# Dynamic simulation models in the planning of experiments for control development

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**Abstract:** This paper focuses on the utilization of dynamic simulation models in the planning of experiments for control development. The simulation system is a set of models based on the first principles for system level simulation of the complete TCP-100 research facility at Plataforma Solar de Almería (CIEMAT). This new research facility replaced the 32-year-old ACUREX facility with which so many advances in Automatic Control were reached by the research community. The dynamic models are developed to speed up this research for the new field. The part for control development is the solar field whose parabolic trough collectors (PTCs) are modelled at module level and combined into PTCs and loops. The presented models of the parabolic trough field (PTC) will be validated with experimental data and the controllers will be tested under real conditions. The sequential loops have different operating conditions. This research uses the parameters based on the parameter selection from providers' data sheets and the engineering design project of the TCP-100. The system level model has been implemented in the Modelica language. All state variables are temperatures according to the modelling hypothesis applied, and the inputs of the model are: solar radiation, ambient temperature, setpoints for both circuits pumps, setpoints for two loops control valves, and setpoint for air cooling power. The simulation experiments are first focused on the modules, PTCs and loops of the solar field and the full model need to be extended with dynamic LE models before going to the full simulation tests. In the test campaigns with the new facility, the dynamic LE models are used for planning the test cases.

*Keywords:* nonlinear scaling, uncertainty, dynamic modelling, first principles, simulation, operation of solar PTC plants

## 1. INTRODUCTION

Modelling and Control of solar thermal power plants is among the research activities performed at Plataforma Solar de Almería (PSA, PSA-CIEMAT). In the past, active developments of mathematical models and control techniques were done with the ACUREX experimental research facility whose key unit was a parabolic trough collector (PTC) field.

The first modelling and control works were done by R. Carmona, Director of PSA center, in the period from 1985 to 1987. Carmona (1985) defended his dissertation presenting a non-linear distributed mathematical model of the ACUREX field and proposing an adaptive control temperature technique (Camacho et al., 1986). Many control strategies for solar systems have been tested in this facility in its 32 years of life (Camacho et al., 2007; L.Brus et al., 2010; Gallego et al., 2013). Nowadays the TCP-100 facility has replaced ACUREX field and it was specially designed to continue the research activities in Automatic Control, aimed at contributing to the enhancement of the efficiency of this plant technology.

Many parabolic trough collector (PTC) plants have been commissioned in the last 20 years. Only in Spain around 45 PTCs power plants have been setup and more than 26 abroad, built or under construction (PROTERMOSOLAR, 2024). As examples, we can mention the three 50 MW Solnova and the two 50 MW Helioenery parabolic trough plants of Abengoa in Spain, and the SOLANA and Mojave Solar parabolic trough plant constructed in Arizona and California, each of 280 MW power production.

The main approach followed in the research activities developed so far was to define as control objective the regulation of the outlet temperature of the PTC field around a desired setpoint. These are complementary additional objectives dealing with the automatic start-up, different operating point operation changes and shutdowns of the plant. A previous simulation based analysis of the facility used the nonlinear distributed parameter model presented in (Gallego et al., 2016). A more recent system level dynamic model based on the first principles has been developed and presented in (Pérez et al., 2018). This model provides various possibilities for simulation experiments for developing and validating control solutions. It was used in (Yebra et al., 2020) for the development of operation training techniques for the TCP-100 facility.

The nonlinear scaling approach has been earlier used for the ACUREX facility (Juuso and Yebra, 2013; Juuso, 2016). The TCP-100 plant has more detailed control possibilities (Fig. 1). This brings new control cases but also makes the tuning more complicated. Simulation models will be used as a replica of the process in the development of controllers.

This paper is organized as follows: Section 2 summarizes the TCP-100 plant. Section 3 focuses on different possibilities to use the first principles simulation model in tuning. Section 4 presents the nonlinear data analysis methodology. Section 5 presents a planning of simulation experiments to be performed for typical operation days. Finally, Section 6 provides some concluding remarks and future works.

## 2. TCP-100 FACILITY

The TCP-100 facility consists of two thermofluid circuits thermally connected by a heat exchanger. This research focuses on the solar field is formed by three PTC loops, each of them composed by two PTCs in a North-South orientation (Fig. 1). Each PTC is 100 meter long, formed by eight modules and all in parallel. Figure 2 shows the first PTC in the first loop.

