User Manual - v1.0

HeatMon

Heat Treatment Control System

January 26, 2024

Contents

1 Description

1.1 System Overview

HeatMon system is intended to digital control and recording of complex heat treatment processes of multiple furnances using one or more computers. It will allow the creation of customized and complex heat treatment programs with any number of segments, together with precise control and recording of process temperature over time, together with up to 4 auxiliary subsystems. The system can be used to retrofit old furnaces or to equip new ones with computerized control. It can work with various temperature controllers and support up to four auxiliary control equipment on a furnace (dependent on temperature controller capabilities).

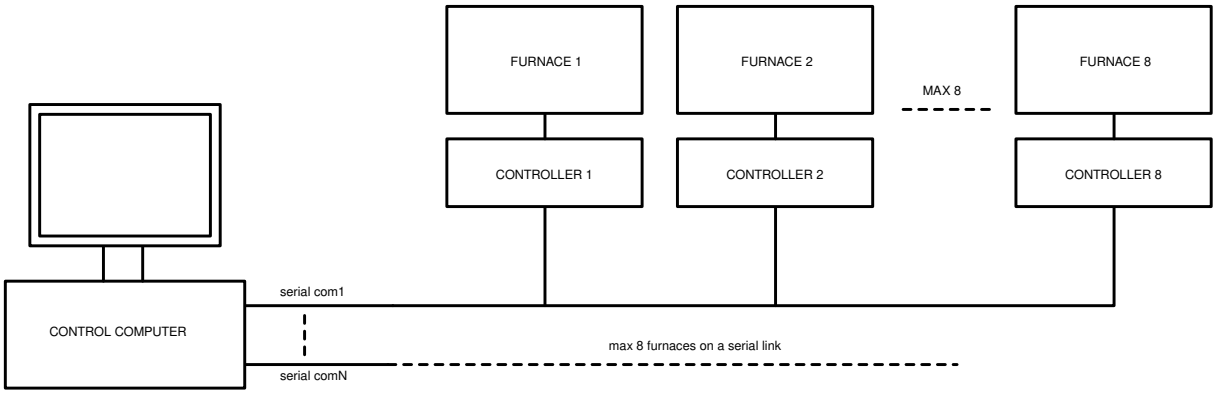

Figure 1.1: HeatMon block diagram

In figure 1.1 the block diagram for one serial connection is presented. Up to 8 furnaces can be connected to a RS-485 serial link, to connect more furnaces additional serial ports are required. A windows application for heat treatment control (htcontrol) can control up to 8 furnaces connected on the same or on different serial links. Multiple instances of the htcontrol application can run on the same computer to control more than 8 furnaces with one computer. Maximum number of furnaces controlled with one computer is limited by the number of serial ports available and by the number of CPU cores.

Another windows application (htprog) is provided to allow the creation and editing of heat treatment programs used by the htcontrol to run the heat treatment processes. This application also allow the remote monitoring of the heat treatments by connecting with control applications that runs the processes and view the process status, over local network or over internet. The htprog application can also print heat treatment reports including the recorded diagram and the programed one. A table with temperature values at a chosen time interval can also be printed, the reports can be printed on paper or as a pdf files through the selection of a pdf printer.

1.2 Furnace Controller

Every furnace included in this system must have a furnace controller installed. This can be made by retrofitting the existing electrical cabinet, or a new electrical cabinet can be installed.

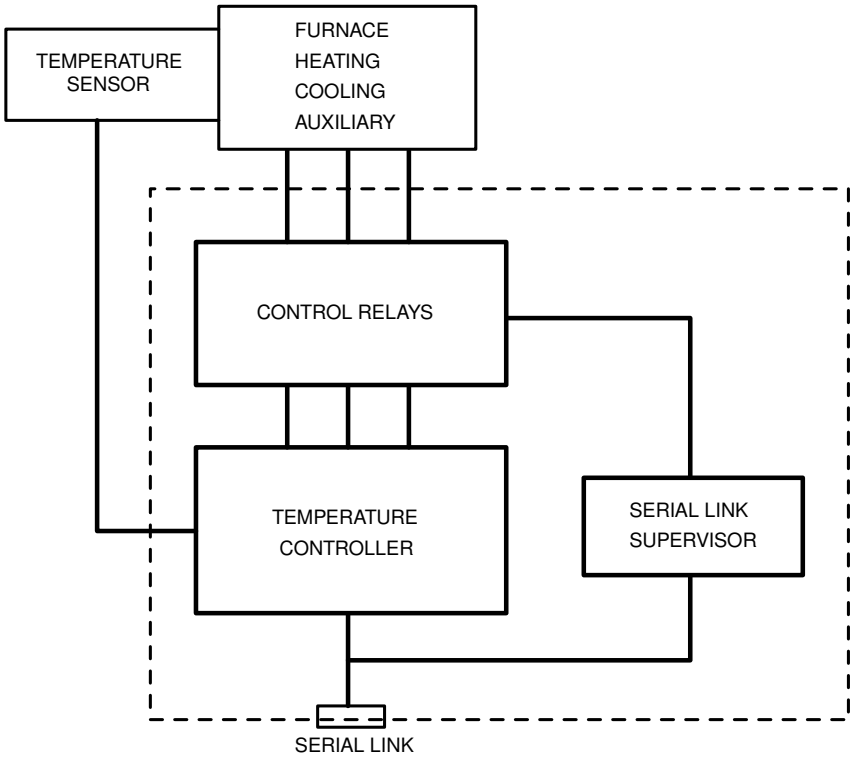

Figure 1.2: Simplified diagram of furnace controller

The central element of the electric cabinet (figure 1.2) is the temperature controller. Its main role is to keep the temperature at the setpoint value, while also allow the computer to read the temperature and set new values for the setpoint. In addition the temperature controller may also have heating and cooling control, and auxiliary outputs which can be used by the computer to control the furnace auxiliary subsystems if any. The control software is designed to work with different types of temperature controllers and also new types of compatible controllers can be added, so that it can be easily adapted to the customer equipment.

