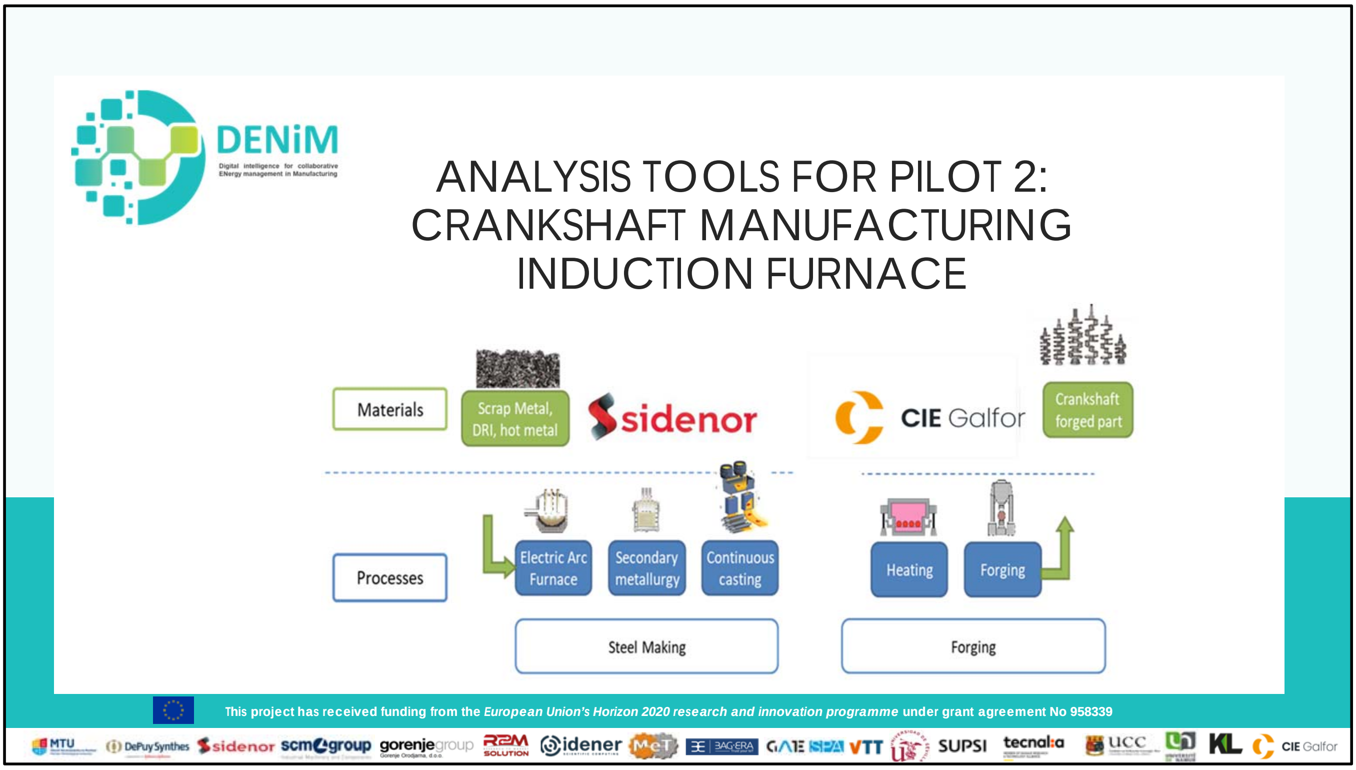
