Gestamp

SAFEPRES - Failure Analysis System for Specific Supervision of Auxiliary Pump Pressure in Presses.

(Executive summary to be entered for the 2018 Advanced Factories Awards, as part of the Advanced Factories Exhibition & Industry 4.0 Congress to be held in Barcelona in March 2018)

Barcelona, 6th February 2018

IThink UPC MCIA NEXIONA CONNECTOCRATS

We are the consulting, advanced technological and software services company of the **Universitat Politècnica de Catalunya (UPC)**.

We help our clients to boost their business agility and enhance the experience of their clients and employees by means of digital technologies.

MCIA UPC: Motion Control and Industrial Applications

Universitat Politècnica de Catalunya (UPC) research centre focused on electrical and electronic engineering technology transfer for industry, with technological experience in energy optimisation, supervision, control, diagnosis and prognosis of mechatronics and industrial processes, instrumentation, smart sensors and industrial communications.

We are a 'Software Manufacturer' based in La Salle Technology Park, Barcelona, and focussed on the Industrial Internet of Things. Through our software framework, **MIIMETIQ**, customers are able to access our extensive experience in IoT to build highly scalable and flexible applications for the Industrial world.

The Challenge

Loire Gestamp, a major global manufacturer of hydraulic presses in the **Automotive Industry** that belongs to **Gestamp Corporation**, wanted to analyse the functionality of their auxiliary pumps in order to detect and identify abnormal patterns that might negatively affect efficiency in their hot stamping facilities, and lead to issues in production, quality or unplanned downtime. Their ultimate objective was to detect and identify these abnormalities in order to implement an effective strategy for **predictive maintenance** and **safely setup and operate the presses**. For developing the AI models, **Loire Gestamp** provide us with more than one year of data (2,000 variables collected by cycle on each press) gathered from 27 presses operating in some of their 100 facilities spread all over the world.

The Project

The project focused on achieving the following three objectives:

1. Detect abnormal behaviour in the auxiliary pump functionality.
2. Identify the probable cause of each abnormal behaviour (Automatic root-cause analysis).
3. Create an application for the automatic analysis and diagnosis -cycle by cycle- of the presses during operation, using an **IIoT platform** (Industrial Internet of Things).

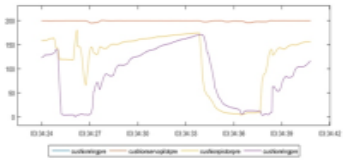
The **supervision** and **diagnosis** system developed is based on a variety of analysis procedures, accessible at the machine. These procedures are supported by **advanced signal processing techniques** and **artificial intelligence algorithms**. The designed procedures allow us to characterize the pump's current operational status and to detect and identify **failure patterns** and **improper setups** identified (and learnt by the AI algorithms) during the pump's operation over time.

Roadmap of the SAFEPRES project

Starting Point

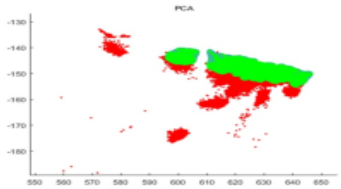
Available data?

- 30 press signals.
- Expert's knowledge.



How is the ideal press cycle?

- Operating behaviour of the press.
- Data filtering rules.
- Cycle segmentation rules.

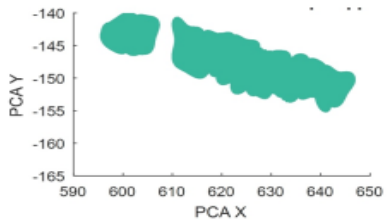


How to characterize the behaviour of the auxiliary pump?

- Statistical characterization of auxpumppre.
- Labelling of "ideal" cycles.
- PCA projection to common base.

Normality Model

- Input data space clustering.
- Normality boundaries detection.
- Characterization of normal operation area.
- Cycle by cycle normality detection.



Do other press elements effects the auxiliary pump pressure?

- Press elements characterization.
- Correlation study.
- Selection of slide and cushion as influent elements.

Negative effects maps

- Correlation of operating area vs. normality of auxpumppre.
- Characterization of the negative effects of the press operation.
- Negative effects modelling based on press data historian.