Serial communication between the controller and computer use the Modbus RTU protocol (standard for most temperature controllers) over RS-485 serial bus or over RS-232 point connection. All temperature controllers connected on a common 485 bus must have identical baud rate and data frame (data bits, parity and stop bits), while addresses and data format may be different. Maximum 8 furnaces can be connected on a 485 serial bus, being the maximum number of furnaces controlled by one instance of the control application. If more than 8 furnaces need to be controlled they must be installed on additional serial links.

The serial link supervisor is an optional element required only in some situations when the temperature controller auxiliary outputs are used to control some of the furnace subsystems if any. It work as a safety watch-dog timer against loss of connection with the computer, with a time-out of about 30s.

1.3 Control Computer

On one or more control computers can be installed one or more instances of the control application, every instance being able to control up to 8 furnaces. A multicore processor is recommended if multiple instances are running on the same computer. In general 1 processor core can execute for 2 or more instances with 8 furnaces each at any sampling time, depending on the additional load. Ultimately the number of instances is limited by the number of serial ports available, since one instance need at least 1 serial port if all of its furnaces are connected on the same 485 serial bus. If not then additional serial ports are required for the furnaces that are connected through other serial links.

Control computer system requirements:

OS: Windows 7 or newer, 32/64 bit

CPU: x86/64 processor 1GHz or better

RAM: 1GB + 35MB/furnace

Graphic: 1280 x 720 resolution or better

Serial: 1+ serial ports RS-232/485 baud 9600 - 57600

1.4 Control Application

This is a Windows application that load and execute the heat treatment program at every active furnace and record and save the temperature data over time. It can control up to 8 furnaces over the same or different serial ports. To control more than 8 furnaces, additional instances of the control application must be run either on the same computer or on other computers. Complex heat treatment programs can be executed and recorded with an unlimited nr of segments and the ability to on/off control up to 4 auxiliary subsystems in a different state in each segment. Periodical backup saves (configurable 5 to 30 minutes interval) are done automatically, so that in the case of an unexpected interruption the process can be resumed from the last saved point. In this way the chance of a long duration heat treatment to be lost by an inadvertent event is reduced to a minimum. The temperature over time is recorded automatically for every process with precise temperature and timing, every sample being timestamped down to miliseconds with the time of read from the begining of the process (process time). Heat treatments up to 248 days in duration can be executed.

1.4.1 Configuration

To operate properly the application need to be configured with the necessary settings. These are instance specific and can be modified from the “Settings” menu.

1.4.1.1 Furnace settings

Menu path: “Settings ▷ Furnaces ▷ Furnace 1. . . 8”

These include furnace specific parameters and must be done in order to be able to enable the corresponding furnace from the general settings.