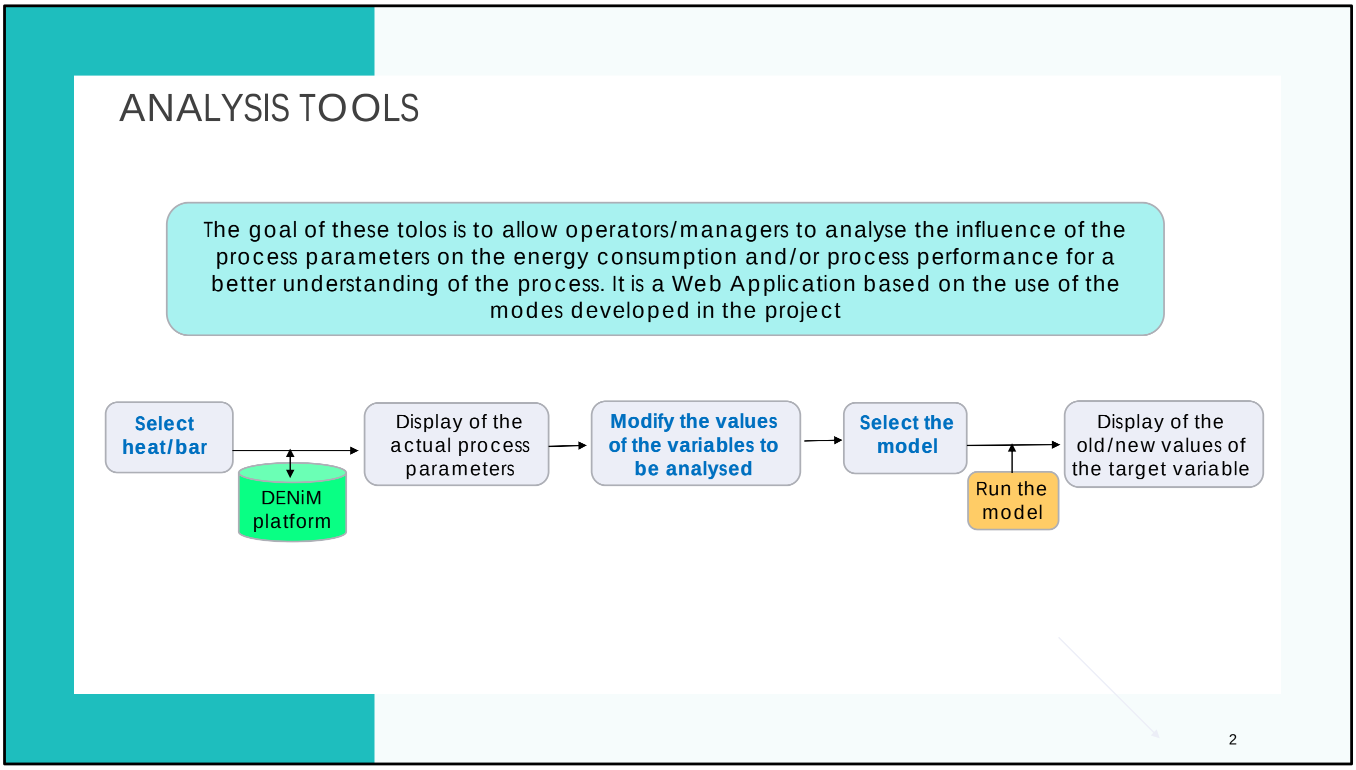


