OPTIBEND

Zero defects manufacturing of Home Appliances bending workpieces

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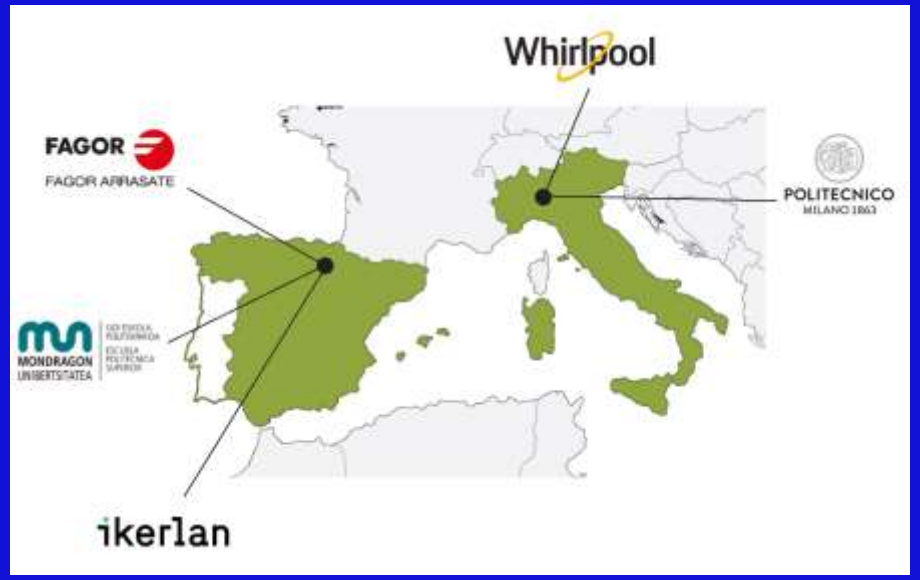
CONSORTIUM

The OPTIBEND consortium is made up of 5 partners coming from 2 different European countries (Spain and Italy). All the participants have expertise in their área of knowledge.

The consortium is formed by a well-balanced collaboration of European organisations representaed by:

- The biggest World home appliances manufacturer.
- A machine-tool builder for home appliance market.
- Two expert universities on developing industrial applied research
- A technology center focused on Advanced intelligent control and monitoring application development.



INTRODUCTION

- WHIRLPOOL bases its competitive advantage on high-quality standards. To do that, they rely on outstanding technology providers when shaping their production lines, such as FAGOR within fridge doors manufacturing.
- The bending station of fridge door manufacturing process states one of the most relevant lack of robustness because of the difficulty in controlling the elastic recovery of the material due to the mechanical characteristics and variations of thickness.

INTRODUCTION

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INTRODUCTION

OBJETIVES

The main objective

- To increase the workpiece quality and process robustness, assuring zero defect manufacturing through process monitoring and advanced control strategies.

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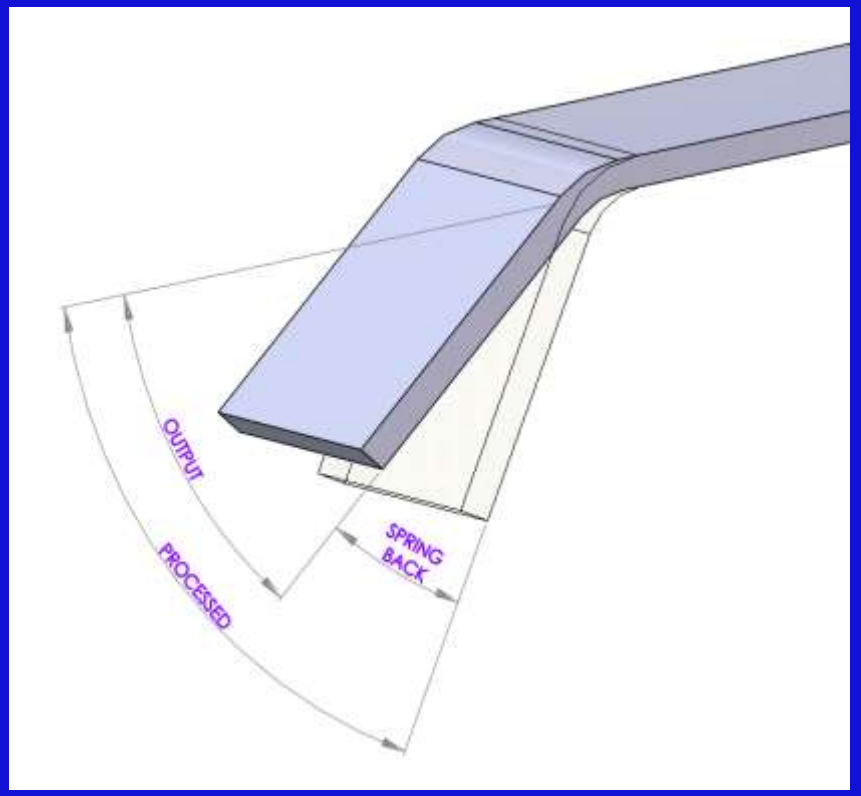
OBJETIVES