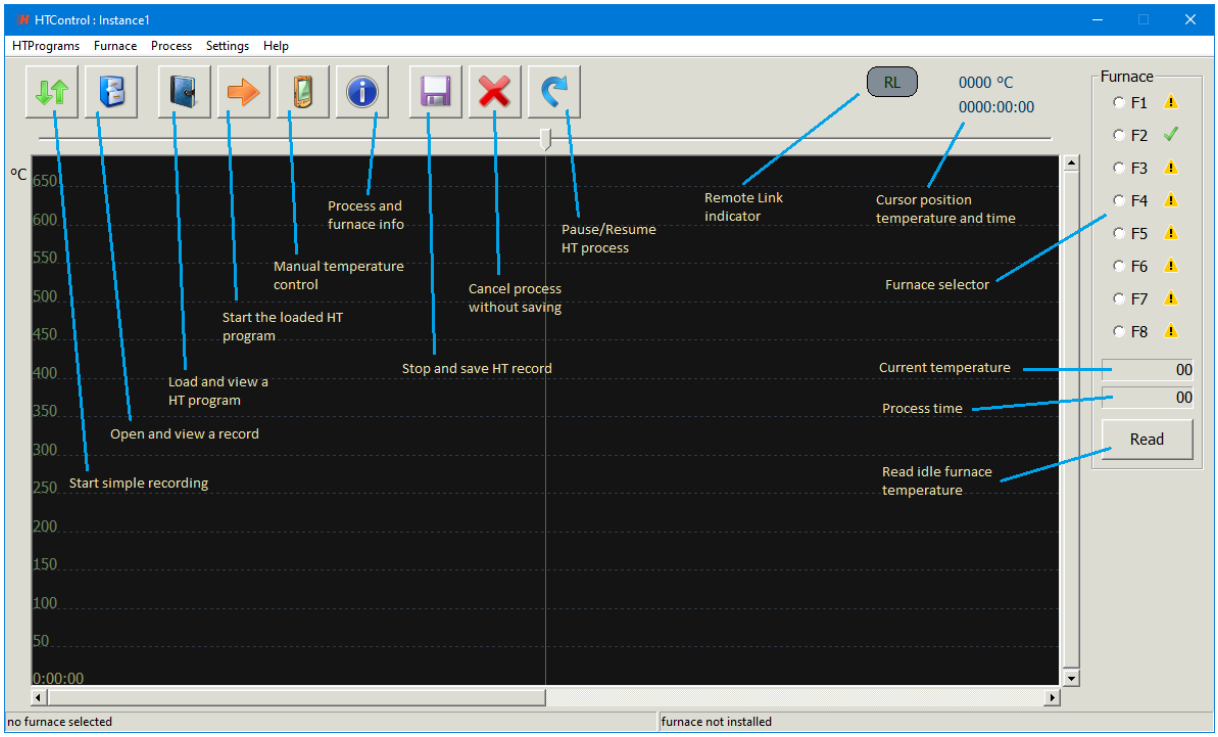

Figure 1.3: Control app screenshot

- TEMPERATURE CONTROLLER – allow to select from the list the type of temperature controller used by the furnace. Only the listed controllers are supported.
- SERIAL PORT – indicate the serial port (e.g. COM1) to witch is connected the furnace controller, either through serial bus 485 or point connection 232. In the case of a 485 serial bus more identical or compatible controllers (up to 8) can share the same serial port.
- BAUD RATE – must match the baud rate set in the corresponding temperature controller. If the serial link is shared then all these controllers must have the same baud rate and data format (nr of data bits, parity, stop bits and use Modbus protocol).
- TEMPERATURE MIN/MAX – furnace minimum and maximum temperature [°C]. These temperatures must correspond with the furnace max and min allowed temperatures. Tmin range is -200 to 0, Tmax can be at any value above 20 up to 5000.
- SAMPLE TIME – the time interval [s] between two consecutive readings of temperature by the application. Range between 1 to 20 seconds, default value is 5 s. Smaller values should be used for furnaces with a faster temperature variation, while larger values can be used for the case of slower temperature variations.
- AUTO-RESTORE TIME GAP – the maximum time interval from the last backup save, inside which the process is automatically resumed when the command *Restore all furnaces* (from the *Process* menu) is used. Between 1 to 48 hrs. Once this time interval has been exceeded the automatic restoration at the corresponding furnace no longer happen. Manual restoration can still be done up to 72 hrs.
- ENABLE AUXILIARY OUTPUT 1...4 – indicate which auxiliary function is enabled for the furnace, if any exist. If the furnace have a cooling system then auxiliary output 1 can

be used to validate the use of cooling as per segment basis. A user friendly description (limited to 31 characters) for the function of enabled outputs can be provided in the coresponding left side edit bar. This help identify the auxiliary function during HT programming.

- FURNACE NAME – a descriptive name can be provided for the furnace. This name will appear on the right side of the status bar at the bottom of the window when the furnace is selected. It is limited to 39 characters.

OBS. Most of these parameters are dependent by the hardware setup of the furnace and they must be set to corresponding values. Failure to do so may result in incorrect operation of the furnace.

1.4.1.2 General settings

Menu path: “Settings ▷ Options”

These include instance specific parameters that apply to the entire application and all its furnaces.

- ENABLE FURNACE 1. . . 8 – allow to enable/disable individual furnaces. Only the enabled furnaces are open and can be used, disabled furnaces are inactive or not installed. In order to enable a furnace it must be installed and configured with the corresponding furnace settings. The application will try to confirm the presence of the controller, if that fail the furnace will remain disabled.

- AUTO-SAVE RECORD WHEN FINISHED – enable or disable the auto-save feature. If auto-save is enabled, when a process is finished (by reaching the end of the program or by user stop and save button) the process recorded data is automatically saved in a file inside the RECO folder of the current instance. A unique file name is generated without prompting the user. This is the recommended method since it guarantee the immediate save of the process data. If the auto-save is disabled, then nothing of these will happen, the process just stop and the data will remain in memory (RAM). The user can still save the data manually by using the stop and save button, it will be prompted for a file name. This manual save can also be done when auto-save is enabled, after the initial automatic save.

- RESTORE ALL PROCESSES AT STARTUP – if enabled then at startup all interrupted processes that have a backup save inside the auto-restore time gap, would be resumed automatically. The same action can be manually triggered using the command “Restore all furnaces” from the “Process” menu. If enabled then time gap filtering should be used to prevent inadvertent resuming of some old processes. Default status is disabled.

- BACKUP PROCESS STATUS PERIODICALLY – when enabled the process status is saved periodically in a special format temporary file, from which it can be resumed later. The default backup time interval is 10 minutes, but can be specified by the user. It is recommended that this option to be enabled so that the ongoing process can be resumed in the case of a power failure or other interruption.

- BACKUP INTERVAL – work in correlation with the previous option. this is the time interval in minutes between two consecutive backup savings. Minimum interval is 5 min and up to 30 min.

- LOCAL ADDRESS OR NAME – identify (by address or name) the local computer network adapter that is used for remote connection. If remote connections are enabled, the control application will listen on this network adapter for remote connections requests. Remote communications are handled in separate threads to not impact the furnaces control. If the local computer have only one network adapter then this field can be left empty. A maximum of 2 simultaneous remote connections can be handled.
- CONNECTION PORT NR – specify the network port number on which the application is listening for incoming connections requests. Every instance must have its unique listening port even if they are located on different computers in the same network.
- IPV4 / IPV6 – indicate the preferred protocol IPV6 or IPV4 used for remote connections if both protocols are available. If the selected protocol is not available then the other protocol is used if is available. The same protocol must be selected for the connected client.
- DISABLE REMOTE CONNECTIONS – check this to disable the application listening for remote connections (this is the default state). This must be unchecked to enable the acceptance of remote connections.
- SAVE OPTIONS BUTTON – both “Save Options” and “Apply” buttons will apply the current options to the running session of the application. In addition “Save Options” button will also save all the current settings to the configuration file so that they will be loaded at the next application start.

1.4.1.3 Default settings

The default values for all settings can be loaded using menu command “Settings ▷ Reset to default”. This command just load the default values for the current running session, the configuration file remain unaltered.

To save the current settings to the configuration file use menu command “Settings ▷ Save Settings”. To manually load the settings from the configuration file use the menu command “Settings ▷ Load Settings”. The configuration file settings are also loaded automatically at application start.

1.4.2 Furnace selector

To the right side of the application window is a group of controls, under the name “Furnace”, that form the furnace selector. The 8 radio-buttons F1…F8 allow the selection of the current furnace, also indicate the currently selected furnace. A similar selection can be done using the “Furnace” menu. Most furnace actions and display data refer to the currently selected furnace.

Next to each furnace radio-button a small icon is shown that indicate the furnace state, which can be one of the following:

- ⚠ DISABLED – the furnace is not enabled and can’t be used, it can still be selected. The only way out of this state is to be enabled in the “Settings ▷ Options” menu.
- ✓ READY – the furnace is enabled and ready, this is the state of an idle furnace that can be used to start a new process. In this state the button “Read” from the selector group can be used to read the current furnace temperature. During a process, the temperature is read automatically, being displayed above the “Read” button together with the current process time.

