**MAGNET\_COPY\_1**: This was created as a learning exercise to understand Dymola. Data (combiTimetable and combiTimetable1) was given by Scott Greenwood in his own version of MAGNET. Dynamic results for 40000 seconds.

**MAGNET\_Insulated\_pipes**: This version is updated from MAGNET\_COPY\_1 using insulated pipes and added correct pipe lengths for all the pipes. Pipe material is SS316 with insulation as fiber glass. Dynamic inputs used are given by Scott Greenwood.

**MAGNET\_PID\_3**: This was created to calculate the new UA values for the recuperator and the heat exchanger in MAGNET with updated insulated pipes and lengths.

**MAGNET\_Insulated\_pipes\_SS**: Steady state results of MAGNET with insulated pipes and pipe lengths added.

**MAGNET\_TEDS\_Boundaries\_1**: MAGNET-TEDS integration with a simple heat exchanger, MAGNET side. Boundaries are used to represent the TEDS side with input of mass flow and inlet and outlet Temperature.

Using a constant input (Q\_vc and m\_flow) for MANGET as well as TEDS (m\_flow and T\_in and T\_out) to calculate UA values for the MAGNET\_TEDS\_simpleHX using a PID controller.

**TEDS\_MAGNET\_1**: MAGNET-TEDS integration with a simple heat exchanger, TEDS side. Boundaries are used to represent the MAGNET side with input of mass flow and inlet and outlet Temperature. Using the UA value calculated in MAGNET\_TEDS\_Boundaries\_1, a PID controller is used to control the mass flow from MAGNET to the heat exchanger, with a temperature set point on the TEDS side set to equal the nominal value of charging temperature (325 oC).

TEDS side: the BOP demand as well as the heat demand is set to change, creating a dynamic simulation of the system.

**MAGNET\_TEDS\_1**: MAGNET-TEDS integration with a simple heat exchanger, MAGNET side. Boundaries are used to represent the TEDS side with input of mass flow and inlet and outlet Temperature. UA value calculated in MAGNET\_TEDS\_Boundaries\_1, a PID controller is used to control the mass flow from TEDS into the heat exchanger, with an outlet temperature set point on the TEDS side set to equal the nominal value of charging temperature (325 oC).

MAGNET side: the heat input of the vacuum chamber as well as the mass flow of the MAGNET system are set to be constant, making this a steady state simulation.

**MAGNET\_TEDS\_2**: MAGNET-TEDS integration with a simple heat exchanger, MAGNET side. Boundaries are used to represent the TEDS side with input of mass flow and inlet and outlet Temperature. UA value calculated in MAGNET\_TEDS\_Boundaries\_1, a PID controller is used to control the mass flow from TEDS into the heat exchanger, with an outlet temperature set point on the TEDS side set to equal the nominal value of charging temperature (325 oC).

MAGNET side: the mass flow of the MAGNET system is set to be constant, while the heat input of the vacuum chamber is a step function, making this a dynamic simulation. The mass flow from TEDS into the heat exchanger is changed to keep the outlet temperature constant as the heat input is changed.

**MAGNET\_TEDS\_3**: MAGNET-TEDS integration with a simple heat exchanger, MAGNET side. Boundaries are used to represent the TEDS side with input of mass flow and inlet and outlet Temperature. UA value calculated in MAGNET\_TEDS\_Boundaries\_1, a PID controller is used to control the mass flow from TEDS into the heat exchanger, with an outlet temperature set point on the TEDS side set to equal the nominal value of charging temperature (325 oC).

MAGNET side: the heat input of the vacuum chamber is set to be constant, while the mass flow of the MAGNET system is a step function, making this a dynamic simulation. The mass flow from TEDS into the heat exchanger is changed to keep the outlet temperature constant as the MAGNET flow is changed.

**TEDS\_MAGNET\_Q\_vc\_1:** MAGNET-TEDS integration with a simple heat exchanger, both sides connected. UA values used is calculated from MAGNET\_TEDS\_Boundaries\_1, a PID controller is used to control the heat rate from the vacuum chamber with an upper limit of 400 kW.

**TEDS\_MAGNET\_Q\_vc\_2:** MAGNET-TEDS integration with a simple heat exchanger, both sides connected. UA values used is calculated from MAGNET\_TEDS\_Boundaries\_1, a PID controller is used to control the heat rate from the vacuum chamber with an upper limit of 250 kW. A constant mflow on the MAGNET side is used. Use dsin\_Qvc\_2.txt as initial file.

**TEDS\_MAGNET\_Q\_vc\_mflow:** MAGNET-TEDS integration with a simple heat exchanger, both sides connected. UA values used is calculated from MAGNET\_TEDS\_Boundaries\_1, a PID controller is used to control the heat rate from the vacuum chamber with an upper limit of 250 kW. A PI controller is used to moderate the mflow on the MAGNET side to keep the temperature coming out of the vacuum chamber (pT\_vc\_pipe.T) constant at 602 C. Use dsin\_Qvc\_mflow\_MAGNET.txt as initial file.

