user is asking for;
- The calculation is accurate enough;
- The input variables are accessible;
- The parameters are identified without ambiguity;
- The user can understand!

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- Computer capabilities are growing much faster than our understanding of the physical phenomena we pretend to simulate

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- “Observe” each component according to its actual impact on global simulation results
- Take profit of all “filtering” effects

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Information flow diagrams

- Start from the end (as in daily life!):
- “What are we looking for?”
- And travel up-stream, until the begin:
- “What do we need?”

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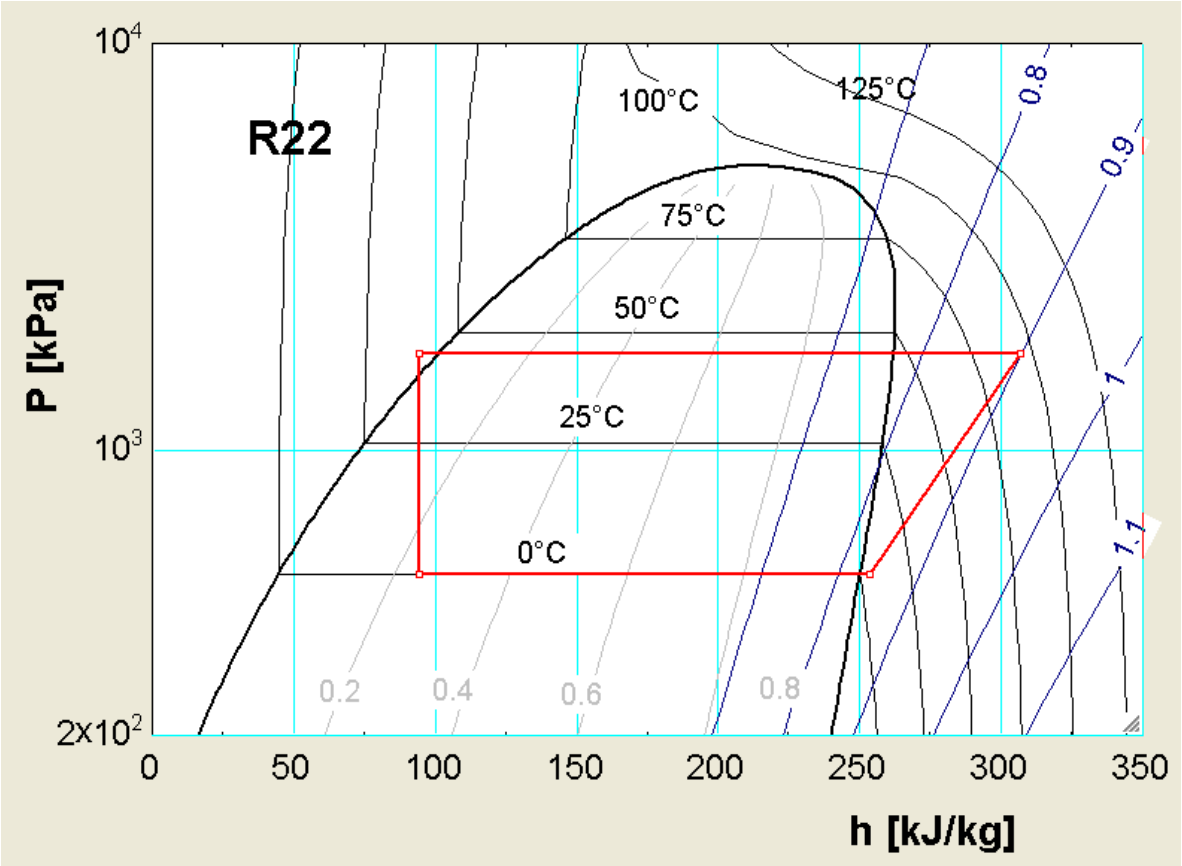
Example: a vapor-compression refrigeration cycle