- FREE COOLING – a process is running and the furnace is executing a segment of free cooling, that is the furnace is losing heat only through its insulation without any additional heating or cooling. This is the only cooling available for a furnace that do not have any additional cooling system.
- SOAKING – a process is running and the furnace is executing a soaking segment, that is a segment during which the temperature is maintained constant. Heating only or heating/cooling control can be chosen in the segment programming.
- FAST HEATING – a process is running and the furnace is executing a fast heating segment, that is the heating system is kept on until the final temperature is reached as fast as possible.
- HEATING RAMP – a process is running and the furnace is executing a segment of controlled rise of temperature. Heating only or both heating/cooling can be used dependent of segment programming.
- FAST COOLING – a process is running and the furnace is executing a fast cooling segment, that is the cooling system is kept on until the final temperature is reached as fast as possible.
- COOLING RAMP – a process is running and the furnace is executing a segment of controlled drop of temperature. Both heating and cooling can be used during this type of segment.
- MANUAL CONTROL – the furnace is executing a manual control command, that allow the manual control of temperature and auxiliary outputs.

In addition to this heating and cooling control, up to 4 additional auxiliary systems can be turned on or off during a segment to provide additional functionality for the furnace.

1.4.3 Auxiliary systems

Up to 4 auxiliary subsystems of a furnace can be controlled by the application, through the auxiliary outputs of the temperature controller. The exact number available is dependent by the type of temperature controller used. These auxiliary systems can be controlled on a segment basis, this mean that every segment of the HT program have its own state (on or off) of the auxiliary outputs. This state remain unchanged for the duration of the segment. To obtain a desired succesion of states the HT program should be segmented accordingly.

If the furnace have a cooling system then the auxiliary output 1 will be wired to enable the working of this cooling system. This mean that the cooling system is still under the control of the temperature controller cooling output, but its overall use during the segment is enabled or disabled by the auxiliary output 1. This allow the programmer to implement heating only or heating/cooling segments. If no cooling system is present then the auxiliary output 1 can be used for other function.

1.4.4 Graphical window

The graphical window display the real time diagram of the process that run at the selected furnace. If the furnace is idle or disabled then the window will be empty. It also display the diagram for the existing HT records that can be open for viewing, and for the loaded HT programs. A

slider on the upper side of the window move a cursor that allow the read of temperature and time from the diagram at cursor position, these values are displayed above the slider.

A scroll bar on the lower side of the window can be used to scroll the diagram along the time axis. A right side vertical scroll bar allow the time compression of the diagram so that more of the diagram fit in the window. When this scroll bar is up then the time compression is 1:1 and the diagram is displayed with its maximum time resolution. When it is down then the entire diagram will fit in the graphical window. When a new process is started the time compression is reset back to 1:1.

1.4.5 Start a HT program

To start a heat treatment program at an idle furnace follow the next steps:

1. Select the desired furnace using the furnace selector, the furnace must be idle.
2. Load the heat treatment program using the button “Load and view a HT program”, this will prompt the user to open a .htp file with the program to be started. A diagram of the loaded program will be displayed in the graphical window. The menu command “HTPrograms ▷ Open HTProgram” can also be used.
3. Start the program using the button “Start the loaded HT program”. The new process description will inherit the HT program description and the user can modify it just before starting. The selected program execution will start, its evolution will be reflected in real time in the graphical window. The menu command “Process ▷ Start HTProgram” can also be used.

Once started a process will run until it reach the end of the program or until is stopped or paused by the user. Its evolution will be recorded and can be observed in graphical window. Current furnace temperature and process time are displayed above the “Read” button for the selected furnace.

The process description that is stored in the recorded file can be any descriptive phrase for the process limited to 75 characters. It is loaded at the start of a process from the description of the selected HT program, but the user can modify it to reflect the individual heat treatment characteristics. The local date at the start of the process is stored in the record file.

1.4.6 Stop a running process

A running process can be stopped by the user before its execution end (HT program end) in two ways:

1. Process stop and its recorded data saved by using the button “Stop and save HT record”, or the menu command “Process ▷ Save and stop”. The process is stopped first and then its recorded data is saved on a .rec file. If auto-save is enabled then the record is saved automatically using an auto-generated file name, otherwise the user is prompted for a file name. In the case of auto-save enabled, the save is also done automatically when the end of the program is reached. The auto-generated file name will indicate the furnace number and starting date like in this example F1_25-3-2023_n245376.rec, that contains a number computed from the start time and give a unique name as long as the computer date and time is not changed.
2. Process stop without saving its recorded data by using the button “Cancel process without saving”, or menu command “Process ▷ Stop without save”. After stop the recorded data

remain in RAM memory and its diagram is displayed until the Cancel button is clicked again or other process is started. During this time it still can be manually saved using “Stop and save” button.

1.4.7 Pause / Restore a process

A running process can be temporary paused by using the button “Pause/Resume HT process”, or menu command “Process ▷ Pause / Resume”. A temporary backup save file will be created from which the process can be resumed latter. If the furnace is running a process then this command will trigger a pause, if the furnace is idle then this command will trigger a resume if a backup file exist and is no older than 72 hours. This time filtering of backup files is in place to avoid resuming an old process that is no longer actual with the furnace status.

A resume of all paused furnaces can be triggered at once with the menu command “Process ▷ Restore all furnaces”, in this case a more restrictive time filtering of backup files is in place (see furnace settings and general settings sections for details).

If enabled in the general options (enabled by default) a backup save of the process status for every furnace individually will be done periodically (by default every 10 minutes but this can be adjusted). This work then as a safety measure against inadvertent process interruption like power failure, software or communication failure, etc. After the cause of failure has been eliminated, the process can be resumed, individually per furnace or at once, from the latest backup file. If such a resume is still relevant is situational.

