

Furnace Data Notes

The furnace is heated by two natural gas burner BIC80 of 90 kW each.

The furnace is comprised of several elements (combustion air skid, gas skid, furnace BCU zone 1 and 2, door, etc...) that will be described in the next section and numerous process parameters/ tags are being recorded within these.

Furnace Data

In total 47 individual tags are currently being recorded at a fixed time interval of 2 s (frequency of 0.5 Hz). All these tags are visible on the various HMI views as represented below in Figure 2.



Figure 2 – HMI views of the different elements with tags of interest.

These views aim to draw together all the important information about the furnace to enable the operator to monitor furnace operation in a safely manner. They are also used to make process change by adjusting some parameters such as temperature, air flow rate, pressure set point, open/close the door etc...

The full list of Tags/ process parameters and description is displayed in the table below.

Table 1 - List of process parameters with description and units

| Reference | Unit | Description |
|------------------------------------|--------------------|--------------------------------|
| AIR_0123_945_07_DPT | Nm ³ /h | Air flow |
| AIR_0123_945_05_TE | °C | Air temperature |
| AIR_PID_COMBUSTION_AIR_PV | mBar | Air pressure PID control value |
| AIR_PID_COMBUSTION_AIR_SP | mBar | Air pressure set point |
| AIR_PID_COMBUSTION_AIR_OUT | % | Fan power use |
| AIR_PID_COMBUSTION_AIR_ACT_P | | PID action Proportional |
| AIR_PID_COMBUSTION_AIR_ACT_I | | PID action Integral |
| AIR_PID_COMBUSTION_AIR_ACT_D | | PID action Derivative |
| AIR_DRIVE_AIR_SPEED | RPM | Fan speed |
| AIR_0123_945_03_PT | mBar | Air pressure |
| | | |
| FURNACE_PID_FURNACE_PRESSURE_SP | mBar | PID Pressure Set point |
| FURNACE_PID_FURNACE_PRESSURE_OUT | % | Opening use |
| FURNACE_0126_341_04_O2 | % | O ₂ Concentration |
| FURNACE_0126_341_02_PDT | % | PID opening control value |
| FURNACE_PID_FURNACE_PRESSURE_ACT_P | | PID action Proportional |
| FURNACE_PID_FURNACE_PRESSURE_ACT_I | | PID action Integral |
| FURNACE_PID_FURNACE_PRESSURE_ACT_D | | PID action Derivative |
| FURNACE_PID_FURNACE_PRESSURE_PV | Pa | Pressure Process Value |
| | | |
| GAS_0110_943_07_FT_Nm3_h | m ³ /h | Gas flow rate |
| GAS_0110_943_13_TE | °C | Gas temperature |
| GAS_0110_943_14_PT | mBar | Gas Pressure |
| GAS_0110_943_07_FT_m3_h | m ³ /h | Gas flow rate |
| | | |
| PID_ZONE_1_PV | °C | PID temperature control value |
| PID_ZONE_1_SP | °C | PID temperature Set Point |
| PID_ZONE_1_OUT | % | Burner Zone 1 cycle usage |
| PID_ZONE_1_0104_300_01_TEC | °C | TC Zone 1 |
| PID_ZONE_1_ACT_P | | PID action Proportional |
| PID_ZONE_1_ACT_I | | PID action Integral |
| PID_ZONE_1_ACT_D | | PID action Derivative |
| PID_ZONE_1_0126_341_06_TC | °C | Exhaust temperature |
| | | |
| PID_ZONE_2_OUT_PV | °C | PID temperature control value |
| PID_ZONE_2_OUT_SP | °C | PID temperature Set Point |
| PID_ZONE_2_OUT | % | Burner Zone 2 cycle usage |
| PID_ZONE_2_0104_300_02_TEC | °C | TC Zone 2 |
| PID_ZONE_2_ACT_P | | PID action Proportional |
| PID_ZONE_2_ACT_I | | PID action Integral |
| PID_ZONE_2_ACT_D | | PID action Derivative |
| | | |
| ROOF_0104_300_01_TC | °C | External Furnace wall/WDS |
| ROOF_0104_300_02_TC | °C | WDS/WSB1100 |
| ROOF_0104_300_03_TC | °C | WSB1100/WSB1100 |
| ROOF_0104_300_04_TC | °C | WSB1100/JM23 |
| ROOF_0104_300_05_TC | °C | JM23/JM26 |
| ROOF_0104_300_06_TC | °C | JM23/JM26 - Hearth |
| ROOF_0104_300_07_TC | °C | Top Chimney |
| ROOF_0104_300_08_TC | °C | External Furnace wall |
| ROOF_0104_300_09_TC | °C | Room Temperature |
| ROOF_0104_300_10_TC | °C | Centre of grid |

The process data is recorded on a NAS (network attached storage) and consists of multiple CSV files (one per sensors / per day approx)) (see Figure 3).