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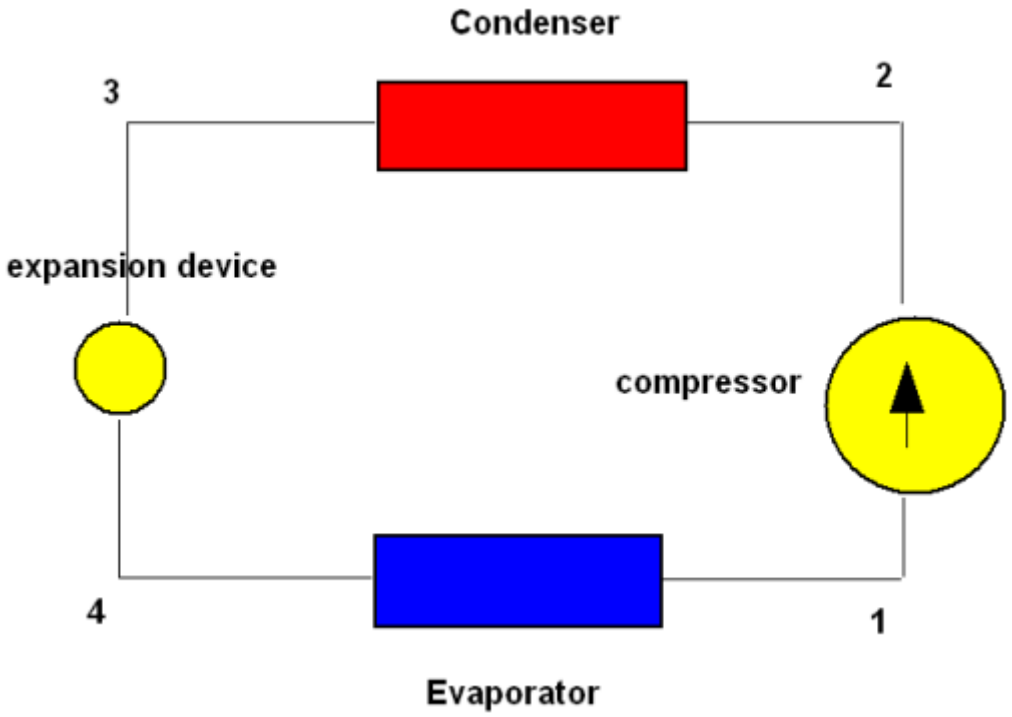
Main components:



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Two questions
(also as in daily life!):

- “How much?”
- “At which cost?”

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Starting from the “hart” of this system: the compressor…

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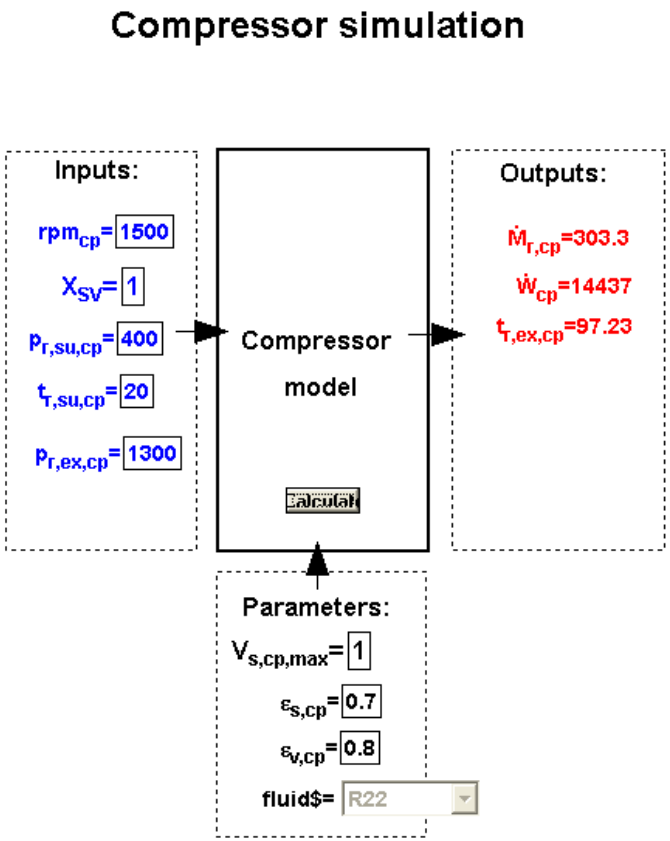
The compressor alone:



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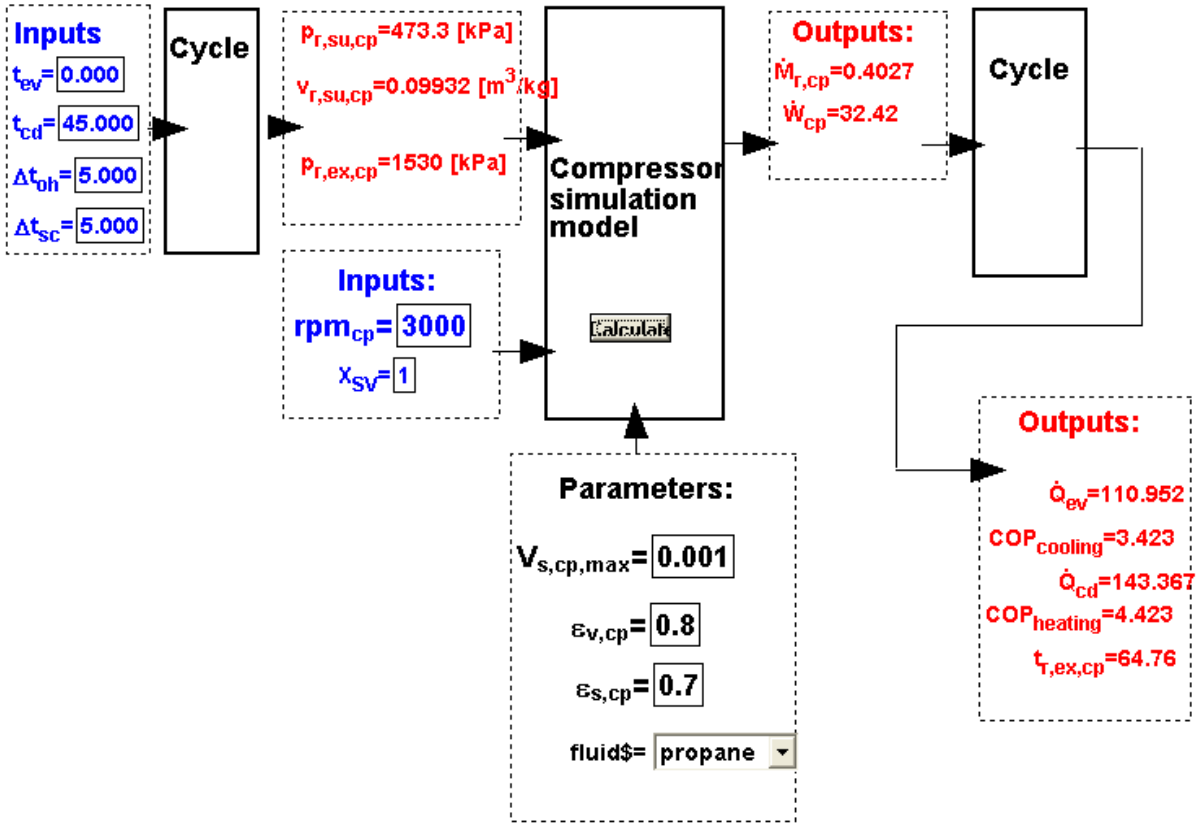
The compressor in the refrigeration cycle:



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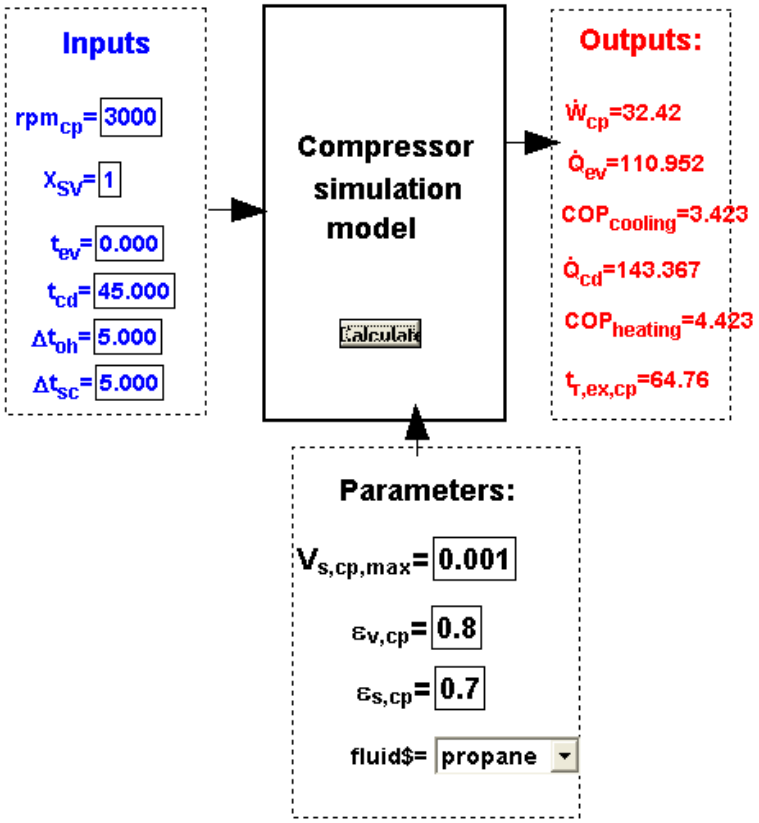
Combination :



