

D10.2 Implementation of overall control system (HMI) including graphical user interface (GUI)

Classification PU

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D10.2 Implementation of overall control system (HMI) including graphical user interface (GUI)

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D10.2 Implementation of overall control system (HMI)
including graphical user interface (GUI)

Executive Summary

Based on the control architecture (D10.1) and the sum of all control parameters of the sub modules, an overall human machine interface (HMI) will be developed to control all parameters. This includes the implementation of the graphical user interface GUI as visible part of this HMI.

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1 Introduction

It is documented in D3.1 that every partner will use his own control unit to control his part of the process chain. However, all these submodules need to be coordinated and synchronised to perform properly. Therefore, an overall control unit is needed to connect the separate modules with their different control units resulting from WP4 to WP9..

In D10.1, the overall control system (top PLC) is described. The top PLC is located between the data downstream (transformation from purchase orders into process parameters), the process chain (individual PLC systems of every module) and the data upstream (transfer from monitoring data into process database). Therefore, the top PLC is the linking part between these parts.

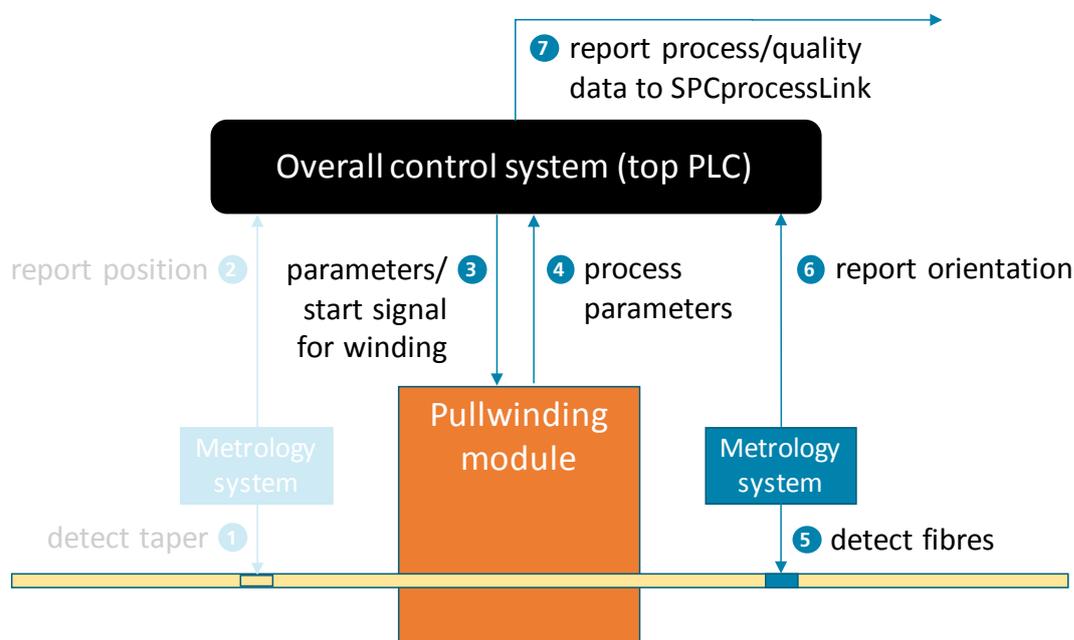


Figure 1: Data exchange concept example for the pullwinding process

OPC UA was chosen as communication standard in the data flow. By using this standard, the compatibility between the different control systems of the separately developed modules of the process chain is ensured. This includes the different manufacturing modules, the in-line methodology system as well as the software components. Another point for the implementation of the OPC UA standard is that the standard is widely used in the industry and supports the exploitation of the project results even beyond the scope of the project.

In addition, a list of control parameter for each sub process is given in D10.1. These parameters are used in the background of the HMI and GUI and will be implemented in the interfaces providing all needed information and giving the operator the possibility to control the machine using these interfaces.

2 Implementation of the top PLC

2.1 Implementation of the hardware

The hardware part of the top PLC consists of a Beckhoff industrial computer. This Beckhoff system is integrated in the Openmind network and is connected to the machine as well as to the database. This is required because the top PLC is the connecting point between the physical process and the back-end of the data flow scheme regarding the data flow scheme defined in D10.1.