The solar field is in the primary circuit (Fig. 1). In each loop, the PTCs are connected in the South extreme, and the *colder* PTC will always be the first in the row, placed at the right part of each loop. Each circuit has one tank: the primary tank T-2 with $10m^3$ volume and the storage tank T-1 in the secondary with a volume of 115 $m^3$. The pumps for each circuit are placed after both tanks and can be controlled. There is an oil cooler in the secondary circuit.

The other loop, including a storage tank, a cooler and the connecting heat exchanger, may be bypassed during the daily operation to let the control system to choose the operational mode at each time. Operating conditions are chosen with different operation modes:

(1) Stopped facility. In this mode, both circuits are in stand-by. Both pumps are stopped and the solar field unfocused.
(2) Both pumps are working and the solar field is unfocused.
(3) The storage tank is charging with the cooler stopped.
(4) The storage tank is charging with the cooler working (variable charge).
(5) The storage tank is discharging.
(6) The solar field is cooling.

The new solar field provides new remarkable features to its predecessor ACUREX. The main differences among both facilities could be summarized as follows: The ACUREX solar field consisted of 480 East–West aligned single axis tracking PTC forming 10 parallel loops. Each loop was 172 m long, and formed by four 12-module collectors suitably connected in series. The active part of the loop (those parts receiving beam irradiance) measuring 142 m and the passive part (those not receiving beam irradiance)

Fig. 1. Top view of the TCP-100 field at Plataforma Solar de Almería (PSA-CIEMAT). The three loops are shown, with two PTCs in each of them, numbered from 1 (rightmost) to 6 (leftmost). The first loop is formed by the connected pair 1-2 (right loop), the second loop by 3-4 (center loop) and the third by 5-6 (left loop).

Fig. 2. Lateral view of the first PTC in the first loop at Pataforma Solar de Almería (PSA-CIEMAT). It is composed of 8 modules of 12 meters length.

30 m. The HTF used was Therminol 55 thermal oil, capable of supporting temperatures of up to 300°C. There were temperature sensors and the intlet and outlet of each loop and the solar field, and the flow rate could be controlled with the pump field. The experimentation of advanced control techniques can utilize the new sensors and actuators installed in the TCP-100 facility summed up in the next. Temperatures are measured in the inlet and outlet of the solar field, the inlet and outlet of each loop, in the inlet and outlet of each PTC and the middle point of each PTC. Volumetric flow rates are measured for each loop. Control valves are used to regulate the mass flow rates in each loop.

## 3. TCP-100 FACILITY MODEL

The simulation studies can use a hybrid (continuous and discrete) system level model based on the first principles model (Pérez et al., 2018). The parameters for that model were obtained from the plant engineering design project data and are also used in this paper. The system level model has been implemented in the Modelica language with the modelling tool Dymola (DassaultSystems, 2018), which applies special algorithms for the manipulation of hybrid models (Mattsson et al., 1999).

After the symbolic manipulations performed by Dymola, the model can be expressed as a general nonlinear state space system in the form

$$\dot{\mathbf{x}} = \mathbf{F}(\mathbf{x}, \mathbf{u}) \quad (1)$$

$$\mathbf{y} = \mathbf{G}(\mathbf{x}, \mathbf{u}) \quad (2)$$

where $\mathbf{x} \in \mathbf{R}^{28}$, $\mathbf{u} = \{(\mathbf{u_c}, \mathbf{u_d}) \in \mathbf{R}^7 \times \{0,1\}^3\}$, and $\mathbf{y} \in \mathbf{R}^{N_y}$, where $N_y$ could be arbitrary chosen from the variables computed in the model detailed in (Pérez et al., 2018). The variables are used in two ways:

**28 state variables ($\mathbf{x} \in \mathbf{R}^{28}$)** .
Each one means a temperature for: each PTC medium control volume (CV), see (Patankar, 1980), each PTC absorber tube, each PTC glass envelope, each tank medium CV, each tank metal walls, each tank isolation layer, each of both medium CVs in the HEX, the HEX metal wall and the air cooler medium CV. All state variables are temperatures according to the modelling hypothesis applied.

**10 input variables ($\mathbf{u} = \{(\mathbf{u_c}, \mathbf{u_d}) \in \mathbf{R}^7 \times \{0,1\}^3\}$)** .
Seven real input variables ($\mathbf{u_c} \in \mathbf{R}^7$): solar radiation, ambient temperature, setpoints for both circuits pumps, setpoints for two loops control valves, setpoint for air cooling power; and 3 boolean input variables ($\mathbf{u_d} \in \{0,1\}^3$): bypass activation for the storage tank, for the HEX, and solar field defocusing activation signal.