1.4.8 Other functions

Start simple recording button, menu command “Process ▷ Simple recording”. During a simple recording the controller do not use any heating/cooling or auxiliary systems, it just record the evolution of temperature under outside control. User can specify a maximum time interval for recording and a minimum temperature under which the record will stop.

Open and view a record button, menu command “HTPrograms ▷ HT Records ▷ View existing record”. Allow the user to open and view the diagram of an existing record. A copy on a new file of the open record can also be done with menu command “HTPrograms ▷ HT Records ▷ Copy record”.

Manual temperature control button, menu command “Process ▷ Manual control”. Allow the manual control of temperature and auxiliary systems. This is a timed action that will stop automatically when “Time to stop” is exceeded, can also be manually stopped using button “Cancel process without saving” or the corresponding menu command. Can be executed when the furnace is idle or under a previous manual control command, cannot be used during simple recording or programmed process.

Process and furnace info button, menu command “Process ▷ View process info”. Display some detailed information about the running process if any and about the selected furnace. Work in any furnace state except disabled.

RECO and HTPROG folders every instance have its own RECO and HTPROG folders. The RECO folder is the default folder to store the data records .rec files from the heat treatments. The HTPROG folder is the default folder for the HT programs .htp files. The menu commands

"HTPrograms ▷ Explore RECO folder" and "HTPrograms ▷ Explore HTPROG folder" will open the respective folders using Windows file explorer.

HT Programming and printing The following menu commands will launch the HT programming application: "HTPrograms ▷ HTProgram editor" and "HTPrograms ▷ HT Records ▷ Print report". These actions are carried out by the programming application.

Remote connections The control application can be configured to accept remote connection requests from the programming applications, to allow for remote monitoring of the furnaces. A maximum of 2 connections can be active at any moment on a control app instance. The corresponding network communication is handled in separate threads so that the furnaces control is not impacted. See general options for more details. The control application handle remote connections transparently without any intervention from the user.

1.5 HT programming application

This is a Windows application that allow the creation and edit of HT programs, print heat treatment reports and also remote monitoring of heat treatments carried by remotely located control applications. The remote connection are only for monitoring, not allowing any control or interference with the remote process. This application is independent of furnaces and can be run on any computer, as such it can be installed as standalone from the control application.

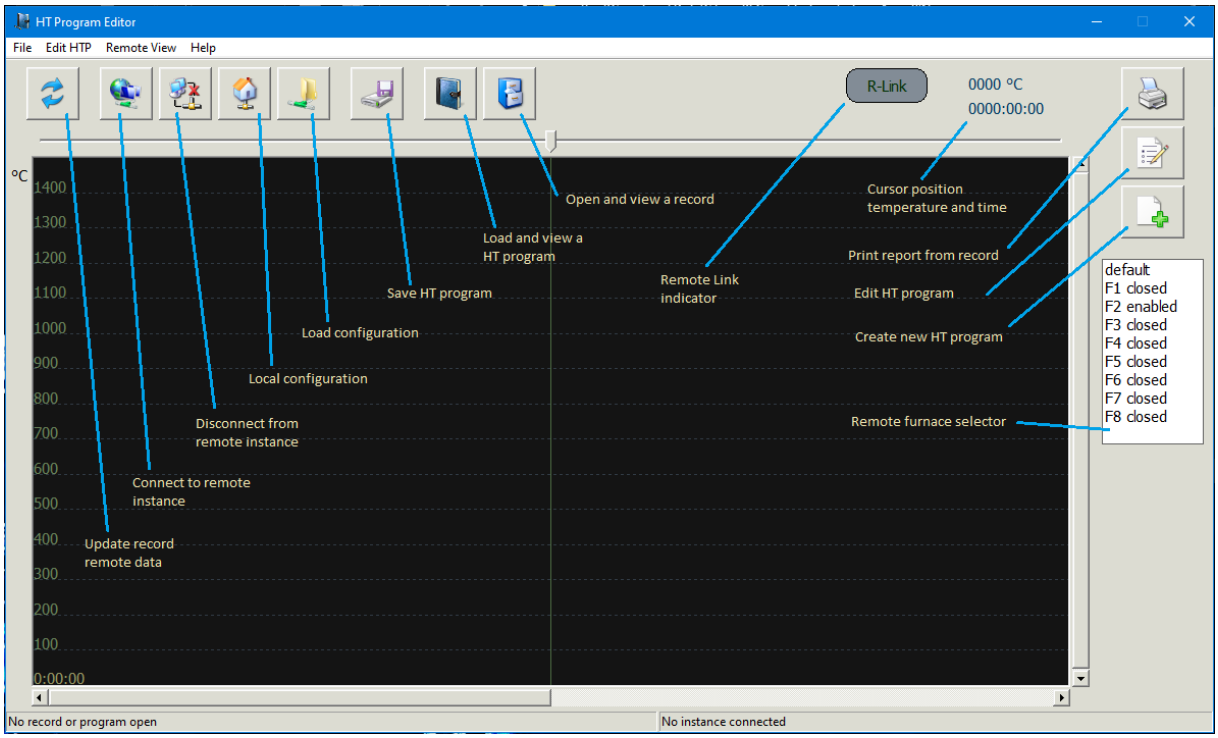

Figure 1.4: Programming app screenshot

Its aspect is similar with that of control application, having a graphical window that will display the diagram of a loaded record or HT program. In addition the graphical window work in conjunction with the HTP editor to display the edited diagram.

1.5.1 Remote furnace selector

On the right side of app window a list of connected furnaces is displayed together with a default furnace. The default furnace is a generic furnace defined inside application that is always available when no other furnaces are selected, it allow the user to create generic programs. Its minim and maxim temperatures can be modified using menu command "File ▷ Default furnace settings", its auxiliary outputs are generic named "auxiliary 1...4" and can be programmed, however if the furnace controller do not have those auxiliary functions then they will not have any effect.