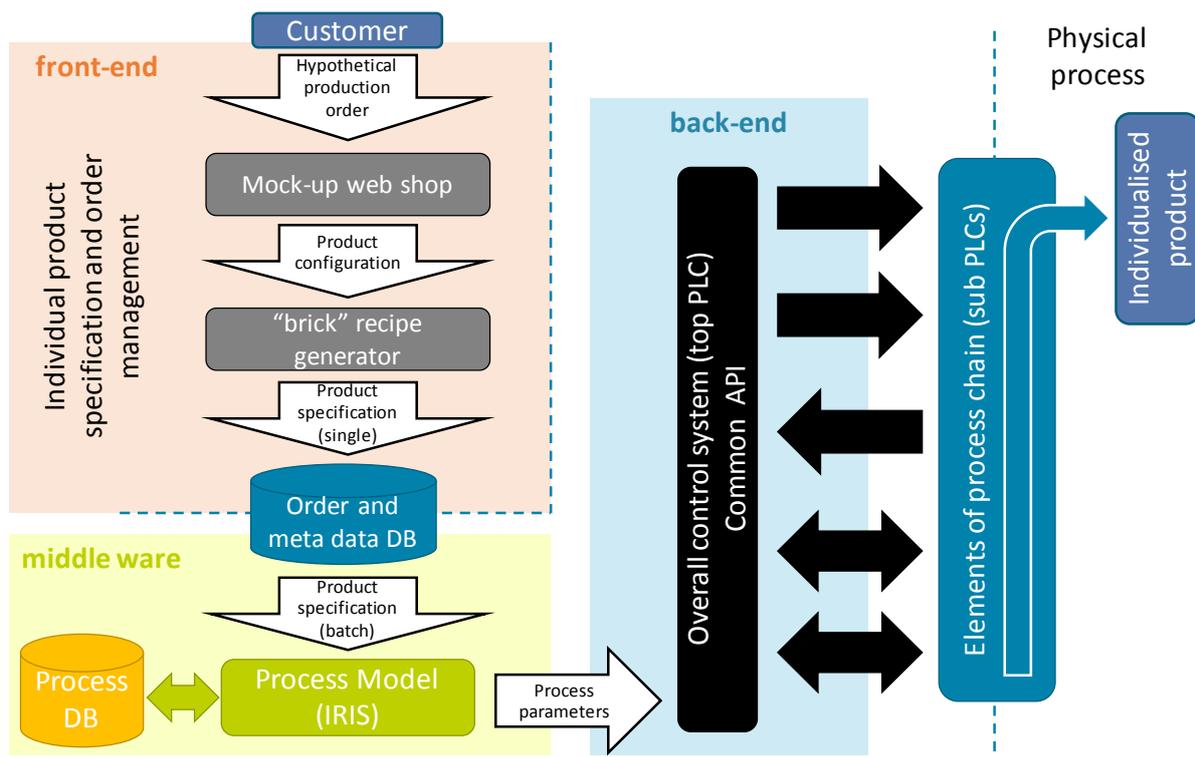


Figure 2: Data flow scheme

At the moment, different systems are implemented in a test set-up to test connectivity and the data exchange. In Figure 3, the test set-up with the actual connections is shown.

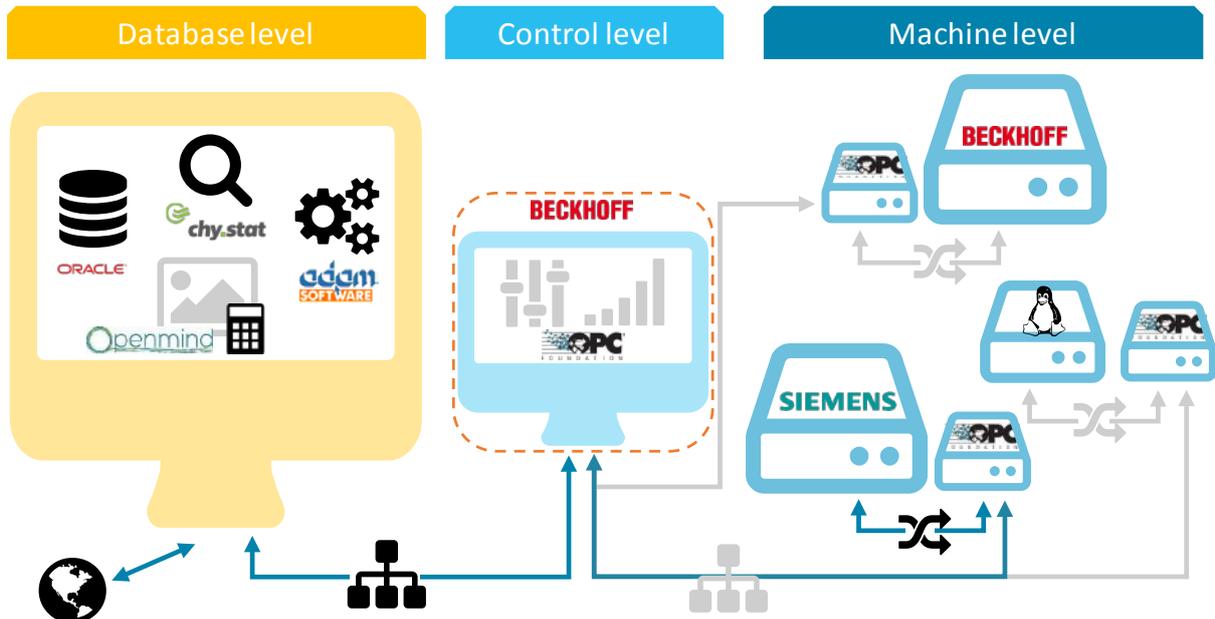


Figure 3: Implementation of the data infrastructure

The Beckhoff system is connected to the control unit of the pullwinding process. With the implemented OPC UA module, the transfer of parameters to the Beckhoff system is possible and implemented. At the moment, the database server is also directly connected to the control unit of the pullwinding process to receive the provided parameters. The connection of the database server to the overall control system is not used yet but implemented. In the final implementation, there is no direct connection between the data base server and the control unit of the pullwinding process.

2.2 Concept of the Human-Machine-Interface (HMI) and the Graphical User Interface (GUI)

Before the implementation of the HMI and GUI a concept is required, which defines the functionalities and requirements for the HMI and GUI. The concept also includes the first design of the GUI.

2.2.1 Functionalities and requirements

The HMI/GUI has to consist of three different parts and functionalities respectively:

- Basic operation mode
- Observation of machine status
- Modification of machine parameters

The basic operation mode provides the general information about the process as well as basic functions of the GUI. This part of the GUI provides possibilities to control the machine in general. This includes functionalities like:

- On-/Off switch
- Start-/Stop button
- Error-/Quit button
- Status overview

The observation of the machine status provides information about the machine status as well

as information about the connection status of the submodules. In addition to the status of the connected hardware modules, the observation of machine status offers some additional options like:

- Order selection
- Order overview
- Approval/modification of the production programmes generated by the data models

The additional functionalities shall give the operator an overview of the orders, which are currently produced, which orders have been produced and which will be produced. Because of the automated configuration of the machine, the production programmes provided by the data models need to be confirmed or modified by the operator before a guidewire is produced. These functionalities ensure a safe operation of the machine.