The final goal of the Pilot 2 is to reduce the energy consumption and environmental impact of the crankshafts production process, taking into account the value chain (steelmaking + forging), ensuring a good performance of the processes involved.

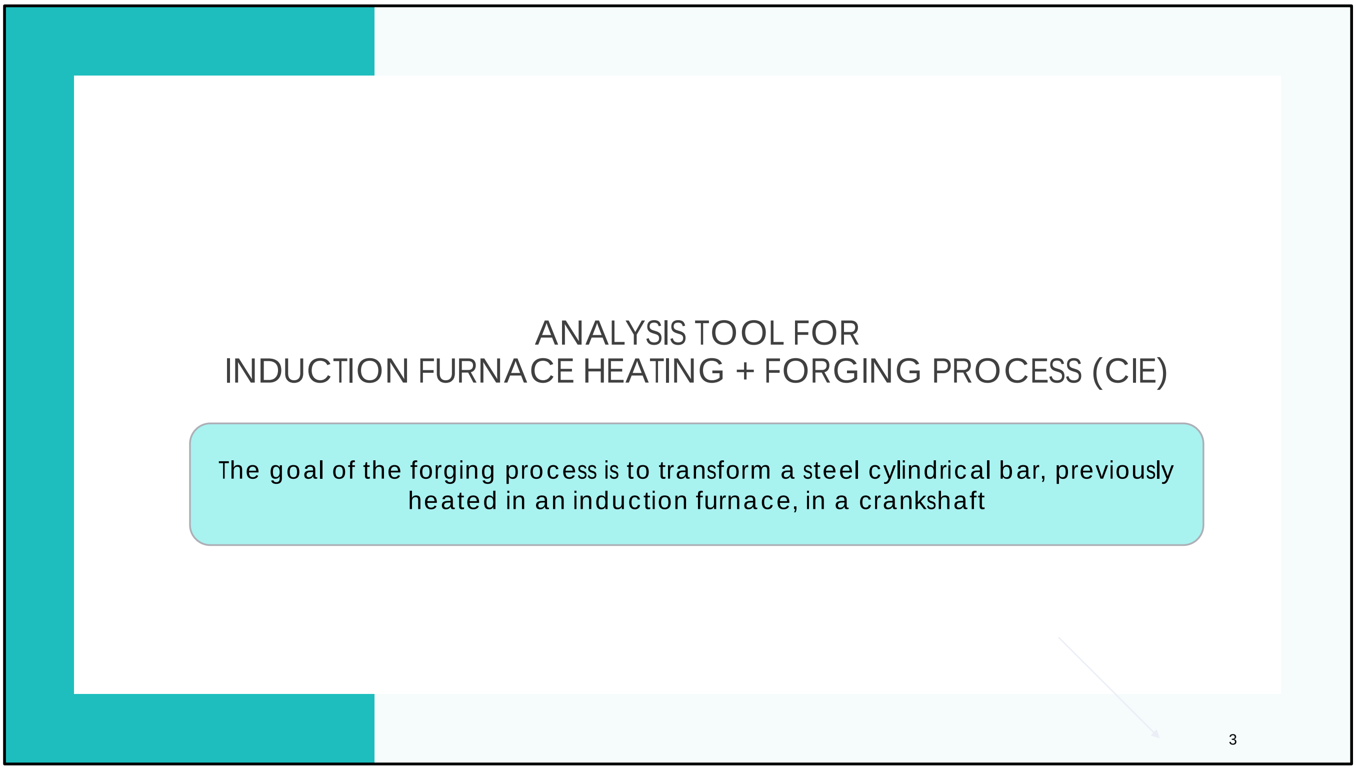


To achieve this goal, some tools have been developed to assist operators in the decision-making process, such as analysis tools that allow them to analyse the influence of process parameters on energy consumption and/or process performance for a better understanding of the process. This is a web application based on the use of the modes developed in DENiM project. The worlfkow of these tools is:

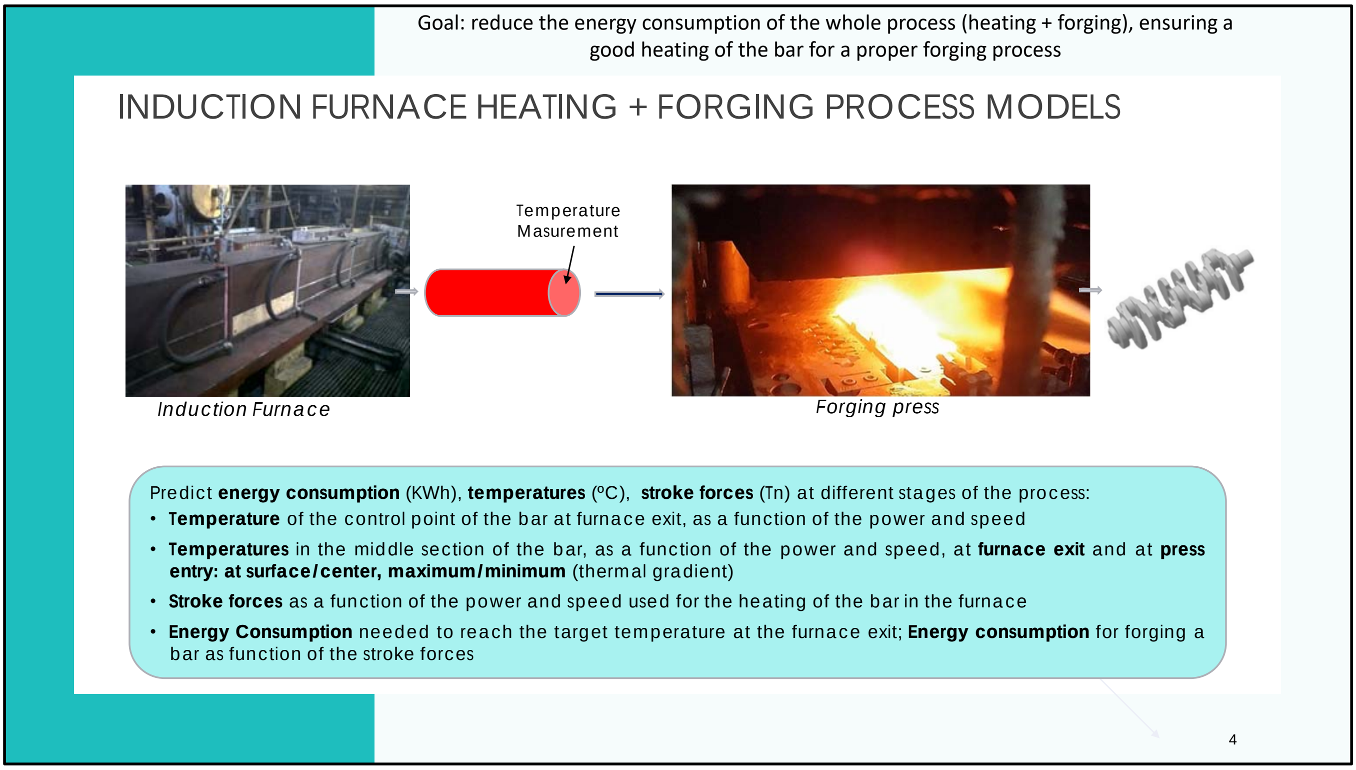
- The user enters the number of the heat (Sidenor) or the batch-bar (CIE) to be analysed and the application displays the actual process data of the selected heat/bar (recovered from the DENiM platform).

- Then, the user enters the new values for the variables to be analysed and selects the model to be executed

The application displays the new estimation for the target variable



Now, we are going to see the analysis tool for the induction furnace heating and forging processes used in CIE GALFOR for the production of the crankshafts addressed in DENiM project.