If the programming application is connected with an instance of the control application, then the additional 8 furnaces will appear in the list together with their status that will appear as "closed" if the furnace is disabled. Connecting with an instance of control application can take place in 2 ways:

1. Through instance configuration file that load the furnaces settings from the configuration file. This method don't allow any monitoring. At startup the programming application will try to connect with the local instance (located in the same folder) by loading local configuration file if any. Menu command "Edit HTP ▷ Local configuration", or the corresponding button, will try to load a local configuration file (located in the same folder as the programming app binary file). Menu command "Edit HTP ▷ Load config file", or the corresponding button "Load configuration", will prompt the user for a non local configuration file to be loaded.

2. Through remote instance connection that will allow both the loading of furnaces settings and monitoring. For this method to work the target instance must have the remote connections enabled. When a furnace from the list is selected, in addition to the load of its settings, if the selected furnace has any acquired data from a running process or a finished one, this data will be displayed in the graphical window as a process diagram. Selecting the furnace again or pressing the button "Update record remote data" will refresh the displayed data. A remote connection will be closed automatically after 14 minutes of inactivity from the last data refresh through connection.

In the case of a successful connection through any of the two methods, a list of the connected instance furnaces with their status will appear in addition to the default furnace.

1.5.2 Remote connection

To initiate a remote connection with an instance of control application use menu command "Remote View ▷ Connect to remote instance", or the corresponding button. A dialog box with a list of configured connections will appear, choose a connection from the list and click "Connect" button. The connection parameters like the address and port number can also be edited manually if necessary. The list with available connections is loaded at the application start from a text file "remoteconfig.txt" and binary file "remotlist.cfg" located in the instance folder and the BIN folder of the programming application respectively. Every line starting with character # describe an individual connection with the next generic format:

[space] name_or_address [space] <x>port_nr [space][line_end]
[the very next line is taken as a name[40] for connection]

---

this is remote connection address or name followed by port nr
if the next line is empty then the # line is used as name for connection [first 59+0]
<x> indicate the recommended INET protocol to be used <4>=ipv4 or <6>=ipv6

port_nr should follow imediate after <x>
at least one space should be present after port_nr

This connection list can be reloaded using the menu command “Remote View ▷ Reload connections list”, useful if modifications have been done to the file after the last load. Every successful new connection will be added to the list of connection and saved when the program close.

To disconnect from a remote instance use menu command “Remote view ▷ Disconnect from instance”, or the corresponding button. After disconnection the instance furnaces and their settings are still available to be selected but without any monitoring. This remain true until another instance is connected either via remote or configuration file.

1.5.3 HT program structure

A heat treatment program is composed from a sequence of segments. Every segment describe the final temperature, segment time, ending condition, together with the status of 4 auxiliary binary functions. The initial temperature is given by the final temperature of the previous segment or by the starting temperature of the program (for the first segment). The number of segments in a program is only limited by the total time of a process that is 248 days for sampling time equal or larger than 4 s. For a 2 s sampling time is limited to 127 days, and for 1 s sampling time to 63 days. A program may be segmented to reflect the different types of temperature variation and also different state of auxiliary functions. For all segments the auxiliary functions state is set at the beginning of the segment and remain in that state until the next segment. When the program end is reached, or the process is stopped or paused, all auxiliary functions are turned off. Heating only or heating/cooling control can be used for all segments with the exception of free cooling segments. The types of segments are:

- SOAKING – constant temperature segment. The final temperature become the new setpoint at the beginning and is maintained constant over the duration of segment. The segment ends when the segment time has been exceeded. The final temperature is usually equal with the final temperature of the previous segment, but this is not a requirement.
- HEATING/COOLING RAMP – linear ramp of heating or cooling dependent of the value of final temperature relative to the initial temperature of the segment. The temperature will increase or decrease over the time of the segment until the segment time expire when the segment ends. The temperature ramp is calculated so that it should reach the final temperature at the end of segment time.
- FAST HEATING/COOLING – the final temperature become the new setpoint at the beginning resulting a fast heating or cooling. The segment ends when the final temperature is reached, the segment time is irrelevant. A similar effect can be obtained by using a soaking segment with the difference that the segment ends when segment time expire, the reach of final temperature being irrelevant in this case.
- FREE COOLING – no forced heating or cooling is used, the furnace will lose heat only through its thermal insulation. The segment ends when the final temperature is reached or its time expires. If the furnace have a cooling system then auxiliary function 1 (enable cooling) must be left inactive (unchecked) to keep the cooling off. The segment time is irrelevant if is bellow 10s (this is the default), or it can be used for segment ending if is set larger than 10s, in this case the segment ends when either the final temperature is reached or the segment time expire.

OBS. The furnace must have a cooling system and the temperature controller must be set on heating/cooling mode in order to be able to have heating/cooling control. Otherwise heating only control will be available.

1.5.4 Create a HT program

A new HT program can be started by using the button “Create new HT program” or menu command “Edit HTP ▷ Create new”. This will clear the previous program if any and will start a new one opening the HTP editor window with the new program. HT program editing can be interrupted in any moment by closing the editor window, the edited program as is will remain in memory and its editing can be resumed later.

To edit a HT program already loaded or to resume previous editing, use the button “Edit HT program” or menu command “Edit HTP ▷ Edit HTProgram”. This will open the editor window with the already existing HT program. The loaded/edited program can be saved in a .htp file either by using the “Save” button from the editor window, the “Save HTProgram” button from the main window, or by using the menu command “Edit HTP ▷ Save as HTP file”. Also the menu command “Edit HTP ▷ Change description” allow to change the description of a loaded HT program and save it in a .htp file.

1.5.5 HT program editor

The HTP editor is open in a separate window as an easy to use dialog based editor, while the main window of the programming application can still be used. However some functions are restricted while the editor is open. This is because the editor work in conjunction with the graphical window, the edited program diagram being displayed while the program is edited and reflect the changes made. In the same time left clicking anywhere on a segment on the graphical diagram will allow for an easy jump to that segment in the editor. The editor can be closed without lose of the edited program and reopen later with button “Edit HT program”, however care should be taken while the editor is closed, because the existing program will be discarded if a new program is started or the currently selected furnace is changed or reselected.