The Dymola model is capturing the thermal dynamics for the validation of the facility operation modes and operation training purposes as a causal block because of the representation of the inputs and outputs. All the manipulable inputs are shown with the `RealInput` interface component:

- The volumetric flow rates ($l/s$) in control loops for pumps in primary circuit (Syltherm800 medium) and secondary circuit (Therminol55 medium).
- The setpoint for the air cooler cooling power that modulates forced convection.
- The setpoints for both control valves apertures that vary the mass flow rate ($kg/s$) through 1st and 2nd loops.
- The Boolean control input is used in commanding the bypass of the storage tank in the secondary circuit.
- The Boolean control input is used to bypass the HEX, simultaneously in both circuits: primary and secondary.
- `SF_Defocus` is the boolean control input to defocus the solar field. The whole solar field is not reached by any solar irradiance when this signal is activated.

The non-controllable or disturbance inputs are the solar irradiance and the ambient temperature.

The output of the model is a generic output vector `y[:]` that represents in a general form any arbitrary output computed by the model and that could vary from one to another simulation experiment.

Figure 3 shows the summarized model of the TCP-100 facility, that is being acted by a discrete controller implemented with the StateGraph formalism implemented in the Modelica Standard Library. More details about this experiment can be found in (Yebra et al., 2020).

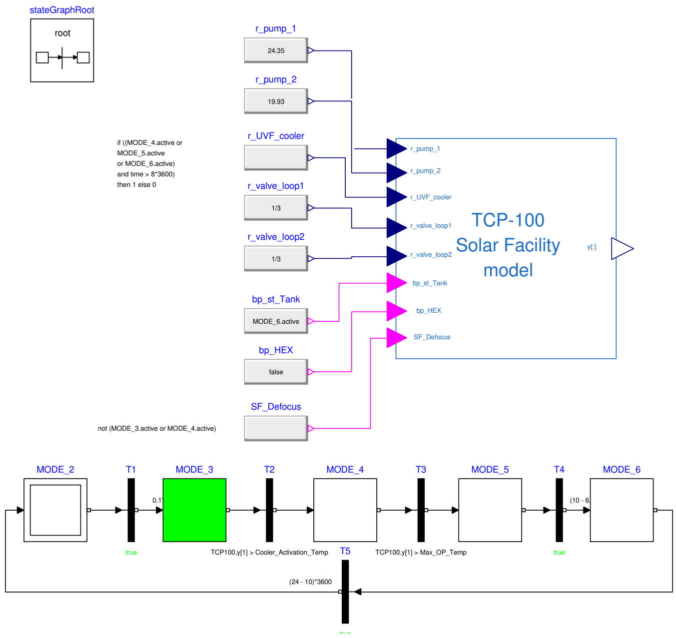


Fig. 3. Modelica model of the TCP-100 facility commanded by a discrete controller implemented with the StateGraph library.

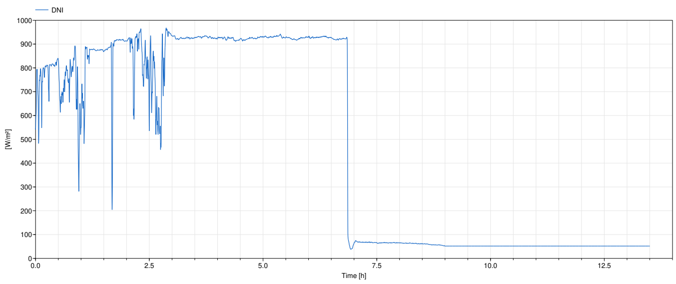


Fig. 4. Direct Normal Irradiance applied in the simulation experiment.

Figures 4 and 5 show respectively the Direct Normal Irradiance (DNI) applied to the model in Figure 3, and the simulated results for the storage tanks in both subcircuits. In the primary circuit with Syltherm800 HTF, the mean temperature of tank T1 is shown when the controller forces the plant to pass through different operation modes. After 5.2 hours from the beginning of the experiment, the T1 temperature rises to its maximum daily value of 316°C. Then, the solar field is defocused and the primary circuit exchanges energy with the secondary, still keeping on charging the T2 tank until it reaches its maximum mean temperature of 219°C at 5.8 hours. During some hours, the system is evolving thermally coupled in the absence of incoming DNI, and at time 8 hours the whole system begins to be cooled. At time 9 hours the bypass of tank T2 is activated, so the cooler is acting over a lower thermal load, which makes the primary circuit cool down to ambient temperature (16°C) at 13.5 hours. In this simulation experiment, the model of the facility has passed through most of the operational modes indicated in Section 2.