All the process data are time series i.e process value vs time stamp which is different from the data we have been using in the course workshops.

Each individual file has a size of couple of MB so the total dataset size of the can go up to several GB depending on the duration of the heat treatment being considered.

| | | | |
|--------------------------------------|------------------|--------------------------|-----------|
| FURNACE_0126_341_02_PDT_37 | 15/10/2022 19:38 | Microsoft Excel Comma... | 2,402 KB |
| FURNACE_0126_341_02_PDT_38 | 16/10/2022 23:31 | Microsoft Excel Comma... | 2,391 KB |
| FURNACE_0126_341_02_PDT_39 | 18/10/2022 03:25 | Microsoft Excel Comma... | 2,326 KB |
| FURNACE_0126_341_02_PDT_40 | 19/10/2022 07:19 | Microsoft Excel Comma... | 2,323 KB |
| FURNACE_0126_341_02_PDT_41 | 20/10/2022 11:14 | Microsoft Excel Comma... | 2,507 KB |
| FURNACE_0126_341_04_O2_7 | 13/09/2022 04:48 | Microsoft Excel Comma... | 6,679 KB |
| FURNACE_0126_341_04_O2_8 | 13/09/2022 09:35 | Microsoft Excel Comma... | 4,860 KB |
| FURNACE_0126_341_04_O2_9 | 14/09/2022 09:35 | Microsoft Excel Comma... | 5,384 KB |
| FURNACE_0126_341_04_O2_10 | 15/09/2022 13:29 | Microsoft Excel Comma... | 4,276 KB |
| FURNACE_0126_341_04_O2_11 | 16/09/2022 17:23 | Microsoft Excel Comma... | 2,385 KB |
| FURNACE_0126_341_04_O2_12 | 17/09/2022 21:17 | Microsoft Excel Comma... | 2,374 KB |
| FURNACE_0126_341_04_O2_13 | 19/09/2022 01:11 | Microsoft Excel Comma... | 2,321 KB |
| FURNACE_0126_341_04_O2_14 | 20/09/2022 05:05 | Microsoft Excel Comma... | 2,378 KB |
| FURNACE_0126_341_04_O2_15 | 21/09/2022 08:59 | Microsoft Excel Comma... | 2,393 KB |
| FURNACE_0126_341_04_O2_16 | 22/09/2022 12:53 | Microsoft Excel Comma... | 4,632 KB |
| FURNACE_0126_341_04_O2_17 | 23/09/2022 16:47 | Microsoft Excel Comma... | 11,420 KB |
| FURNACE_0126_341_04_O2_18 | 24/09/2022 20:41 | Microsoft Excel Comma... | 11,341 KB |
| FURNACE_0126_341_04_O2_19 | 26/09/2022 00:35 | Microsoft Excel Comma... | 11,305 KB |
| FURNACE_0126_341_04_O2_20 | 27/09/2022 04:28 | Microsoft Excel Comma... | 3,614 KB |
| FURNACE_0126_341_04_O2_21 | 28/09/2022 08:22 | Microsoft Excel Comma... | 2,393 KB |
| FURNACE_0126_341_04_O2_22 | 28/09/2022 09:09 | Microsoft Excel Comma... | 67 KB |
| FURNACE_0126_341_04_O2_23 | 29/09/2022 13:02 | Microsoft Excel Comma... | 2,339 KB |
| FURNACE_0126_341_04_O2_24 | 30/09/2022 16:56 | Microsoft Excel Comma... | 2,341 KB |
| FURNACE_0126_341_04_O2_25 | 01/10/2022 20:50 | Microsoft Excel Comma... | 2,338 KB |
| FURNACE_0126_341_04_O2_26 | 03/10/2022 00:44 | Microsoft Excel Comma... | 2,338 KB |
| FURNACE_0126_341_04_O2_27 | 04/10/2022 04:38 | Microsoft Excel Comma... | 2,341 KB |
| FURNACE_0126_341_04_O2_28 | 05/10/2022 08:32 | Microsoft Excel Comma... | 2,334 KB |
| FURNACE_0126_341_04_O2_29 | 06/10/2022 12:26 | Microsoft Excel Comma... | 2,337 KB |
| FURNACE_0126_341_04_O2_30 | 07/10/2022 16:20 | Microsoft Excel Comma... | 2,335 KB |
| FURNACE_0126_341_04_O2_31 | 08/10/2022 20:14 | Microsoft Excel Comma... | 2,341 KB |
| FURNACE_0126_341_04_O2_32 | 10/10/2022 00:08 | Microsoft Excel Comma... | 2,342 KB |
| FURNACE_0126_341_04_O2_33 | 11/10/2022 04:02 | Microsoft Excel Comma... | 2,223 KB |
| FURNACE_0126_341_04_O2_34 | 12/10/2022 07:56 | Microsoft Excel Comma... | 2,157 KB |
| FURNACE_0126_341_04_O2_35 | 13/10/2022 11:50 | Microsoft Excel Comma... | 2,115 KB |
| FURNACE_0126_341_04_O2_36 | 14/10/2022 15:44 | Microsoft Excel Comma... | 2,101 KB |
| FURNACE_0126_341_04_O2_37 | 15/10/2022 19:38 | Microsoft Excel Comma... | 2,145 KB |
| FURNACE_0126_341_04_O2_38 | 16/10/2022 23:31 | Microsoft Excel Comma... | 2,133 KB |
| FURNACE_0126_341_04_O2_39 | 18/10/2022 03:25 | Microsoft Excel Comma... | 2,076 KB |
| FURNACE_0126_341_04_O2_40 | 19/10/2022 07:19 | Microsoft Excel Comma... | 2,005 KB |
| FURNACE_0126_341_04_O2_41 | 20/10/2022 11:14 | Microsoft Excel Comma... | 2,233 KB |
| FURNACE_PID_FURNACE_PRESSURE_ACT_D_7 | 13/09/2022 04:48 | Microsoft Excel Comma... | 8,263 KB |
| FURNACE_PID_FURNACE_PRESSURE_ACT_D_8 | 13/09/2022 09:35 | Microsoft Excel Comma... | 6,114 KB |
| FURNACE_PID_FURNACE_PRESSURE_ACT_D_9 | 14/09/2022 09:35 | Microsoft Excel Comma... | 6,651 KB |