**TEDS\_MAGNET\_Q\_vc\_SS:** MAGNET-TEDS integration with a simple heat exchanger, both sides connected. UA values used is calculated from MAGNET\_TEDS\_Boundaries\_1, a PID controller is used to control the heat rate from the vacuum chamber with an upper limit of 400 kW. The TEDS control hub is Control\_System\_Therminal\_4\_element\_SS, with the BOP\_total\_demand and the Heater\_total\_demand set to 100% (which is equal)

**TEDS\_MAGNET\_valve:** MAGNET-TEDS integration, controlling the valve positions in the MAGNET loop now instead of the amount of heat generated in the vacuum chamber. The central control is modified to control all the valves from both MAGNET and TEDS. Use ds\_valve\_TEDS\_in.txt as initial file.

Valve 1 (Valve\_vc\_TEDS) is controlled by first calculating the amount of heat needed to heat the therminol66 from the TEDS side from Tin\_TEDside to 325 C.

A necessary mass flow is calculated from the heat needed as:

An error value is calculated based on the difference between the mass flow needed and the actual mass flow to control the valve opening of valve 1:

Valve 2 (valve\_vc\_rp) is controlled by first calculating the left-over mass flow that is not needed to heat the therminol66:

An error value is calculated based on the difference between the mass flow needed and the actual mass flow to control the valve opening of valve 2:

Valve 3 (valve\_TEDS\_rp) is controlled via an interlocking system with valve 1. If valve 1 is open, valve 3 is open. If valve 1 is closed, valve 3 is closed. This is done in the code with the following if then logic:

If m\_needed>0.001 then

Error3\_MAGNET := 1;

Else

Error3\_MAGNET:=-1;

End if;

**MAGNET\_TEDS\_valve\_1:** A simplified version of the TEDS\_MAGNET\_valve, where MAGNET is integrated with TEDS, the amount of heat transferred to TEDS is controlled by the valves (valve\_vc\_TEDS which controls the valve between the vacuum chamber and TEDS, valve\_TEDS\_rp which controls the valve between TEDS and the recuperator, and valve\_vc\_rp which controls the valve between the vacuum chamber and the recuperator)

A steady-state flow rate of 0.689 kg/s coming from TEDS at a constant T at 225 C gets heated by the fluid coming from the MAGNET loop through the MAGNET\_TEDS\_simple\_HX. The outlet temperature of the TEDS side is set to 325 C.

A flow controller to control the flow inside the MAGNET loop is set up to keep the temperature leaving the vacuum chamber constant at 602 C.

Sensors are used to measure the flow rate inside the MAGNET loop (mflow\_co\_rp\_2), the flow rate inside the TEDS loop coming into the heat exchanger (TEDS\_flow\_rate), as well as the flow rate flowing from the vacuum chamber to TEDS (mflow\_vc\_TEDS) and the flow rate from the vacuum chamber to the recuperator (mflow\_vc\_rp). Temperature sensors are also used to measure the inlet temperature of the MAGNET side into the heat exchanger (T\_vc\_TEDS), temperature exiting the heat exchanger from the MAGNET side (pT\_TEDS\_rp), temperature entering the heat exchanger from the TEDS side (TM\_HX\_Tin).

The control logic is based on these measurements as follows:

First, the amount of heat needed to heat up the fluid from the TEDS side from its inlet temperature to its set point of 325 C:

Then the amount of flow rate needed from the MAGNET side to heat up the TEDS fluid is calculated:

An error value is calculated based on the actual measurement of the flow rate from the vacuum chamber to TEDS and the amount of flow rate needed:

This error value is set to 0 through a PID controller, which controls the valve position between the vacuum chamber and TEDS to meet the flow rate needed.

The amount of flow rate left is calculated as:

An error value is calculated based on the actual measurement of the flow rate from the vacuum chamber and the recuperator and the amount of flow rate left:

This error value is set to 0 through a PID controller which controls the valve position between the vacuum chamber and the recuperator to meet the flow rate left.

Valve 3 (valve\_TEDS\_rp) is controlled via an interlocking system with valve 1. If valve 1 is open, valve 3 is open. If valve 1 is closed, valve 3 is closed. This is done in the code with the following if then logic:

If m\_needed>0.001 then

Error3\_MAGNET := 1;

Else

Error3\_MAGNET:=-1;

End if;

**MAGNET\_TEDS\_valve\_2:**  A dynamic version of **MAGNET\_TEDS\_valve\_1**¸with the inlet temperature on TEDS side ramp down to 210 C starting at time 1000s. The flow rate from TEDS was also reduced from .689 kg/s to .289 kg/s starting at time 2000s. Simulated for 18000s.