How to characterize the effects of slide and cushion operation?

- Fisher based feature selection.
- PCA projection to common base.
- Feature space segmentation in operating areas.

Reliability Maps

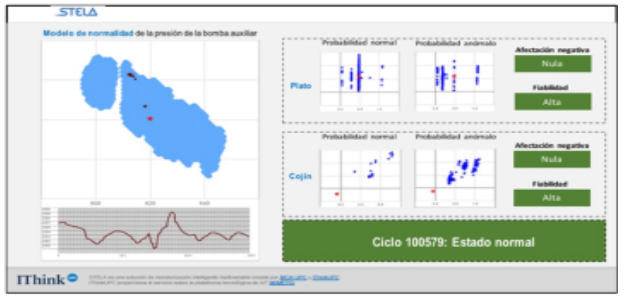
Can we give information regarding the significance of each operating area?

- Significance modelling of each operating area in regard with the press data historian.
- Readjustment of the reliability map in regard with the stable operating points of the press.

STELA

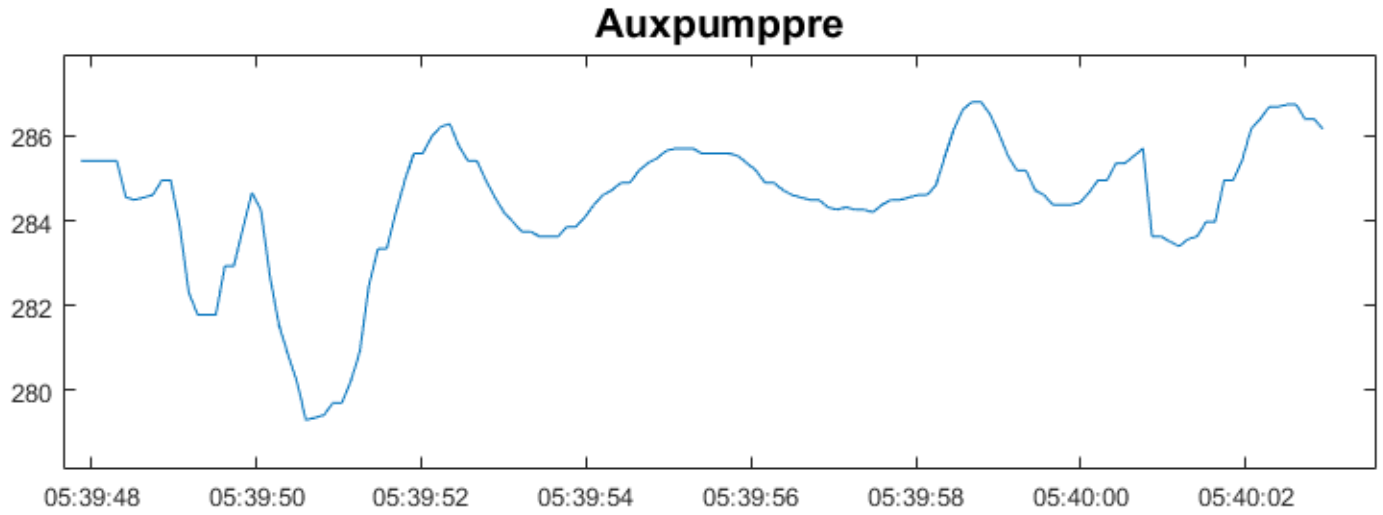
Monitorization agent

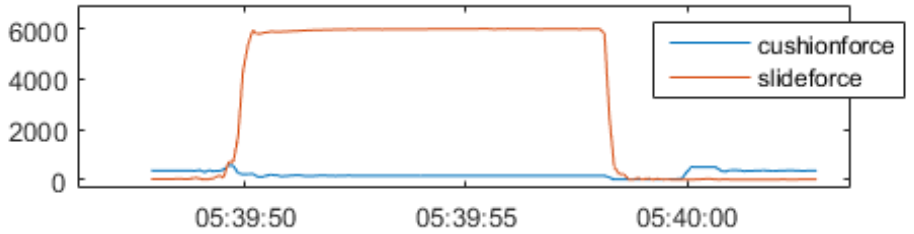
- Intelligent monitoring solution based on a multivariate approach.
- Application developed under IoT framework – MIIMETIQ
- Allows real time analysis of press cycles.
- Shows normality model, effects and reliability of slide and cushion.