The main part of the GUI will be covered by the area for display and modification of machine parameters. Each of the elements of the section 'observation of the machine status' will be linked to a subpage that allows access to detailed information about the selected element.

2.2.2 Implementation concept

In a first concept, the screen is split in different frames, which provide different information, shown in Figure 4. The elements in the concept are colour coded: buttons/switches are blue, non-editable text fields are yellow, input fields are green.

On top of the screen, the basic operation mode for the whole machine is provided, including functionalities like an on-/off-switch and general parameter information like the overall speed. This basic operation mode gives the operator an overview on the production process and the possibility to intervene in the production process in case of emergency or error by switching the screen.

In the left side of Figure 4 the machine status and the status of the separate modules is visible. This list consists of different buttons, which are used to switch the frame on the right side. Next to general information like machine status or an order overview, the operator can switch between the separate modules of the production process, where detailed information for the module is given. It is also planned to implement elements that allow access to a status overview to the database and the model, which generates the machine parameters.

To modify the machine parameters, a detailed view on the separate modules is provided. Through the list on the left side of Figure 4, the detailed view on the separate modules is selectable. Regarding the different modules, a detailed and individual visualisation of the parameters of the module is available. Functionalities to modify the parameters are provided in these detailed views.

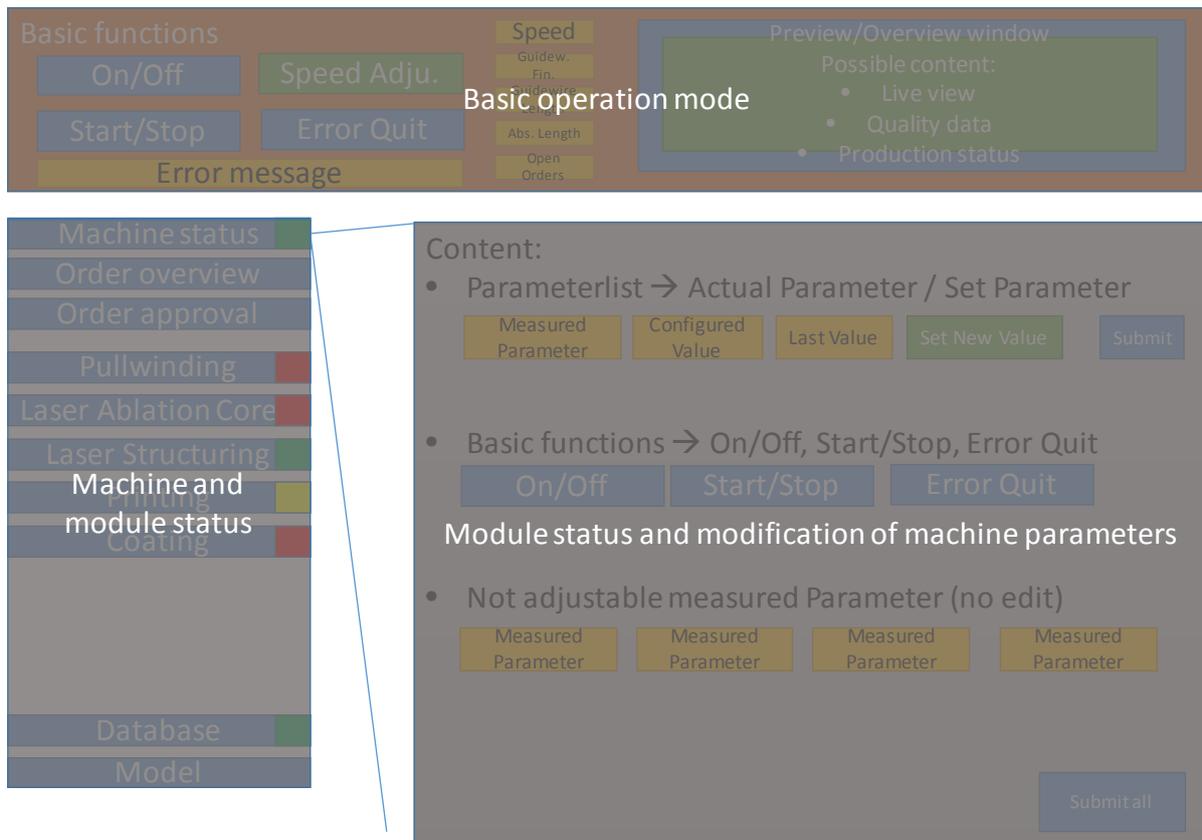


Figure 4: General concept of GUI

2.2.2.1 Basic operation mode

The basic operation mode includes functionalities, which should be available and visible in every situation. This means that the basic operation mode has to be permanently visible in the GUI. To realise that, a part of the screen is used for these standard operations and some parameters, which need to be monitored while producing guidewires.