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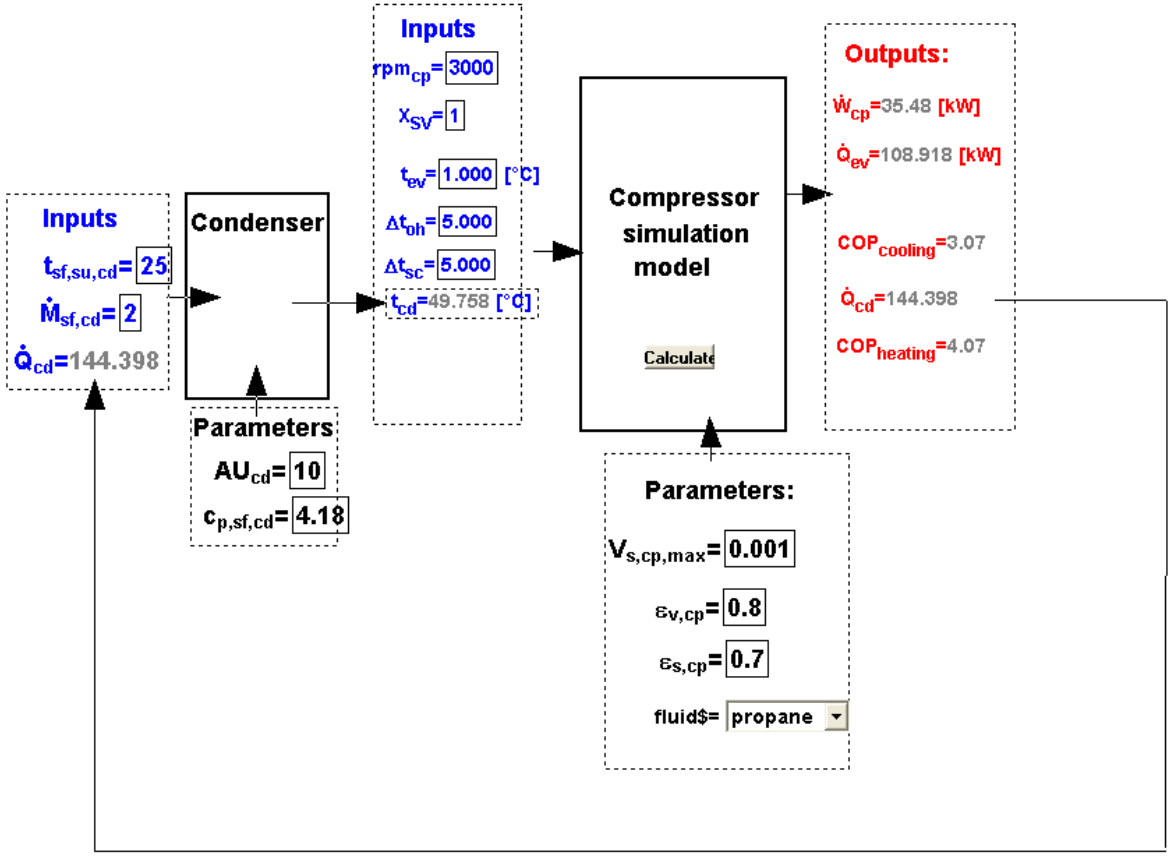
The condensing unit:



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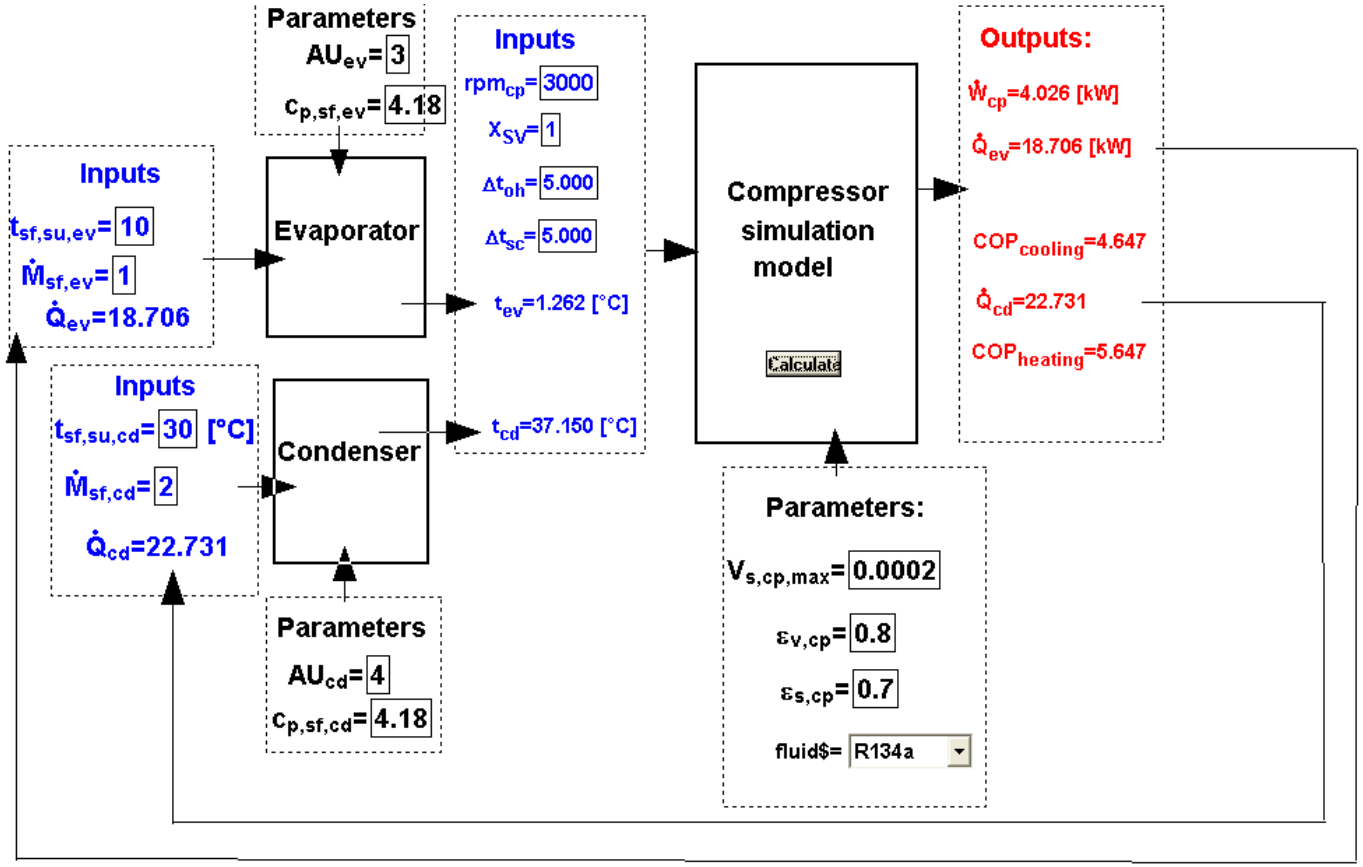
Condensing unit + evaporator:



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“Mother”, “daughter” and “orphan” models:

- *How to choose?*

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Two typical cases:

1) “Simplified” model preferred when the component is well known

2) More detailed model preferred when the component “makes problem”, i.e. its characteristics must be (re)identified

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. “Mother” models:

- Based on real physics,
- Application-oriented
- Based on old children game: “let’s do as if”.