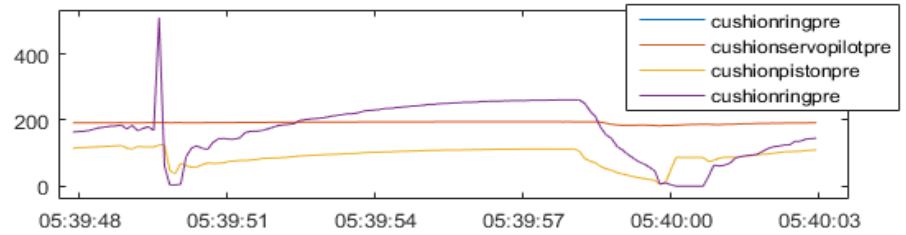


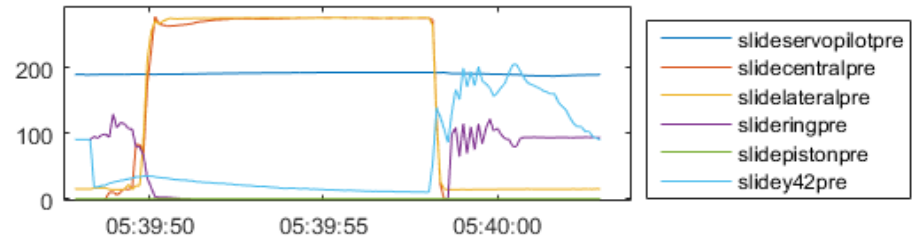
INITIAL DATA

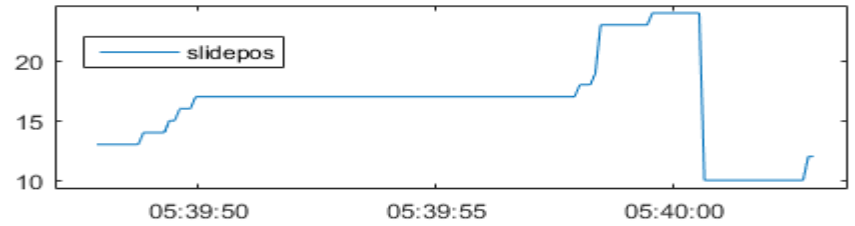
- Signals recorded during the press cycle.
- 30 signals considered in the analysis due to their statistical significance in the behaviour and effects identified in the auxiliary pump.