The editor display one segment at a time, all fields being segment specific, with the exception of “New HT program description” which is the description of the HT program and can be any descriptive name or phrase limited to 75 characters.

For each segment can be chosen the segment type, start and end temperature, segment time, and the state of auxiliary functions (a check-mark indicate that the function is active). The start temperature is editable only for the first segment. The “<<” button allow the conversion of a heating/cooling ramp expressed in ℃/hr into necessary segment time, for that be sure that the start and end temperatures have their intended values, input ramp rate in the segment time edit field and click the “<<” button.

If a furnace (other than default) is selected then the auxiliary functions descriptions will be loaded from the furnace settings, also the graphical window temperature range will be updated to the furnace maximum and minimum temperatures.

Navigation is done with “Previous Segment” and “Next Segment” buttons, or by left clicking on diagram. Moving to a different segment will update the program and the diagram with the data entered in the current segment.

The button “Delete Segment” will delete the current segment, connecting the segments from before and after it, the user will be ask for confirmation before this action. The first segment cannot be deleted, only changed.

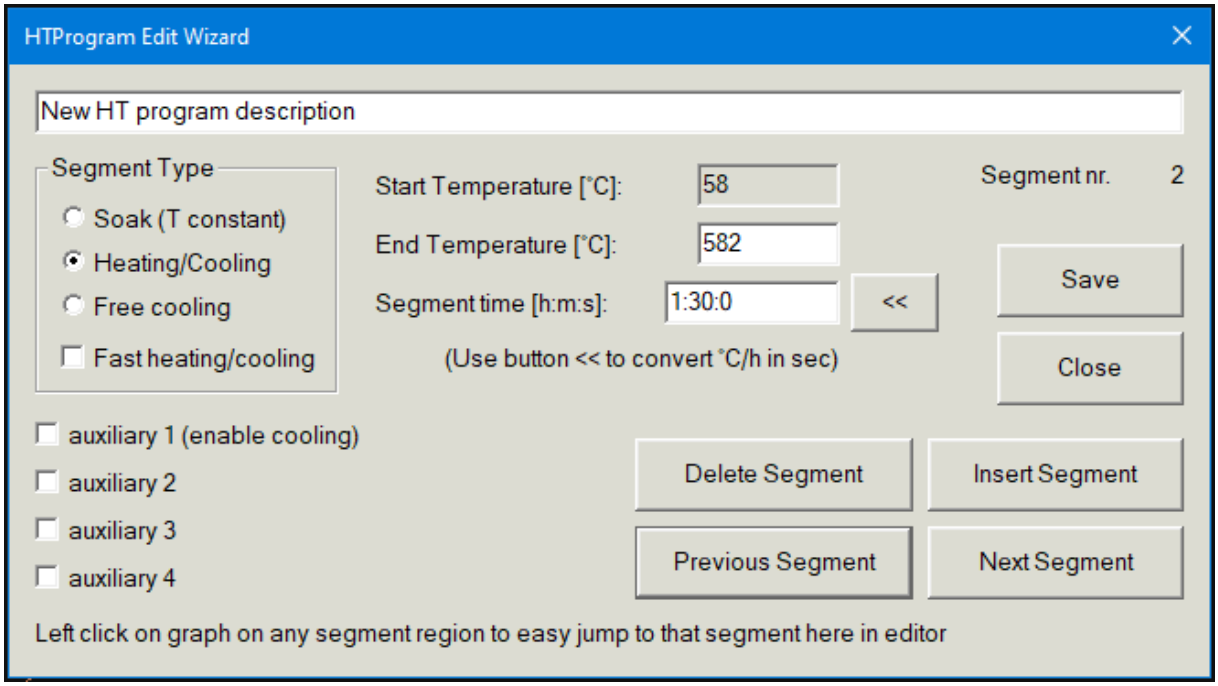

Figure 1.5: HTP editor screenshot

The button “Insert Segment” will insert a new segment after the current segment, the user will be ask for confirmation before this action. If the current segment is the last one then this button will become “Add Segment” and will add a new segment to the end of the program. The editor will move automatically to the newly added or inserted segment. The user should observe that deleting or inserting a segment inside a program may change the start temperature for the next segment after it, this may require remedial actions to the affected segment.

The “Close” button will close the editor but the HT program will remain in memory and its editing can continue later. The “Save” button do the same things as Close and will also prompt the user to save the program in a .htp file. The existing program in memory can also be saved from the menu or the main window save button.

1.5.6 Print HT report

To print a report, first the record of the desired process must be open with “Open and view a record” button or menu command “File ▷ View record file”. Once the record is open, the “File” menu print command or the button “Print report from record” can be used to open the preprint dialog. This allow to print one document composed from 3 parts, by marking the corresponding check-boxes as follow.

- PRINT HTPROGRAM DIAGRAM – print one single page with the diagram of the HT program currently loaded. The page will also contains the program description, current date, and the name/signature entered in the signature edit field.
- PRINT RECORD DIAGRAM – print one or more pages with the recorded diagram of the heat treatment that is currently loaded. It will also contains the process description and the starting date as recorded at the start of the process. By default the diagram is printed with a time compression so that it fit on 1 page. In the preprint dialog the user can chose

the maximum number of diagram pages to be printed, a value of 0 (or a value large enough) will print as many pages as necessary for no time compression (1:1).

- PRINT RECORD TABLE – print one or more pages with a temperature vs time table generated from the currently loaded record. The table is generated using recorded data at a time interval in minutes entered in the preprint field. The default time interval is 10 minutes. The table may spread on multiple pages, dependent by the time interval used. If in the print dialog the user chose pages, the table is truncated to the number of pages specified.

If “Use default printer” is checked then the default printer is used and the user is no longer prompted with a print dialog before printing. Any combination of these 3 parts can be selected, they will be printed as a single document, in the case of pdf printing it will produce a single pdf file. The order in the document is: program diagram, record diagram, record table.