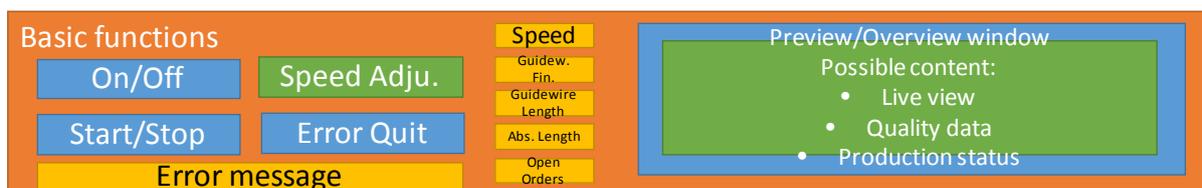


Figure 5: Basic operation mode concept

This frame includes the switches:

- On-/Off: Whole machine is switched on or off
- Start-/Stop: Production process is started with the actual production program or stopped
- Error Quit: Error messages could be acknowledged

In addition to these switches, there need to be different text fields showing information about the production process and the machine status. These text fields, which are not editable only show measured parameter and notifications. The not-editable text fields are:

- Error message: Error messages are shown in a permanent text field

- Speed: The overall process speed is displayed
- Guidewire fin.: Displays number of finished guidewires
- Guidewire Length: Displays the actual guidewire length
- Abs. Length: Total length of the produced guidewires is displayed
- Open Orders: Displays number of future orders

The basic operation mode should also provide information about the production status or the quality data in a diagram. This is foreseen on the right side of Figure 5 as a placeholder. The provided visualisation in this place depends on the possibilities resulting in the final implementation of the other software systems and the database.

2.2.2.2 Observation of machine status

In Figure 6, the concept for the observation of the machine status is shown. The machine status is mainly displayed by the frame of the machine status, which is shown in Figure 6 exemplarily. An overview on the machine and the module status is given by the colour indication of the different bottoms on the left. In the concept, a traffic light logic was chosen because this logic gives a good visibility and simple overview.

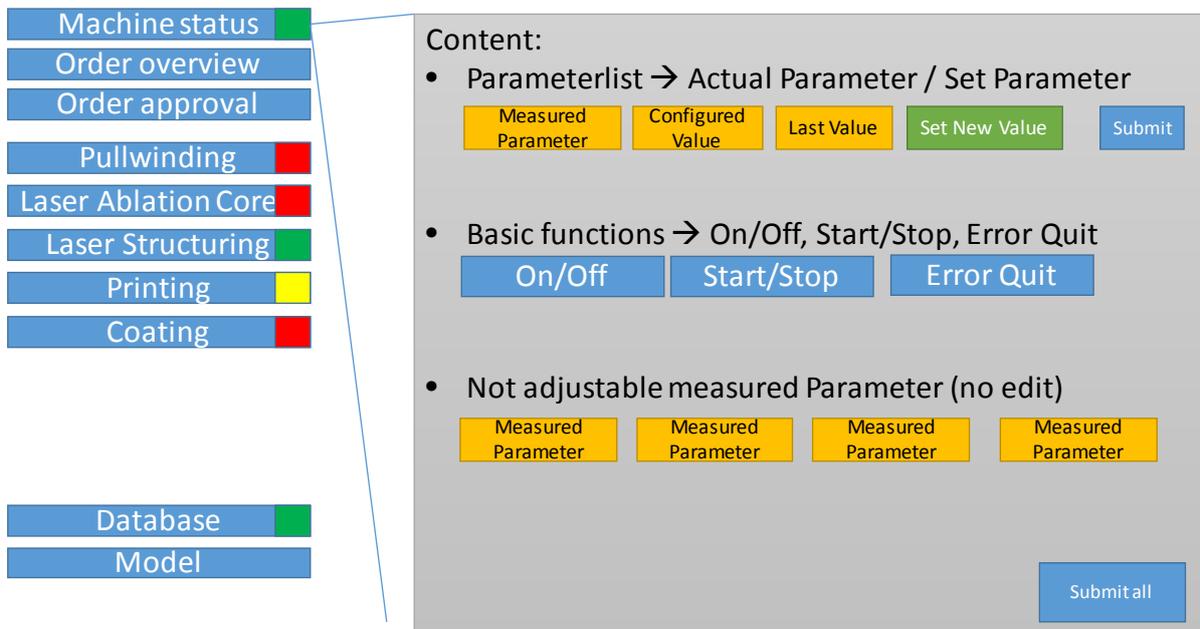


Figure 6: Observation of machine status concept

The right frame is split into three different sections. In the upper part, different measured parameters are displayed, which are editable. Every edit of a parameter consists of two text fields showing the actual measured value and the value, which is configured by the production program. Next to these two parameters, the value is shown, which was set before the actual one (last value). To edit a parameter the text field “Set New Value” has to be used. This field is editable and the new value can be typed in. With the submit bottom, the value of the “Set New Value” field is set as the actual parameter.

The second section provides basic functions of the different modules. In this machine overview frame it is possible to shut down the different modules with the on-/off-button. It is also possible to start or stop a module. This enables the operator so produce guidewires where different production steps are left out. This is especially interesting during the testing stage of the project to validate the different production steps.

Last, a general overview of the most relevant parameters of the production process is shown. The parameters are mainly measured parameters, which should provide information about the quality of product und process. The parameter list provided in D10.1 is the basic document for this part of the overview and should be extended with the modelling results of the data model.

2.2.2.3 Modification of machine parameters

One possibility to modify the machine parameters is given in the frame of the machine status, shown in Figure 6. The modifications aim at the modification of machine parameters but not at module specific parameters.

The modification of the module specific parameters is possible in the module specific frames and is done in the same way as described in Chapter 2.2.2.2. It consists of the same three sections in the frame and the same way of modification.

2.2.2.4 Order overview

Another interesting part of the HMI/GUI is the overview of the orders. Because of the length of the machine, the guidewires and the continuous process, different guidewires are produced at the same time. Therefore a view is needed, which provides an overview of these orders. In addition, an overview of recent and future orders is interesting. The orders are structured regarding their needed machine parameters to ensure the continuous production. In the end, a manual modification of the following orders should not be possible but a manual cancelation of single orders should be implemented.