Figure 3 - Typical CSV files being recorded on the NOS.

In general, no IP restrictions apply to make use of the furnace process data files so they can be use freely for this assignment.

This set of data was recorded from the heating treatment of steel parts at 1100 degC for various oxygen concentration within the furnace (different air to fuel ratio settings on the burners) as well as a test run of the furnace beforehand. The total duration is more than

a month (this was chosen intentionally to represent the worst-case scenario i.e. largest amount of data to check efficiency of python for extremely large dataset).

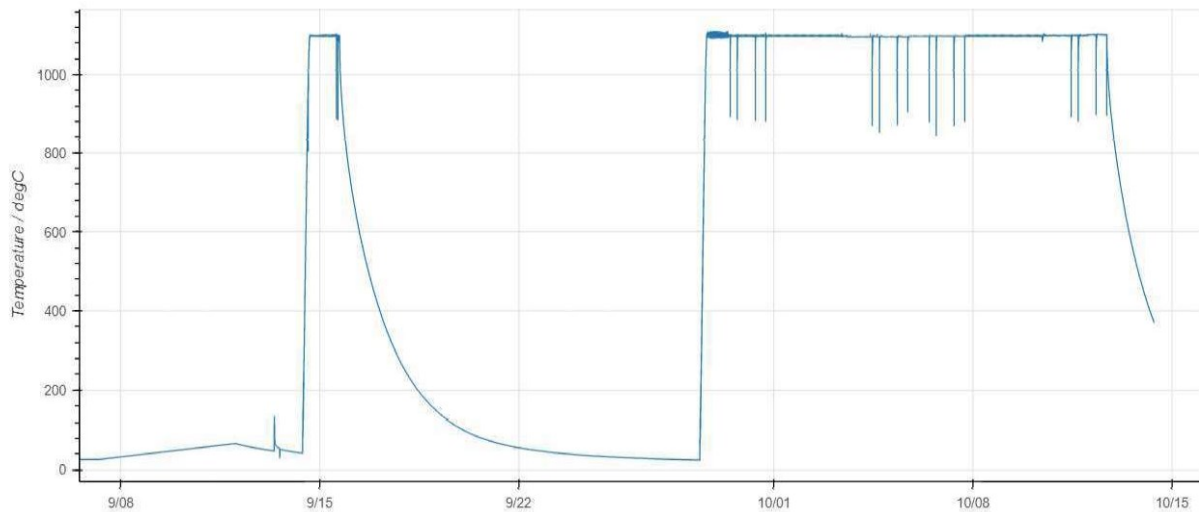


Figure 4 – Global view of the temperature profile within the furnace for the whole heat treatment duration.

For some experiments, we also record temperature data on a laptop from thermocouples installed in the instrumented metal part via National Instrument CompactDAQ system / NI 9213 module.