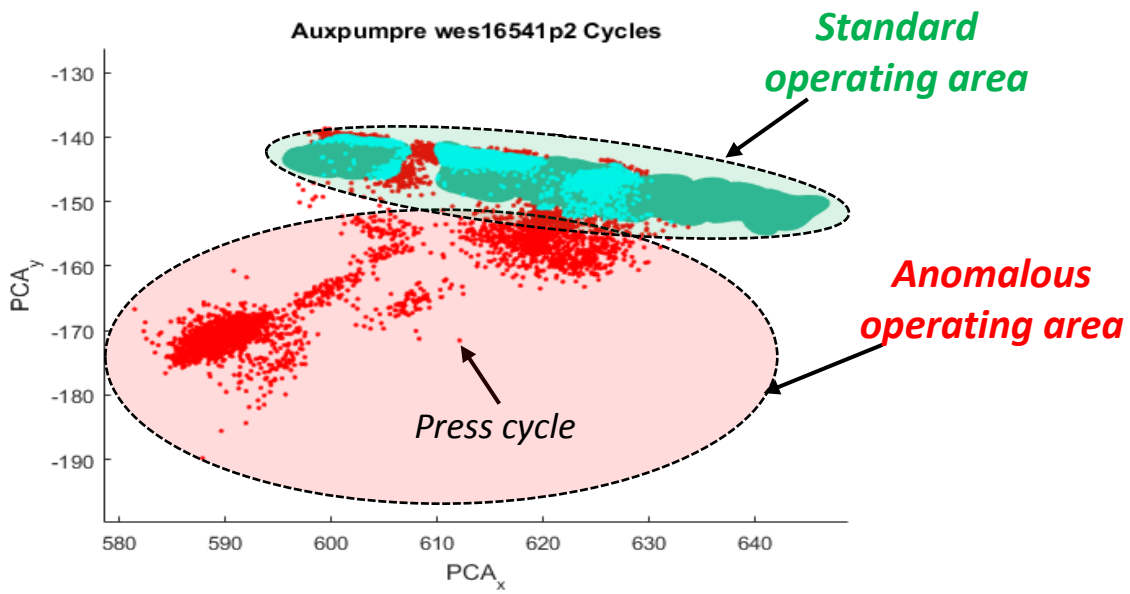








Normality model of auxpumppre (auxiliary pump pressure)



PCA Projection of Auxpumppre indicators

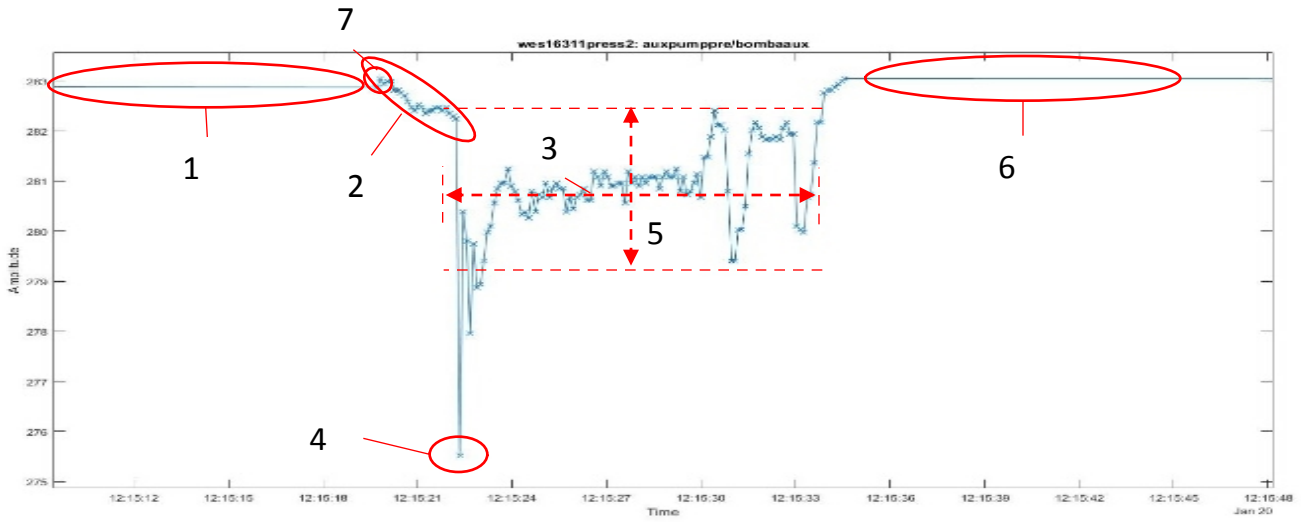
- Based on the modelling of expert knowledge in segmentation rules.
- It labels each new press cycle based on a statistical definition of the auxpumppre signal.
- It indicates whether the cycle analysed is standard or anomalous in the operation of the auxiliary pump, regardless of the part being stamped and the press setpoints.
- The normality model defined is common for all the presses under study.

- **It provides no information on which components of the press affect the anomalous operation of the auxiliary pump.**