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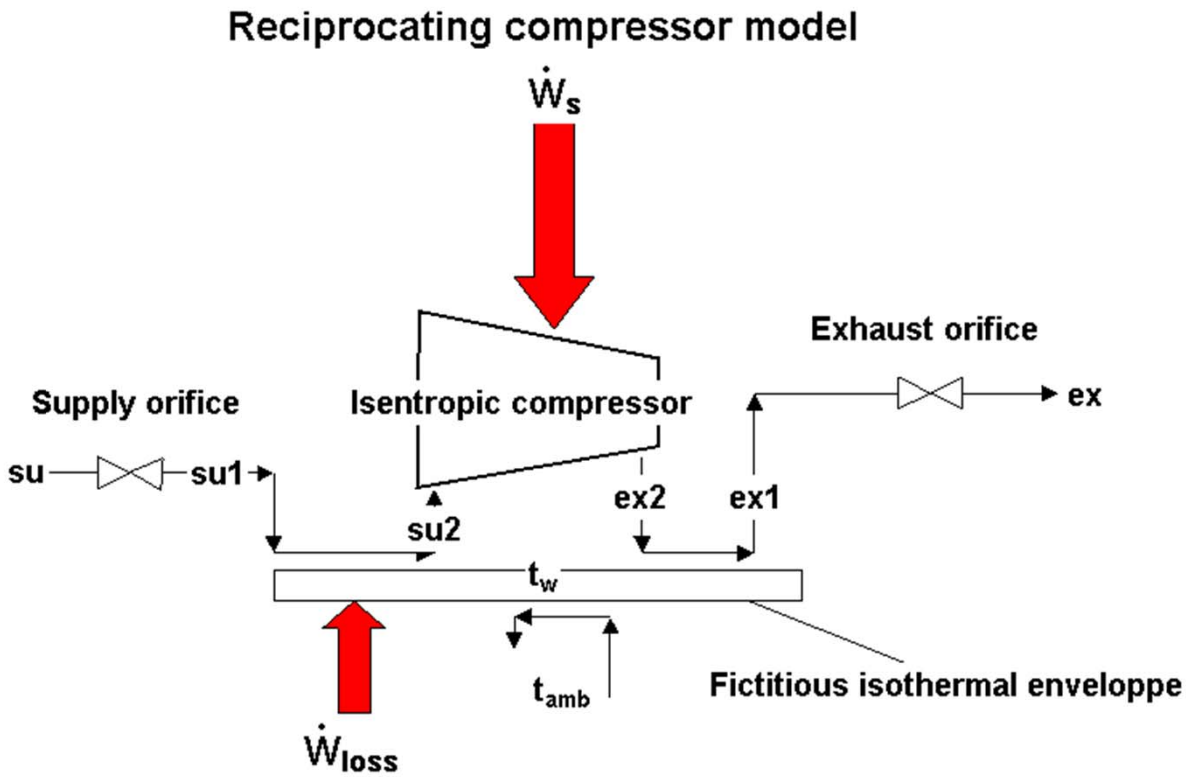
Example of mother model: conceptual schema of a reciprocating compressor



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- Such detailed model might be too much “deterministic”
- i.e. containing too many parameters
- whose respective influences are difficult to discriminate…

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“Simplified” models:

- Welcome to simulate a large system on a large time period
- Friendly calculation tools badly needed
- Making it understandable more urgent than reducing the number of equations
- Similarity laws welcome
- Simple polynomial laws very often sufficient
- Global modelling optimisation badly needed
- No a priori judgement about what is negligible!

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“Orphan” models:

- directly tuned by laboratory tests without passing through any reference
- Similarity laws are then very helpful

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Tuning, validation and evaluation

- Caution to accuracy and to meaning of experimental and simulation data
- “The most beautiful girl couldn’t give more than what she has!”

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Tuning:

- Even if “mechanistic”, the model has to be tuned *before* validation
- There is no shame in that,
- But the tuning should not depend on the humor of the user…

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Validation:

It can be performed in three ways:

- Analytically
- By comparison with *other* simulation results
- By comparison with experimental results.

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Evaluation:

Qualitative evaluation must integrate:

validation results

tuning easiness

Robustness

…

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Use of an equation solver

- Scientists and practitioners have to speak to each other
- Using an equation solver makes equations as easy to read as a good novel!

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