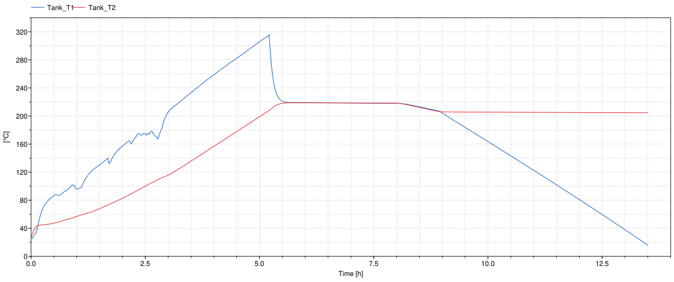


Fig. 5. Simulated temperature profiles for the tanks T1 and T2 in the TCP-100 facility, under the DNI profile in Fig. 4 and StateGraph controller in Fig. 3.

## 4. NONLINEAR DATA-BASED MODELS

Tests with the previous collector system have shown clear nonlinear behaviour in the normal operating range. The directions of interactions remain constant but the meanings of the variables depend strongly on the operating conditions. In many cases, the nonlinear systems can be implemented with nonlinear scaling and linear interaction models. In the beginning of tuning, the uncertainties need to be taken into account. The representation with natural language is beneficial for understanding an comparing with expert knowledge.

The *energy balance* of the collector field can be represented by expression (Juuso, 2009):

$$I_{eff}A_{eff} = (1-\eta_p)F\rho cT_{diff}, \tag{3}$$

where $I_{eff}$ is effective irradiance ($Wm^{-2}$), $A_{eff}$ effective collector area ($m^2$), $\eta_p$ a general loss factor, $F$ flow rate of the oil ($m^3s^{-1}$), $\rho$ oil density $kgm^{-3}$, $c$ specific heat of oil ($Jkg^{-1}K^{-1}$) and $T_{diff}$ temperature difference between the inlet and the outlet ($^oC$). The effective irradiance is the direct irradiance modified by taking into account the solar time, declination and azimuth. The density decreases and the specific heat increases resulting a nonlinear increase of the term. In the start-up, the flow is limited by the high viscosity.

### *4.1 Nonlinear scaling*

The nonlinear scaling was presented as a methodology for improving membership functions of fuzzy set systems already in (Juuso and Leiviskä, 1992; Juuso, 1992). Nonlinear scaling functions (*NSFs*) are monotonously increasing functions $x_j = f(X_j)$ where $x_j$ is the variable and $X_j$ the corresponding scaled variable in the range [-2, 2]. The function $f()$ consist of two second order polynomials, one for the negative values of $X_j \in [-2, 0]$ and one for the positive values $X_j \in [0, 2]$, respectively. Five parameters are needed to define these functions since the overall functions are continuous (Fig. 6). The core area $[(c_l)_j, (c_h)_j]$, corresponding [-1, 1], is within the support area defined by the minimum and maximum values (Juuso, 2004). The corresponding inverse functions $X_j = f^{-1}(x_j)$ based on square root functions are used for scaling to the scaled range.

Everything can be defined manually, but it is important to obtain the variable specific parameters of the scaling functions by data-based methodologies. Arithmetical means

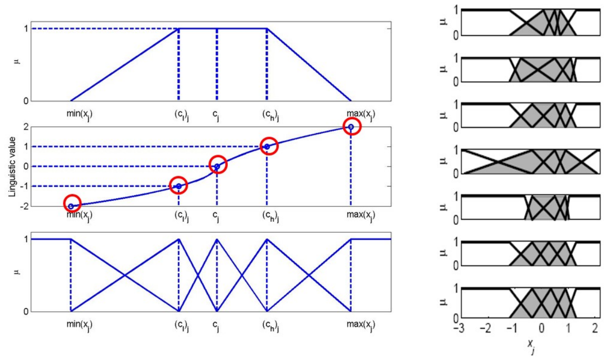


Fig. 6. Nonlinear scaling and membership functions.