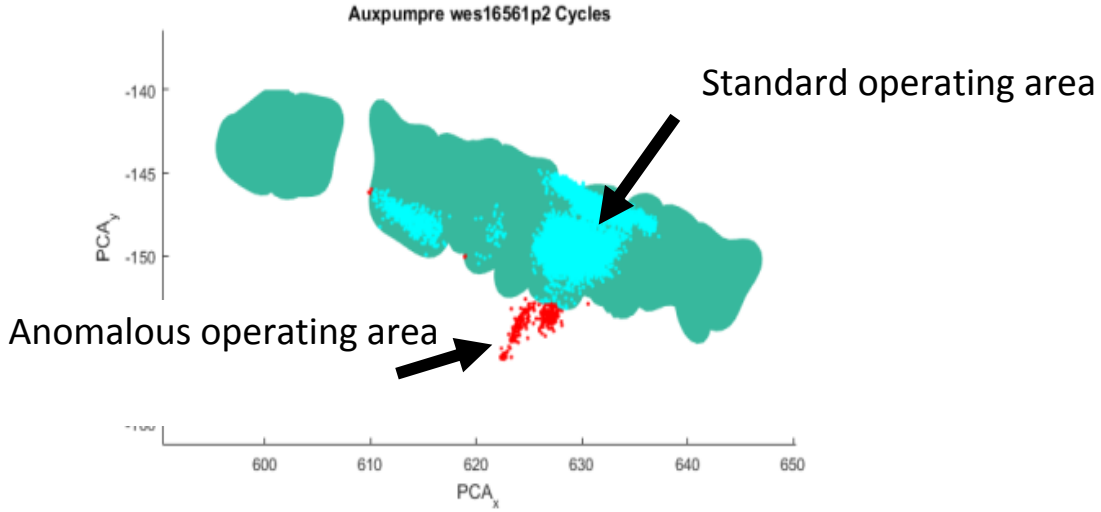
1. Detection of anomalies. Classifier in accordance with auxpumppre.

A. Auxpumppre Features

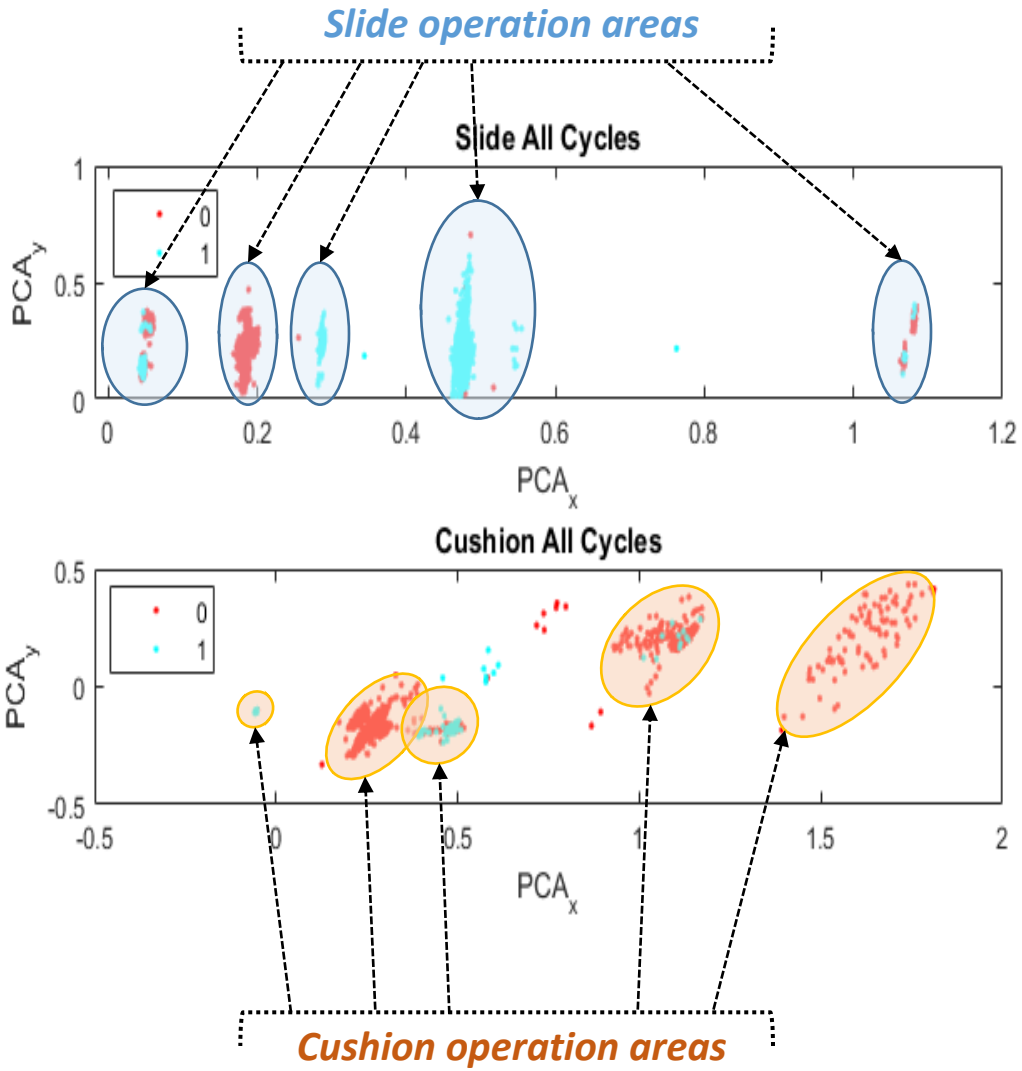
1. Value at rest
2. Variance of initial interval
3. Maintenance value
4. Minimum maintenance value
5. Variance during maintenance
6. Post-maintenance value
7. Maximum cycle value