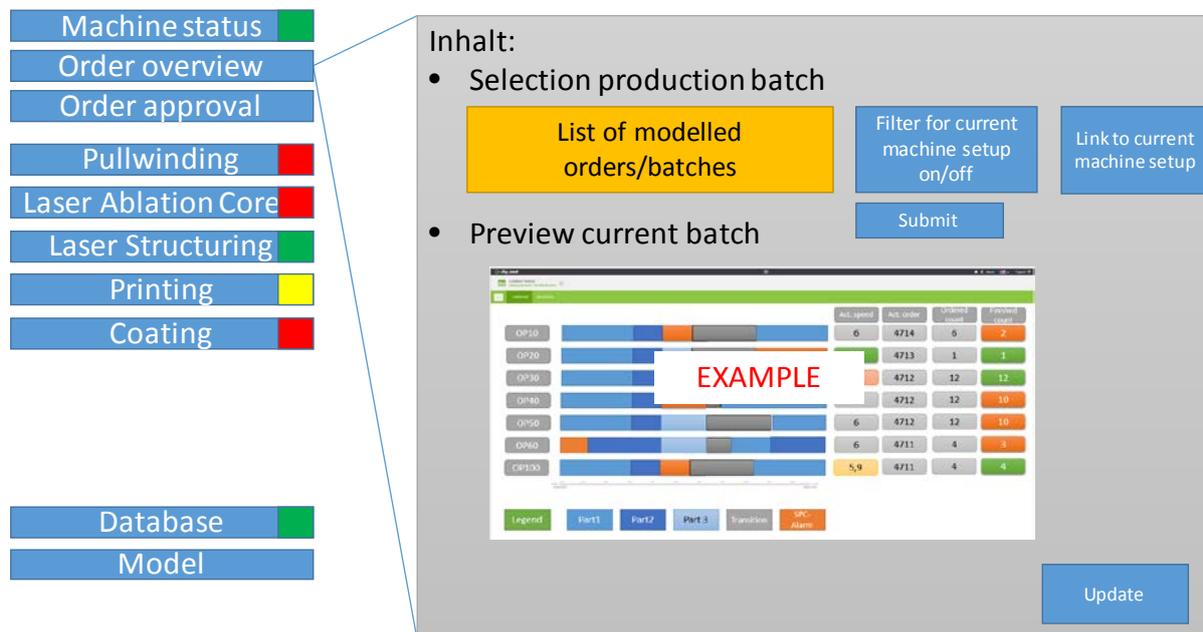


Figure 7: Order overview concept

The model in this project generates suggestions for the machine parameters with which the guidewires are producible. However, the operator will still have an important role in the production process. Only with this explicit approval of the orders, an order is added to the order list and is produced afterwards. A detailed overview on the different orders is given in the frame of the "Order approval".

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2.2.3 Implementation of the HMI/GUI

For the implementation of the HMI and GUI, the software TwinCat 3 is used.

2.2.3.1 Implementation of Basic Operation Mode

At first, the Basic Operation Mode is implemented in the GUI. Based on the concept, the Basic Operation Mode is implemented at the top of the user interface and is permanently visible (Figure 8 and Figure 9).

Critical parameters, which could lead to a destruction of the guidewire, like the force in the forming dies in the pultrusion and winding section, are visualized with horizontal bars and are permanently shown. These bars have coloured sections (green, yellow, red) to support the interpretation of the shown values.

The only editable parameter in the Basic Operation Mode is the line speed, that defines the speed in the whole machine and has a higher importance.

Other parameters like the number of finished guidewires, are visualized with horizontal bars to show how many guidewires from the current order have been produced. This gives an overview on the production progress and shows when new orders have to be approved.

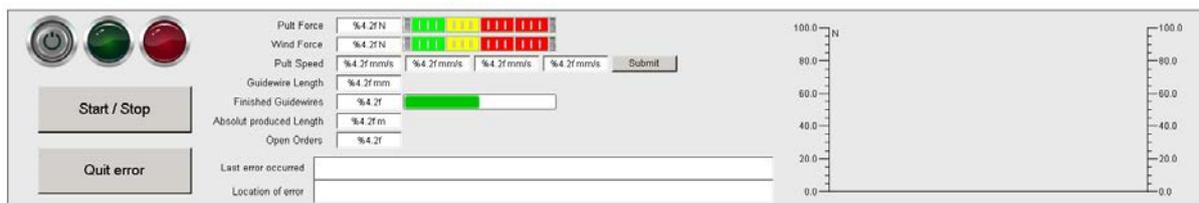


Figure 8: Basic Operation Mode in developer mode

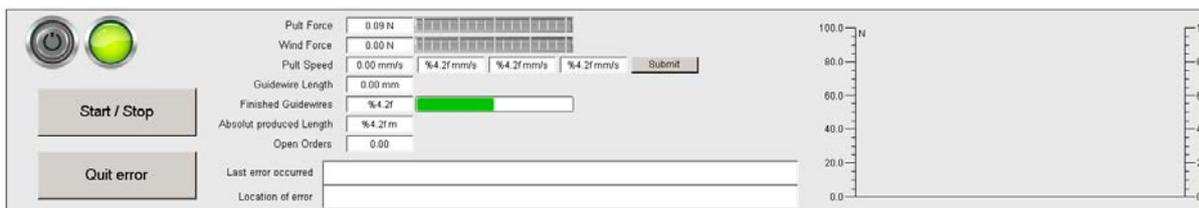


Figure 9: Basic Operation Mode in running mode

Because of the high number of available data from the different submodules, the GUI should be structured clearly. This requirement will be focused by using lamps and visual changes in case of error or failure. Every machine module is represented by a button in the machine and module status area on the left of the GUI (cf. Figure 4). An additional overall machine status lamp is visible at the top of the basic operation mode screen (Figure 8).