and medians were used in Juuso (2004). The current solution uses the central tendency values based on generalised norms (Juuso and Lahdelma, 2010). The generalised norm is defined by

$$||^\tau M_j^p||_p = (M_j^p)^{1/p} = [\frac{1}{N}\sum_{i=1}^{N}(x_j)_i^p]^{1/p}, \tag{4}$$

where the order of the moment $p \in R$ is non-zero, and $N$ is the number of data values obtained in each sample time $\tau$. The norm (4) calculated for variables $x_j$, $j = 1, \ldots, n$, have the same dimensions as the corresponding variables. The norm $||^\tau M_j^p||_p$ can be used as a central tendency value if all values $x_j > 0$, i.e. $||^\tau M_j^p||_p \in R$.

The analysis divides the measurement values into two parts by the point where the skewness changes from positive to negative, i.e. $\gamma_3^p = 0$. Then the data set is divided into two parts: a lower part and an upper part. The same analysis is done for these two data sets. The estimates of the corner points, $(c_l)_j$ and $(c_h)_j$, are the points where $\gamma_3^p = 0$ for the lower and upper data sets, respectively. Since the search of these points is performed by using the order of the moment, the resulting orders $(p_l)_j$, $(p_0)_j$ and $(p_h)_j$ are good estimates when additional data sets are used. The orders of the norms help in changes in operating conditions.

### *4.2 Steady state LE models*

Linguistic equation (LE) models consist of two parts: *interactions* are handled with linear equations, and nonlinearities are taken into account by *nonlinear scaling* (Juuso, 1999). In the LE models, the nonlinear scaling is performed twice: first scaling from real values to the interval $[-2, 2]$ before applying linguistic equations, and then scaling from the interval $[-2, 2]$ to real values after applying equations The linguistic level of the input variable $x_j$ is calculated the inverse functions of the polynomials (Juuso, 2004). More inputs can be included with a steady state LE model represented by

$$x_{out} = f_{out}\left(-\frac{\sum_{j=1, j\neq out}^{m} A_{ij}\, f_j^{-1}(x_j) + B_i}{A_{i\,out}}\right) \tag{5}$$

where the functions $f_j$ and $f_{out}$ are nonlinear scaling functions of the input variables $x_j, j = 1, \ldots, m$ and the output $x_{out}$, respectively.

The LE model includes linguistification and delilinguistification blocks for the nonlinear scaling of variables. The linear interaction model is used in the equation block which can include a set of equations as well. These blocks are shown in Fig. 7.

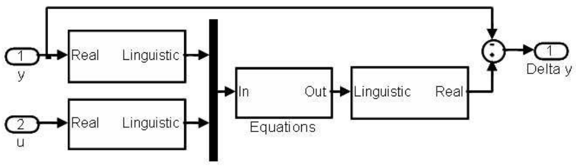


Fig. 7. Blocks of dynamic LE models for calculating $\Delta y$.

### *4.3 Dynamic LE models*

*Dynamic LE models* are rather simple input-output models, where the old value of the simulated variable and the current value of the control variable as inputs and the new value of the simulated variable as an output, can be used since nonlinearities are taken into account by nonlinear scaling functions (Fig. 7). For the default LE model, all the degrees of the polynomials in parametric models become very low, i.e. all the parametric models become the same:

$$y(t) + a_1 y(t-1) = b_1 u(t - n_k) + e(t). \quad (6)$$

This model is a special case with three variables, $y(t), y(t-1)$ and $u(t-n_k)$, and a zero bias.

The output, the derivative of the variable $y$, is integrated with numerical integration methods:

$$y = \int_0^{T_I} F(t, y, u)dt + y_0, \quad (7)$$

where $T_I$ is the time period for integration, and $y_0$ *the initial condition*. Usually, several values from the integration step or the previous steps are used in evaluating the new value. Step size control adapts the simulation to changing operating conditions.

*Effective time delays* depend on the working conditions (process case), e.g. the delays are closely related to the production rate in many industrial processes. In the block shown in Figure 8, the delay of the variable *Var1* depends on the variable *Var2*: the linguistic level of the variable *Var2* is multiplied by *1* or *-1* to get the linguistic level of the delay for the variable *Var1*, coefficient *1* means that the delay increases when the variable *Var2* increases. The real value of the delay is obtained by the delinguistification block.