B. Graphic display of the auxiliary pump operating point in a press within a set of presses in the study. Common normality model.



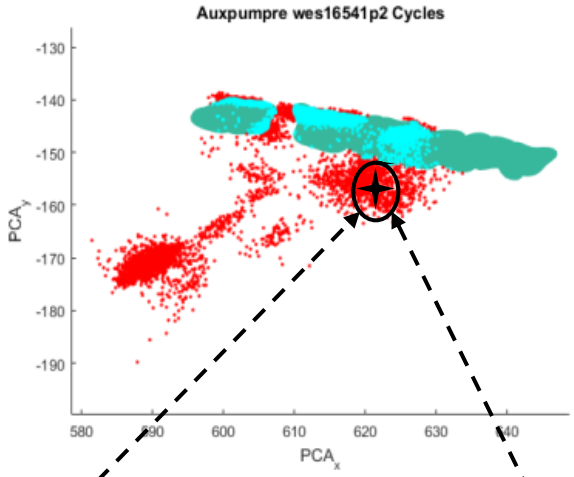
Effect of the Cushion and Slide on Auxpumppre normality



- We wish to characterise the negative effect of the different operating modes of the cushion and slide to quantify their influence on anomalous auxpumppre behaviour.
- To this end, these elements are characterised separately in the areas where the value and variability of auxpumppre is critical (at rest, maintenance, post-maintenance).
- The best indicators are selected based on the average Fisher per press and a common PCA projection is carried out for all the presses.
- In the resulting projections (for cushion and slide) areas it can be seen that they correspond to the operating areas (different configurations) of the press elements.
- **We wish to analyse the correlation between the cycles of these areas and the normal operation of the auxiliary pump. This will give us the negative effect of said operating area on the normality of the auxpumppre cycles.**

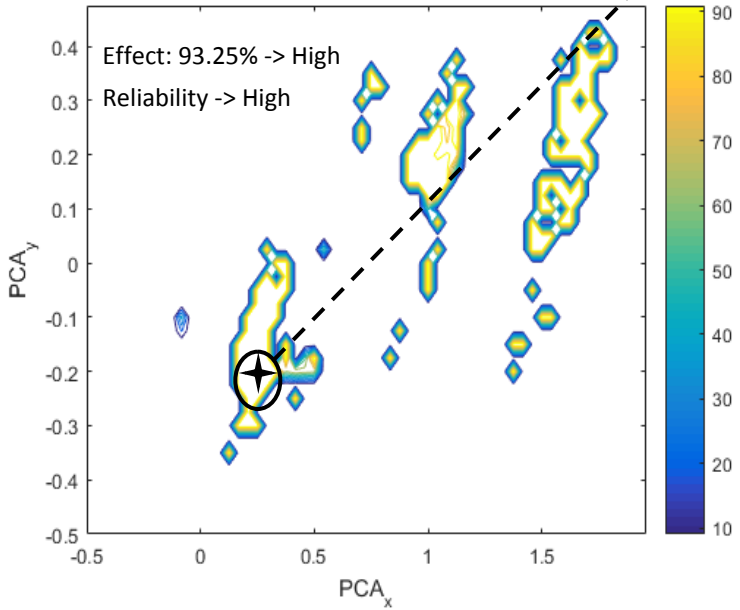
2. Determining the origin of the abnormality.

