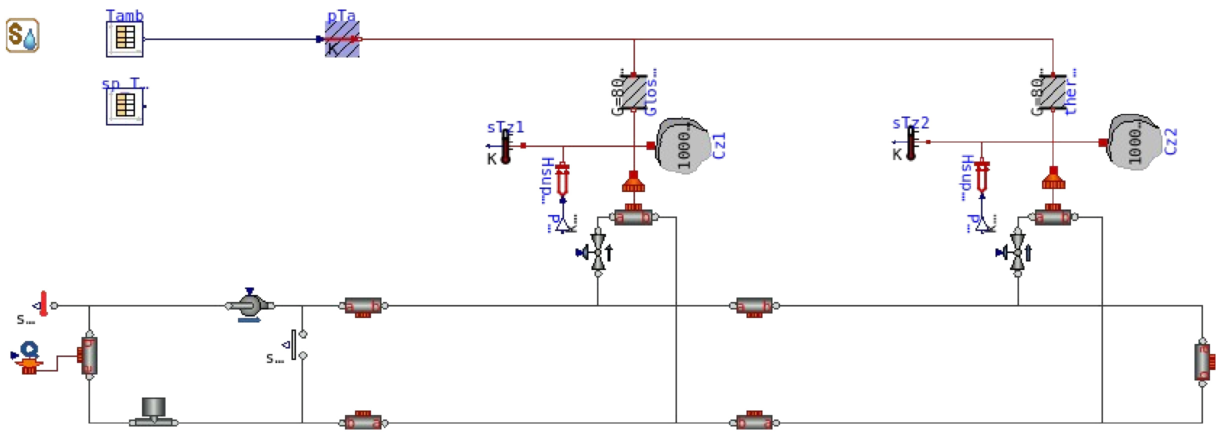
Automation of Energy Systems – A. Leva

Project for the academic year 2021/2022

Consider the small heating system composed of one central heater and two utilisers depicted in the following Modelica block diagram, that corresponds to the model named `Plant_heater_without_control` in the provided project library.



Assignment 1

Complete the scheme with

- a control loop to regulate the temperature at the outlet of the heater represented by the pipe on the left, acting on the power released to that pipe;
- a loop to control the pressure difference between the forward (top) and the return (bottom) piping, measured by the differential pressure sensor near to the pump, by acting on the pump itself;
- a loop to govern the temperature of thermal zone 1 (the heat capacitor near the diagram centre) acting on the corresponding valve and the electric heater near the valve in a daisy-chain configuration,;
- an analogous loop for thermal zone 2 (thermal capacitor on the right).

In the said loops, employ PI/PID controllers with tracking functionality (available in the AES library) for the reasons clarified in the following. For simulation efficiency, analogue controllers are suggested.

The set point for the heater outlet temperature shall be constant and around 40-50°C; the set point for the forward-return pressure difference shall be around 2 bar; the set points for the two thermal zone temperatures shall be equal and provided by the Modelica `CombiTimeTable` component named `sp_Tzones` (top left in the diagram); another such component named `Tamb` (similar position in the diagram) prescribes the ambient temperature as a boundary condition, and must not be modified.

Name the so completed scheme `Plant_heater_with_control_1` and save it in the project library.

Assignment 2

Tune the introduced controls under the hypothesis that the heating system is always active. You can use whatever technique you deem convenient, also performing simulated open-loop experiments such as step responses if you need to do so: the only mandatory requirement is that your tuning must be accompanied by some motivation and properly documented (e.g., with plots).

After providing a first tuning for the scheme, try possible different combinations of heater temperature and pressure difference set points – as well as tuning refinements – in an attempt to reduce the overall consumption (which you can obtain from the variables available in the model components by adding the necessary equations to the `Plant_heater_with_control_1` model). The simulation horizon for all the project is ten days, as set in the provided model.

In this part of the assignment do not overkill: you just need to demonstrate the capability of reasoning properly on the problem, and acting consequently. Here too, (briefly) motivating your decisions is a requirement.

Assignment 3

Suppose now that the control has to function in a "day" and a "night" mode, which you will realise by duplicating (some of) the controller blocks and properly using their tracking functionality to set either of the two in each couple into operation.

- The "day" control will act as in assignment 2 to maintain the set points.
- The "night" control will conversely aim for just keeping both zone temperatures above 5°C excluding the use of the electric heater. You can use the `Modelica.Blocks.Logical.Switch` component for realising the control signal selection. Refer to the Modelica help system for the use of components taken from the Modelica Standard Library.

Name the so created scheme `Plant_heater_with_control_2` and save it in the project library.

Assignment 4

Tune the new scheme as per assignment 3. You can decide freely the time to enter and leave the "night" mode, provided this does not impact too much on the control quality (i.e., the set point tracking) during the "day" mode.

You can also change the way to manage the heater outlet temperature and the pressure difference, for example altering their set points depending on the operating mode ("day" or "night") or taking whatever action you wish, if you believe that this is convenient for reducing the overall consumption.

Also in this assignment, do not overkill (for the same reason as above) but pay attention to properly motivating your decisions.

Documentation and delivery

Once you carried out the assignments above, proceed as follows.

- Create a presentation of *approximately* 15 slides to describe your work.
- With the aid of the said presentation create a screencast of maximum 15 minutes (first *sharp* constraint) where all the team members (second *sharp* constraint) have to participate into the explanation. The team is expected to be composed of four members.
- Name the presentation **Slides.xxx** and the screencast **Video.yyy**, the **xxx** and **yyy** extensions depending on the file format you use (for the screencast mp4 is preferred, but not mandatory). To ease revision, please provide the slides in an editable format such as .ppt(x), .odp, .tex and so forth. At the same time, to deal with possible compatibility issues, please also provide a **Slides.pdf** file.
- Create a text file named **Team-members.txt**, containing the family name(s), given name(s) and polimi person codes of all the team members.
- Pack the library with the models you created and all the files above into a single compressed file named

  AES-2021.2022-Name.zzz

  where the **zzz** extension depends on the particular compressed format employed, while **Name** is the (first) family name of the team member who comes alphabetically first.
- Deliver only the so created compressed file via WeBeep. A delivery folder will be created for each exam call, with expiration date set to the day of the written test. Please respect the deadlines, you have plenty of time.