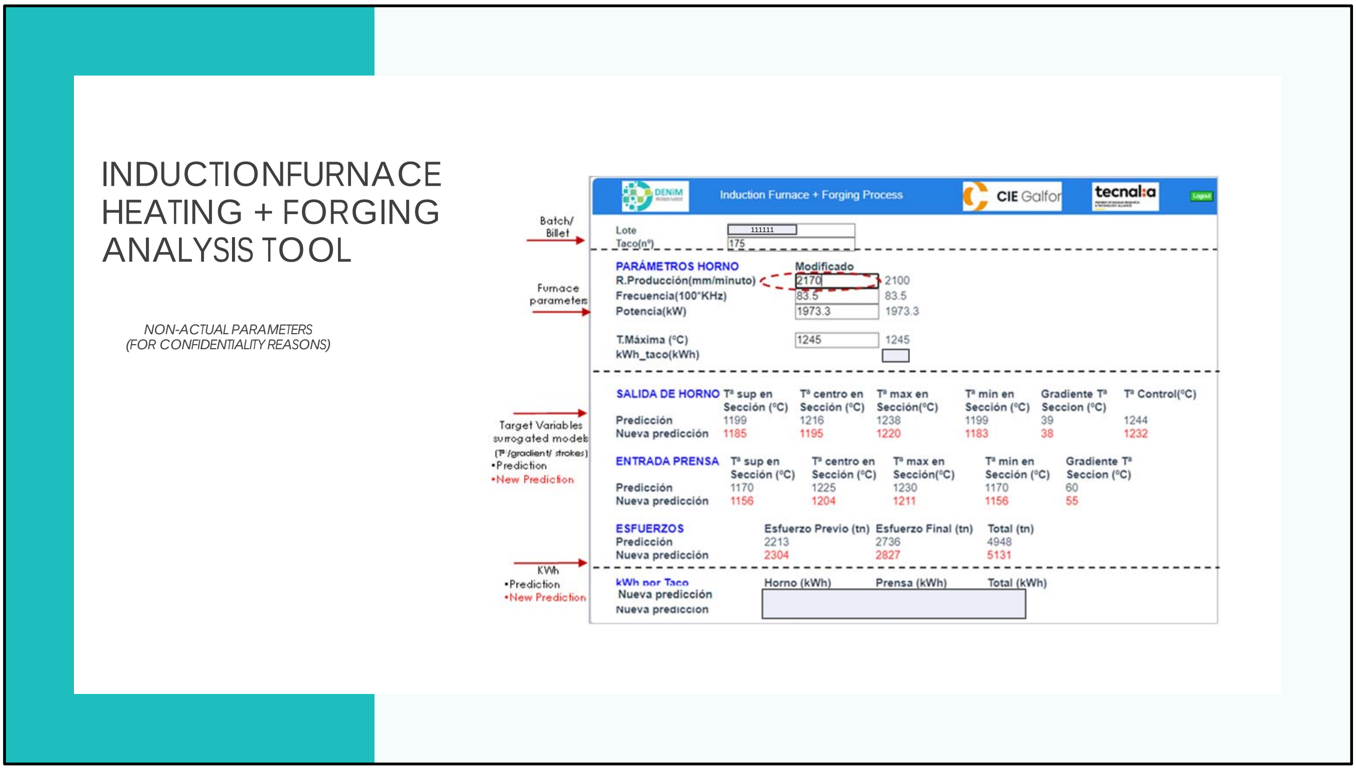


For the crankshafts production, the steel bars are first heated in an induction furnace. The main parameters controlled by the operators are the power and speed of the furnace. The temperature reached by the bar at the end of the heating is measured with a pyrometer and is key to properly deform the material in the forging dies. High temperature gradients in the bar may also cause quality problems in the forging process and higher stresses. When the bar leaves the furnace, it is transferred to the forging press, where the forging operation, which transforms the cylindrical bar in a crankshaft is made. For the DENiM crankshafts, this operation is performed in 2 strokes. The first one makes a preform of the part to be obtained and the second stroke is made to obtain the desired geometry.

Taking into account the importance of the temperature of the bar and its thermal gradient for the good performance of the forging operation, both in terms of product quality and energy consumption, in order to achieve the proposed goal of reducing the energy consumption of the whole process (heating + forging) ensuring a good heating of the bar, different models have been implemented to predict the energy consumption, temperatures and stroke forces at different stages of the process:

- Temperature of the control point of the bar at the exit of the furnace, as a function of the power and speed
- Temperatures in the middle section of the bar, as a function of the power and speed, at the exit of the furnace and at the entry of the press: temperatures at surface and center, and maximum and minimum temperatures, it means the thermal gradient.
- Stroke forces as a function of the power and speed used for the heating of the bar in the furnace.
- Energy Consumption needed to reach the target temperature at the exit of the furnace; Energy consumption for forging a bar as function of the

stroke forces.



This figure shows the Analysis tool developed for the Induction heating and forging processes of CIE GALFOR.

When the user enters the number of the batch and bar to be analysed, the application displays the actual process data for the bar. For each variable, the tool displays its actual value together with a box where the user can change the value.

On the top, the screen shows the main furnace parameters (speed and power) and the temperature of the bar at the exit of the furnace (in this case 1245ºC).

Then, we can see the information provided by the models. First, predictions about temperatures and thermal gradient at the exit of the furnace, such as the temperature at the surface and center in the middle section of the bar, the maximum and minimum temperature and thermal gradient in that middle section, and the temperature of the control point of the bar:

- The first row shows the predictions obtained by the DENiM models using the actual data, for example the models predict a Temperature of 1244ºC for the control point
- The second row shows the new predictions obtained by the models using the data modified by the user.

In a similar way, we can see the predictions about temperatures and thermal gradient at the entry of the press. And the predictions about the stroke values for the two operations. Finally, at the bottom, the tool displays the predictions about the energy consumption for the heating and forging process.

For example, suppose the user wants to analyse the influence of an increase in the speed and change this value from 2100 to 2170 mm/min. The tool shows the new predictions of the models, observing that a significant decrease of 12 degrees in the temperature of the control point is estimated, reaching 1232ºC, which could be too low for the forging. It is also observed an increase in the stoke forces due to the decrease in the temperature.

THANK YOU!

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