The elements of the machine and module status area react to the status of the machine. If the respective module is online and an OPC connection has been established, an icon at the left edge of the button is displayed. If the module is ready, but not running a status bar with a thin border is displayed at the right edge of the button. If the respective module is running the status bar is filled with green colour. In case of an error, the border of the whole button turns red.

Figure 10 shows an example of the machine status of the hardware modules in running mode. In this example, the pullwinding module is running. The laser ablation module is online and ready, but not running. The laser structuring module in an error state. The pad printing module is online, but not ready. The extrusion coating module is not online and the button is

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deactivated.

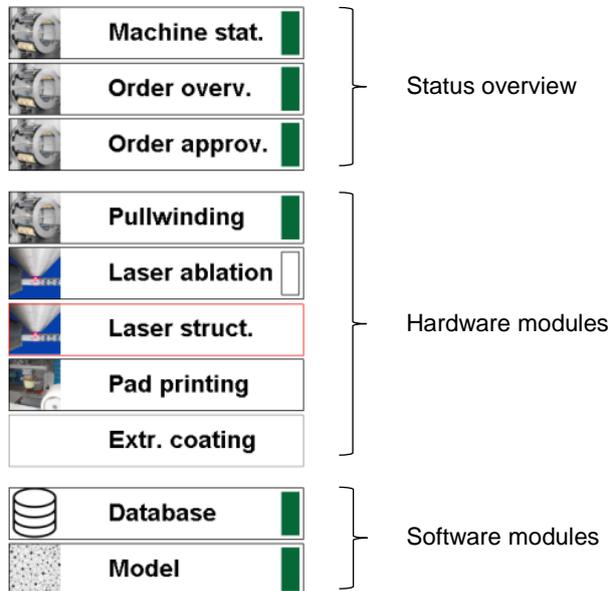


Figure 10: Machine status in running mode

2.2.3.2 Modification of Machine parameter

Every frame of the different modules provides all editable parameters in the upper right corner (Figure 11 red). The list of editable parameters is based on the definition in D10.1. The parameters are editable with the approach, which is described in Chapter 2.2.2.2. The different boxes have a description as tooltip, when the cursor reached the text field. Not editable text fields are grey.

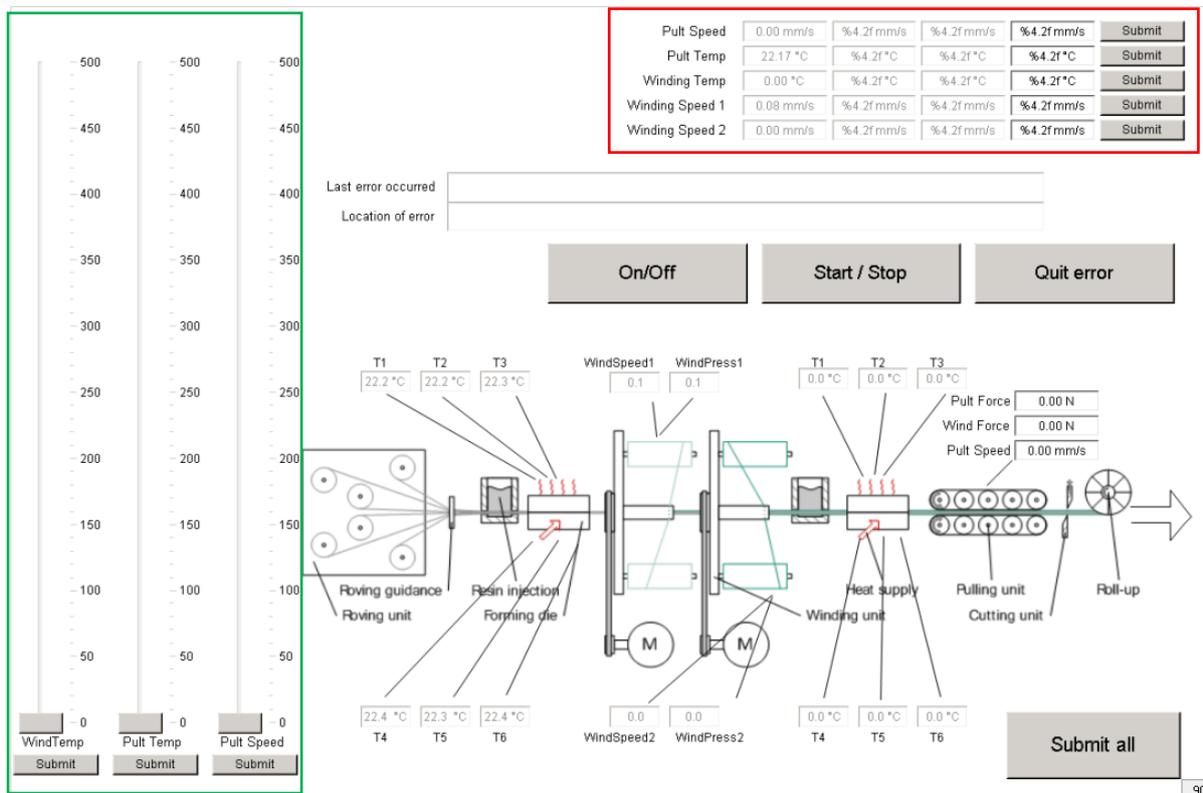


Figure 11: Frame for pullwinding module

The GUI will be used with a touch screen directly at the machine. To make the configuration of the different parameters easier with the touchscreen, sliders were added for frequently used parameters (Figure 11 green). They are easier to use on a touchscreen than small text fields.