2 Installation

2.1 Safety Precautions

- Use the computer software of this system only together with the corresponding electric cabinet and temperature controller for which it was configured. Reconfiguration should be done by qualified personnel that understand the system functionality. Failure to follow these guidelines may result in malfunctions or property damage.
- Risk of electric shock! dangerous voltage is present in some of the circuits inside the electric cabinet while it is powered, maintenance work should be executed by qualified personnel only.
- The static electricity can damage some of the electronic components from inside the cabinet, avoid touching them, or connected circuits, before taking the necessary actions to prevent static electricity damage.
- To avoid excessive electromagnetic interference, keep the signal wiring away from power cables that carry high voltages or large currents. Do not wire power lines together or very close and parallel to signal wiring. Using shielded cables and using separate conduits or ducts is recommended.
- Do not use the system outdoors unprotected. Do not use in areas with excess humidity that may lead to condensation, or in areas where significant water splashing may occur.
- Is the responsibility of the user to ensure the effectiveness and safety of operation of the heat treatment furnace and the associated system while is in use or maintenance.

2.2 Electric cabinet upgrade

The electric cabinet of each furnace must have a supported temperature controller and a serial link supervisor (only if the auxiliary systems are used). If the existing controller is not supported it must be either replaced or the support for it can be added to the communication module, for this a specialized assessment of compatibility should be done first.

Another important aspect is that the communication signal ground of the temperature controller to be isolated from the furnace common and protective ground. Otherwise possible potential differences between different ground systems and formation of undesired ground loops can appear, leading to increased noise interference and even damage. Isolation can be obtained either by using a 24Vdc temperature controller with isolated power supply, or by using a controller with an isolated communication module. Isolation can be checked with the cabinet turned off, by measuring the electrical resistance between the communication signal ground of controller and the chassis of the cabinet or protective ground. This resistance should be above 100 kΩ.

If additional functionality is desired from the upgraded cabinet then a more extended redesign and upgrade can be done. Overall the electric cabinet upgrade can range from unnecessary

to extensive upgrade dependent on customer requirements and the capabilities of the existing cabinet.

2.3 Serial link

Two types of serial links can be used dependent of type of communication available at the temperature controller: RS-232 and RS-485. Through RS-232 only 1 controller can be connected to the link, using a cable with minimum 3 wires as RXD, TXD and common ground.

Through RS-485 up to 8 controllers can be connected to the link, this being the case for most controllers. However all controllers connected together on a RS-485 link must have identical baud rate and data frame (that is 8 data bits, same parity, same number of stop bits). The default and recommended baud rate is 19200 bps, the minimum that can be used is 9600 bps. These bauds are relatively small, which allow the use of simple twisted pair cable with 120 - 150 Ω terminating resistors at both ends. For long distances or high EMI environment, a shielded twisted pair is recommended, the cable length can be up to 1200 m. A connection between the communication signals grounds is necessary to keep the common mode voltage low, if not then every device differential line must have 2 clamping diodes to their own ground to limit the common mode voltage between -7 and +12 V.

Ground loops should be avoided since they can be induced with perturbative currents by the stray magnetic fields. If not possible then the loop area should be reduced to a minimum by keeping the wires together. Is highly recommended that the signal ground of temperature controller (or communication module) to be isolated from the cabinet ground for every furnace. Distant grounds connected together without isolation can result in damage due to voltage differences and also unreliable communication due to the noise induced in resulting ground loops.

2.4 Software installation

The control and programming applications must be installed using the dedicated installer. This is a setup wizard that can install multiple instances of the control application, together with the programming application. The control application require a registration key to be used, the programming application can be used without a key. After the welcome screen and license agreement, the software installation will go through a series of steps as described bellow.

2.4.1 Registration key

Once typed in the key can be validated for the current user or for all users, dependent of selection made through the corresponding radio buttons. Installation for all users require that the installer to be run as administrator or from an administrator user account.

The installer can also be used just for key validation or revalidation for an existing installation, in this case after validation the installer can be closed. Revalidation may be required for another user to use an existing software (when the initial installation was for the current user only), also may be required in the case of a computer hardware or configuration change that may lead to the loss of key validation.

2.4.2 Install folder

The install folder is the common folder where all individual instances folders will be installed. This folder should not be located inside Program Files folders or other system restricted folder,

instead a folder where the user or users of the applications have full access rights should be selected.

Both the control app and the programming app will be installed inside one or more instance folders. The user must provide an instance name that will also be used as a folder name for the instance by the installer. Multiple instances are installed if chosen so by repeating this step and the next one. The default language for the applications is english, but other languages can be selected from the language selection.

2.4.3 Instance setup

Additional setup elements for the current instance. Two buttons “Browse TXT” and “Browse CFG” allow the user to import the settings for the instance from the two configuration files “remoteconfig.txt” and “htcapp.cfg” from a previously installed instance. If no import files are selected then the setup will provide the default settings. Desktop shortcuts to the instance control and programming applications can be created.

The “Add New Instance” button will add a new instance by repeating the last 2 steps, a new instance name should be provided. Press the “Next” button to finish installing the instances.

2.4.4 Finish the installation

Once the installation has finished the user can chose to add shortcuts to the start menu, the shortcuts added will be to the installation folder of all instances, the uninstall shortcut and this user manual.

Also the user can chose to allow the installer to adjust windows colors implied in the rendering of the control elements in win32api applications. This is recommended on Windows 10 and 11 to improve the visual aspect of win32api applications. These changes apply for the current user only, the changes will take effect at the next login of the current user. The original colors will be saved in the file “restorecolors.reg” located in the installation folder.

2.5 Uninstall the software

To uninstall this software simply use the uninstall shortcut from “Start ▷ Programs ▷ HeatMon”, this will run “keyremove.exe” from the installation folder. This will remove the registration key, the shortcuts created by the installer and the software executable files. It will not delete the installation folder nor its subfolders, because the heat treatment records and programs are located in these subfolders. The folder can be deleted manually once these files are no longer useful.