Conventional mechanistic models do not work since there are problems with oscillations and irradiation disturbances. In dynamic LE models, the new temperature difference $\tilde{T}_{diff}(t+\Delta t)$ between the inlet and outlet depends on the irradiance, oil flow and previous temperature difference:

$$\tilde{T}_{diff}(t + \Delta t) = a_1 \tilde{T}_{diff}(t) + a_2 \tilde{I}_{eff}(t) + a_3 \tilde{F}(t), \quad (8)$$

where coefficients $a_1$, $a_2$ and $a_3$ depend on operating conditions, i.e. each submodel has different coefficients.

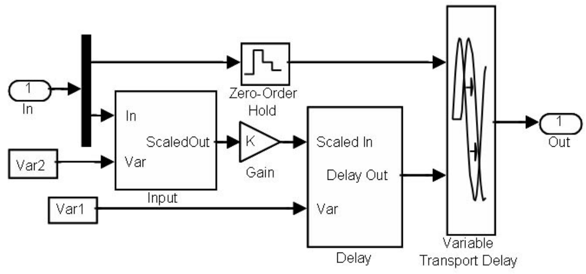


Fig. 8. Time delay of *Var1* depends on *Var2*.

The nonlinear scaling functions of the outlet temperature does not depend on time. Model coefficients and the scaling functions for $T_{diff}$, $I_{eff}$ and $F$ are all model specific. For the ACUREX field, the fuzzy LE system with four operating areas is clearly the best overall model (Juuso, 2003, 2009): the simulator moves smoothly from the start-up mode via the low mode to the normal mode and later visits shortly in the high mode and the low mode before returning to the low mode in the afternoon. Even oscillatory conditions, including irradiation disturbances, are handled correctly. The dynamic LE simulator predicts well the average behaviour but requires improvements for predicting the maximum temperature since the process changes considerably during the first hour. For handling special situations, additional fuzzy models have been developed on the basis of the Fuzzy–ROSA method (Juuso et al., 2000).

### *4.4 Working point model*

The volumetric heat capacity increases very fast in the start-up stage but later remains almost constant because the normal operating temperature range is fairly narrow. This nonlinear effect is handled with the working point LE model

$$wp(i) = \tilde{I}_{eff}(i) - \tilde{T}_{diff}(i), \quad (9)$$

where $\tilde{I}_{eff}(i)$ and $\tilde{T}_{diff}(i)$, which are obtained by nonlinear scaling of variables: efficient irradiance $I_{eff}$ and temperature difference between the inlet and outlet, $T_{diff} = T_{out} - T_{in}$, correspondingly. The outlet temperature $T_{out}(i)$ is the outlet temperature of the module $i$. Since each loop consists of 16 modules, there are 48 sequential modules in the solar field. The outlet temperatures at modules 16, 32 and 48 are controlled.

The working point, $wp$, represents a fluctuation from the normal operation. In the normal working point, $wp = 0$: the irradiance $\tilde{I}_{eff}$ and the temperature difference, $\tilde{T}_{diff}$, are on the same level. A high working point ($wp > 0$) means low $\tilde{T}_{diff}$ compared with the irradiance level $\tilde{I}_{eff}$. Correspondingly, a low working point ($wp < 0$) means high $\tilde{T}_{diff}$ compared to the irradiation level $\tilde{I}_{eff}$. The normal limit ($wp_{min} = 0$) reduces oscillations by using slightly lower setpoints during heavy cloudy periods. This is not sufficient when the irradiance is high between cloudy periods. Higher limits ($wp_{min} = 1$) shorten the oscillation periods after clouds more efficiently.

## 5. PLANNING OF EXPERIMENTS

The TCP-100 solar thermal power plant replaces the ACUREX experimental research facility. Therefore, the scaling functions of the irradiance ($W/m^2$) do not change which means that also the indicator of the cloudiness remains the same. This is a good starting point for the planning of the experiments. All the other variables are in totally different value ranges.

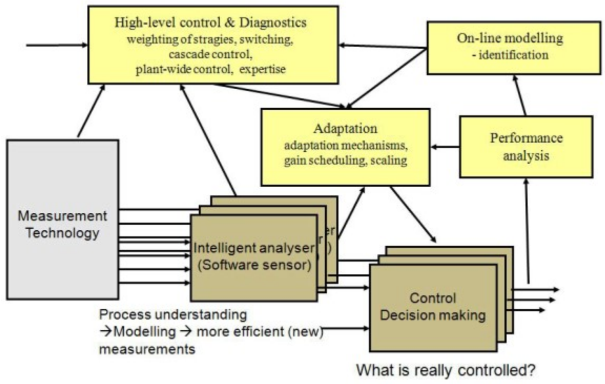


Fig. 9. Modules of the intelligent analyzers and control.