In Figure 11, the pullwinding process is shown. Because the machine is already implemented in IPT, the shown visualization works. For the other process steps, the frames are already configured, but the physical modules are not integrated yet and provide no data. An example of the laser ablation process is shown in Figure 12.

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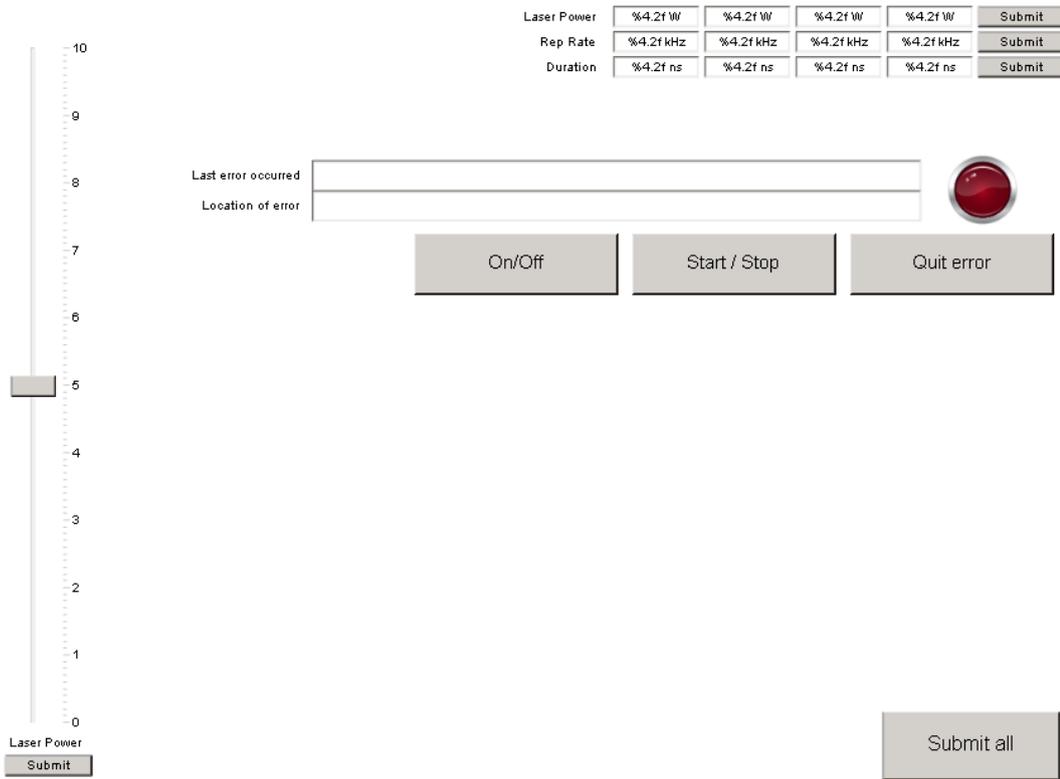


Figure 12: Frame for laser ablation in the developer mode

2.2.3.3 Observation of the machine status

The machine status is observable at several positions on the screen. In the basic operation mode is the status of the overall machine visualized with lamps (green and red). The list on the left side gives an overview on the module status and visualizes where an error occurs. Last, the machine status is shown on the different frames. In these frames is also an error text field implemented with a lamp switching to red, if an error occurs and switching to green when the error is quitted. At the bottom of every frame, the machine parameters provided by the modules in the machine are shown. All parameters listed in D10.1 are mentioned in the bottom of every frame. In Figure 13, the developer mode is shown of the whole GUI, showing all lamps and machine module status. The running mode is shown in Figure 14, where some functionalities of the GUI are invisible based on the status of the machine.

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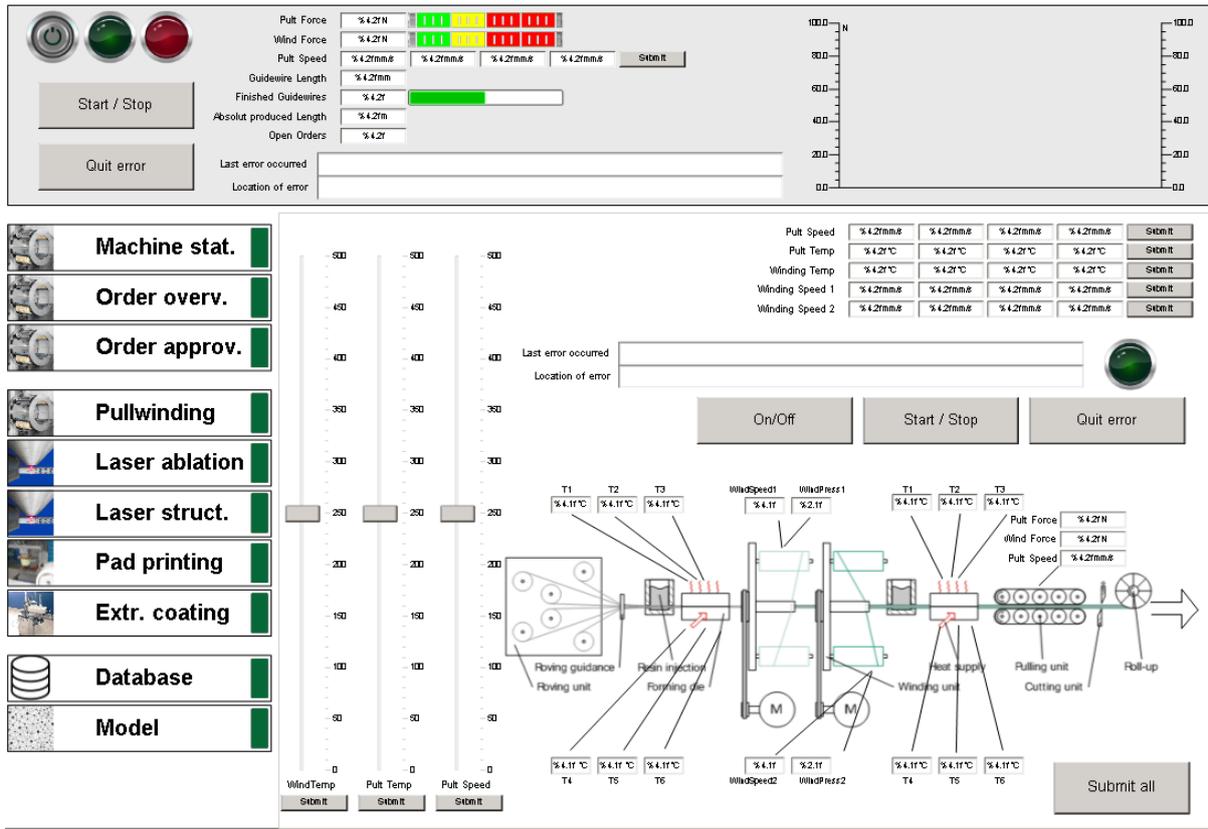