Example of analysis: Anomalous cycle in accordance with the operation of auxpumppre with effect due to cushion operation.

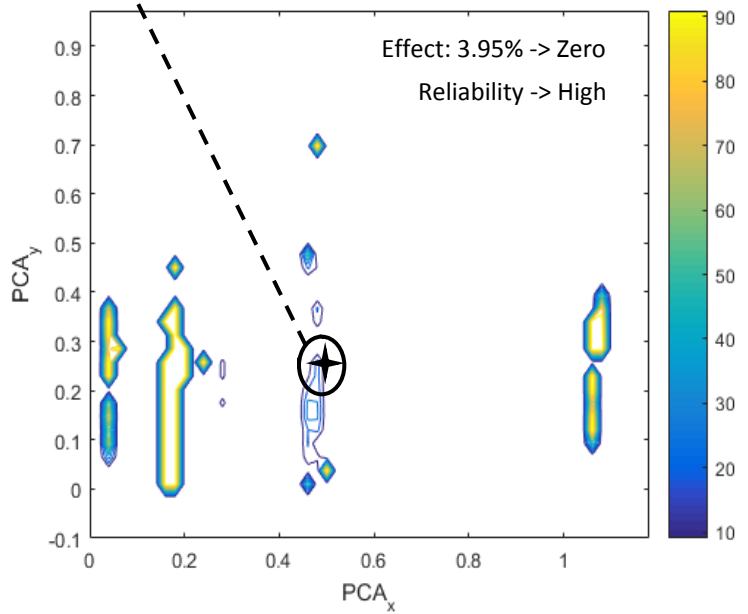


Normality model of auxiliary pump pressure

Cushion Effect Map



Slide Effect Map



Maps of effects on auxiliary pump operation, based on the features calculated using the recorded cushion and slide signals.

3. Visualizing the normal or abnormal operation and the root cause in case of abnormal operation.

In top of our **MIIMETIQ IIoT Platform**, used to handle the data from the presses and deploy the advanced analytics procedures and artificial intelligence algorithms for the **SAFEPRES** project, we have developed an application, called **STELA**, to visualize the results of the cycle-to-cycle diagnosis and root-cause analysis.

Figure 1 shows a set of normal cycles and their track cycle-to-cycle (in Spanish "estela") that falls within the normality projected shape on the left area of **STELA** application. On the right of **STELA** application, the area that shows root-cause effects, everything is green confirming that there is no adverse effect detected neither in the slide nor in the cushion of the press. Each star represents a press cycle, and the red one is the one that belongs to the last cycle registered.

Figure 2 shows abnormal cycles of operation in the auxiliary pump. The background colour of **STELA** is red. The stars are outside the normality projection shape on the left. The root-cause analysis area on the right shows that something wrong happened with the operation of the cushion and the slide affecting the normal operation of the auxiliary pump.

Figure 3 shows that there is also a malfunctioning in the operation of the auxiliary pump (the stars are outside the normality shape), but this abnormality is not originated neither by the operation of the cushion nor by the operation of the slide. That's a clue that there is a problem in the operation of the auxiliary pump. This situation warns us that there is a deterioration in the operation of the auxiliary pump which can end up in a failure of the pump itself.