In the LE systems, all variables $x_j$ are handled with variable specific nonlinear scaling functions: $x_j = f_j(X_j)$ and $X_j = f_j^{-1}(x_j)$, see Section 4. The interactions of the scaled values $X_j$ are presented with linear equations, like (8). In the starting phase, the scaling functions are available only for the irradiance. The scaling of the temperature differences $T_{diff}$ is estimated for the loops from the configuration of the field.

The *feedback controller* is a PI-type LE controller with one manipulating variable, oil flow, and one controlled variable, the maximum outlet temperatures of the loops. The PI-type means that the change of control is the sum of the error and the change of error. The acronym LE means that dimensionless scaled values are used in the control equation. The very compact basic controller provides a good basis for advanced extensions: the scaling functions can be to versatile operating conditions, and control equations can extended from the PI type with different algorithms, e.g. all different types of PID controllers could be used. The blocks are the same for different modules and loops.

The LE controller contains several parametric scaling functions for variables, errors, changes and corrections. Since there is no actual test data available from the new research plant, the parameters are chosen before the test campaign by using previous test results from the ACUREX plant and adjusting or scaling them to correspond better to the specifications of the new TCP-100 collector field or using the simulator of the new field. These properties are tuned after the test campaign.

*Intelligent analysers* have been used for detecting changes in operating conditions to activate adaptation and model-based control and to provide indirect measurements for the high-level control (Fig. 9). There are many improvements, which are planned to be introduced to the new TCP-100 facility. For the first tests, the intelligent analysers are not used. The correction factors based on the working point value *wp* are utilized in the adaptation of the LE control. The fine-tuning with the predictive braking and asymmetrical actions are left for later studies.

The *working point wp* is important in both in this study and the final system since the model-based control limits the acceptable range of the temperature setpoint by using the chosen working point (Fig. 9). The fluctuation indicators are used for modifying these limits to react better to cloudiness and other disturbances. The manual setpoints are used only within these limits. Dynamic models developed for the TCP-100 facility could be used for development in this task.

*High-level control* is aimed for manual activating, weighting and closing different actions. As there are many actions, this is needed to run the tests efficiently. These ideas will be developed interactively during the test campaigns to provide a basis for The performance analysis and integration of expertise (Fig. 9).

The full *first principles model* is highly complicated and a lot of tuning work is needed before it can be used in tuning the controller for the special cases listed above. Actually, the simulator would already need adaptive parts. A better way is to focus first on the PTC loops (Fig. 2). There are three loops in the solar field (Fig. 1) which all consist of two PTCs both having eight similar modules. These can be handled with the same parametric LE model. The modules are working in different operating conditions: the input and output temperatures depend on the sequence of the modules. The control of the loops introduces additional differences between the loops.

The project will then continue first with the full dynamic models enhanced with the new LE models. Then the full set of the experiments can be started in the real new TCP-100 facility which finally provides the data which can be used in the tuning of the plant and the control system. The simulation studies provide a starting point for the test campaigns with the new field. The parameters will be updated offline during the test days by using the recursive approach. The TCP-100 facility includes more units, loops and connections. There are more sensors for the temperatures and volumetric flows. The control is available in each of the loops. The dynamic simulation model includes 28 state variables and seven input variables (Section 3).

The dynamic simulation model is used as a plant in this research. This is a flexible solution for analysing different weather conditions and disturbances. The strongly fluctuating situations are difficult to handle reliably with models. However, they can be taken as scenarios in this model based analysis. The idea of the nonlinear scaling is that the algorithms remain unchanged.

## 6. CONCLUSIONS AND FUTURE RESEARCH

This research focuses on starting to apply the intelligent models and control algorithms for the new TCP-100 solar thermal plant. The scaling functions of the ACUREX facility remain unchanged for the irradiance which also means that the earlier indicators of the cloudiness can be used. The new facility includes more units, loops and connections. The algorithms are not changed and the data analysis can be done by using the dynamic models for a limited set of measurements and subsystems. This research means preliminary simulation experiments. The first principles models would require adaptive parts before going the full simulation experiments. The work can be started with the loops and modules by using parametric linguistic equation models. The simulation studies will be extended with these models before going to the test campaigns with the new facility.

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