Figure 13: GUI in developer mode

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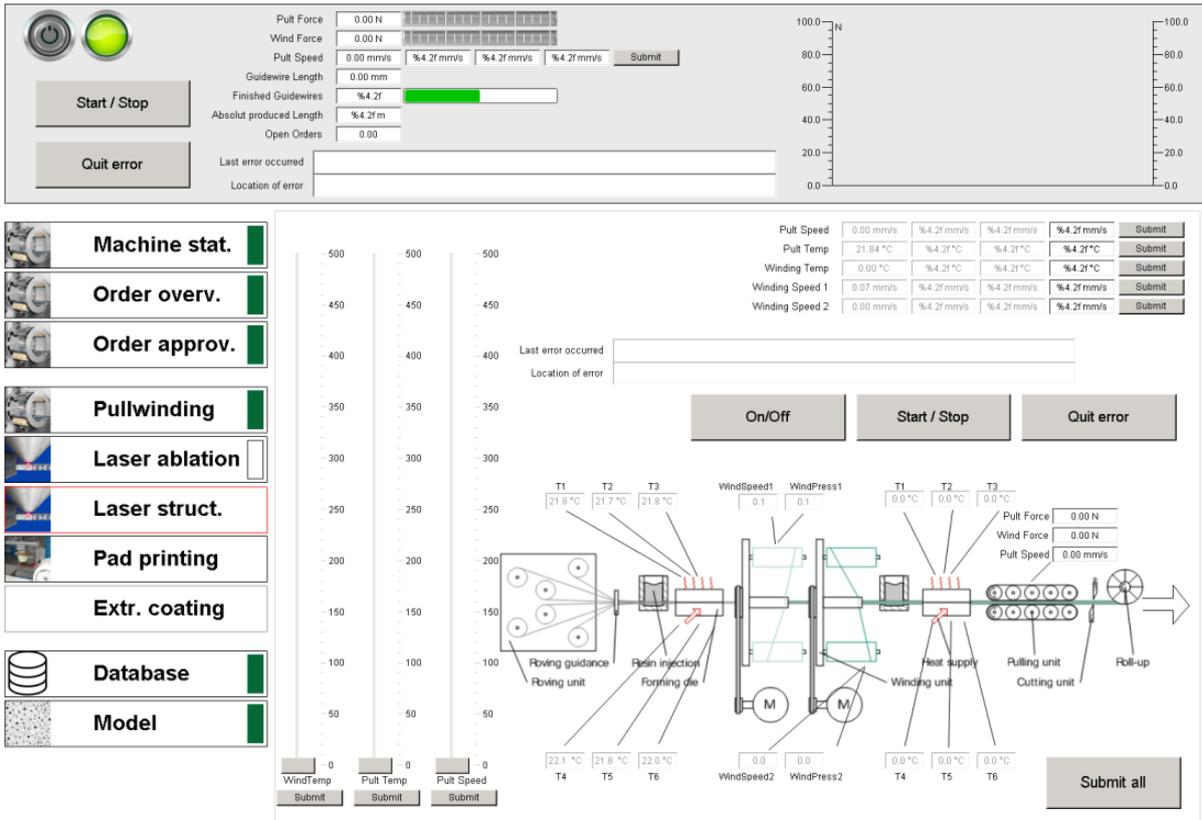


Figure 14: GUI in running mode

3 Conclusions

This deliverable provides an overview on the HMI and GUI for the Openmind project. The HMI and GUI is provided in the overall control system. This overall control system is a Beckhoff industrial computer on the hardware side and programmed with TwinCat 3 visualisation in the software side.

The GUI as visible part of the HMI is shown in screenshots in this deliverable. The GUI provides the functionalities of controlling the process with the possibility to modify the process parameters on the one side and giving an overview on the machine status and the process parameters on the other side. The GUI is usable by mouse and keyboard, for example in the case of remote controlling the machine, and by touchscreen on the shop floor. The development of the HMI and GUI is explained in this deliverable as well.

In the further project progress, the HMI/overall control system will be connected to the separate machine modules to connect them into one process chain. Therefore, the different modules will be implemented in the HMI as well as the pullwinding process is now. Connecting the other machine modules will be possible in short time, because the parameters, defined in D10.1, are already prepared in the HMI.

Another future action is the integration of the order overview and the process model. This will take place after the integration of dataflow into the real process and the integration of the other hardware modules into the process chain.