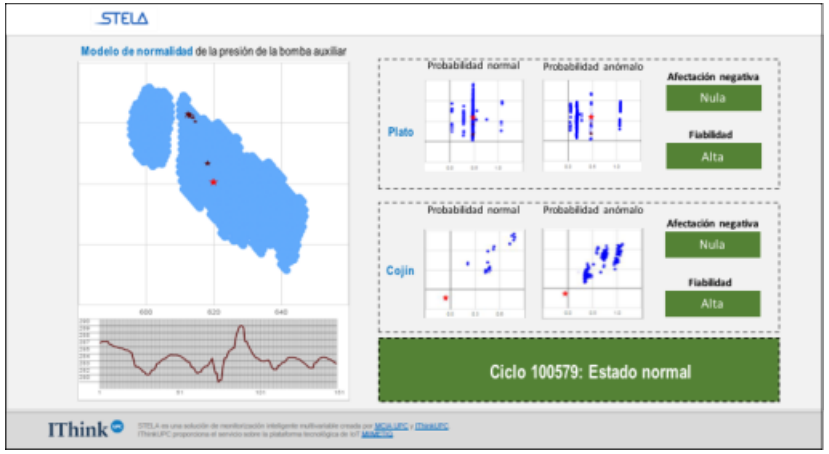


Figure 1

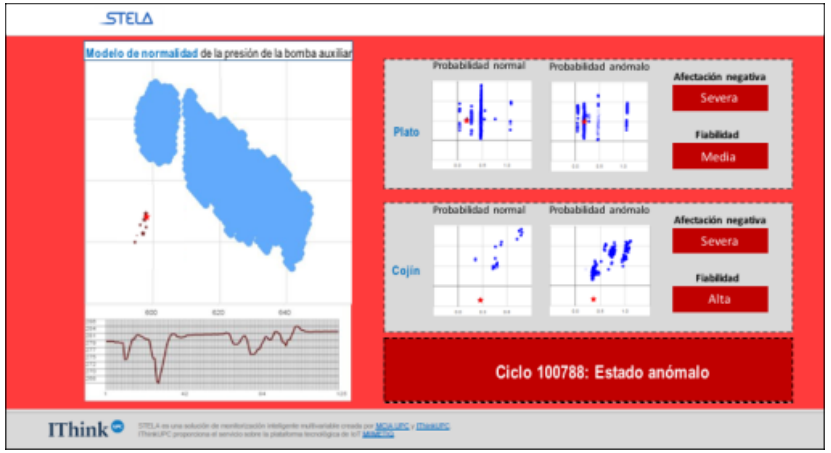


Figure 2

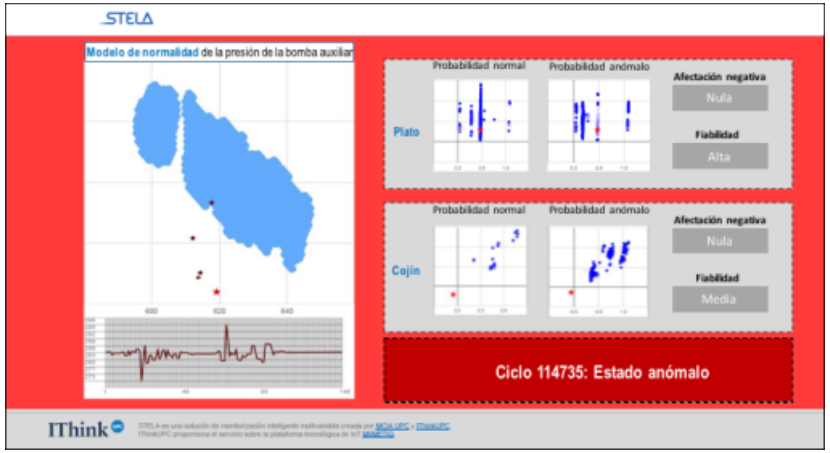


Figure 3

The Outcome

In summary, the most significant benefits of this project provided to **Loire Gestamp** are:

1. **Loire Gestamp** has now an advanced analytics tool, which allows them to automatically analyse and administer hundreds of thousands of production cycles from presses operating in their manufacturing plants, spread all over the world, and quickly identify improper cycles in order to quickly and automatically find root-causes to production issues.

2. **The STELA** application, developed using **NEXIONA's MIIMETIQ® platform** , allows press machine operators, plant supervisors, press setup teams and plant engineers to quickly detect abnormalities in the operation of the press which fall outside the manufacturers reference guidelines. It also allows the visualization of results in a simple user interface, tailored to the plant operator, and a more detailed view for the plant engineer or data scientist.

3. **Loire Gestamp** is able to early detect issues identified in its auxiliary pumps which might cause improper operation of the presses or to early detect the degradation of the auxiliary pump itself.