Specific objectives:

- To collect process, quality and asset health data along the bending machine
- To integrate data decision making system able to control in real-time and adapt the bending process
- To analyze data from different sources (thickness, material properties, bending angle, etc)
- To increase system performance integrating data generating knowledge owned by FAGOR



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EXPECTED OUTCOMES

The White Goods or Home Appliance industry is characterized by the ambition of process optimization and increase of the produced parts quality. One of the main components of White Goods, such as refrigerators, is sheet metal. The industrial demonstration case, which includes the machine-tool builder FAGOR, the White Goods producer WHIRLPOOL (WHR) and the participation of MONDRAGON UNIVERSITY, POLITECNICO MILANO and IKERLAN, will show a complete supply chain contributing to the successful integration of advance technologies in a relevant manufacturing environment.

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EXPECTED OUTCOMES

With the work planned during the project, it is expected that overall equipment effectiveness is increased thanks to the following factors:

- Reduction in defective parts. With a smart database adapting process parameters to the product specifications (material properties, environmental conditions, required mechanizations...)
- Reduced time for set-up. Market is demanding more and more flexibility, which requires shorter batches in order to avoid stocks and reduce lead times to market. Each change of product requires a new adjustment of the line, which in addition to defective parts result in almost fully manual configuration of the system. A proper monitoring of process information and generated databases would mean an improvement of machine availability.
- Reduction of further assembly difficulties. Although quality requirements for a good part are set, combination of tolerances through consecutive processes can lead to defects in further assembly steps. A reduction in the variability of bending processes can directly benefit the global OEE.

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EXPECTED OUTCOMES

In this sense, WHR as end-user has to collaborate with suppliers along the complete value chain in order to excel in their expectations. In this sense, with the development of this project FAGOR will make another step in achieving one of its main objectives which is: the adequacy of their equipment to the latest information and communication technologies.

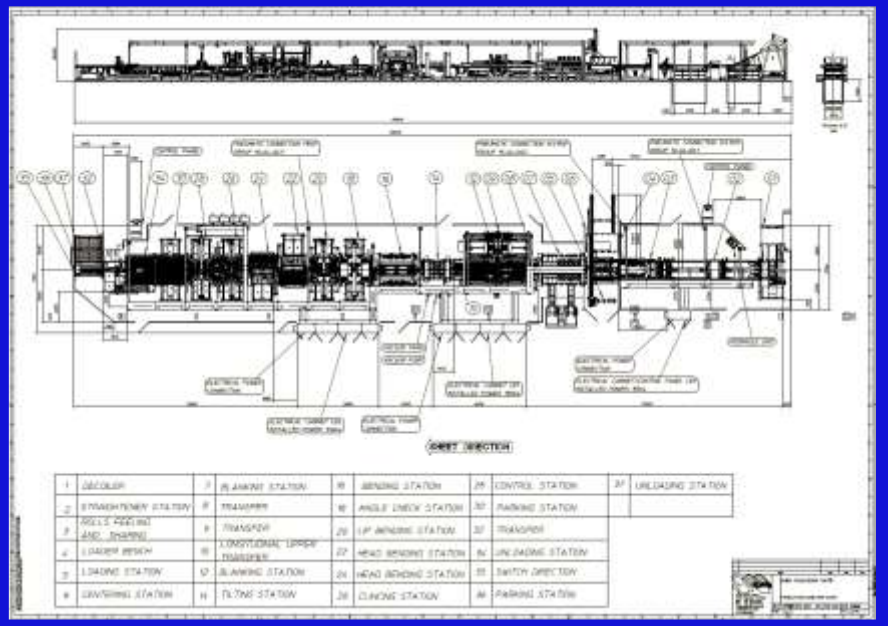
PROYECT PLANNING

		2020											
WP1. SELECTION OF WHIRLPOOL PRODUCTION LINE AND SPECIFICATION OF NEW		1	2	3	4	5	6	7	8	9	10	11	12
T1.1	Selection of the demonstration Whirlpool line, materials and lubricants												
T1.2	Material properties measurement sensor specifications												
T1.3	Angle measurement sensor specifications												
T1.4	Current production variability measurements and new control specifications												
WP2. DEVELOPMENT OF THE INLINE MATERIAL PROPERTIES MEASUREMENT UNIT BY		1	2	3	4	5	6	7	8	9	10	11	12
T2.1	Mechanical characterization of selected materials (pre-painted and black steel)												
T2.2	Selection of commercial thickness measuring sensor and integration in the selected Whirlpool line												
T2.2	Design and set-up of a laboratory scale punching operation based measurement unit												
T2.3	Simulation of punching operation and development of analitycal rules for material properties												
T2.4	Industrialization and integration in the selected Whirlpool line												
WP3. DEVELOPMENT OF THE FINAL PRODUCT MEASURING UNIT		1	2	3	4	5	6	7	8	9	10	11	12
T3.1	Selection of the comertial laser measuring sensors												
T3.2	Laboratory tests for measurements validation and calibration of sensors												
T3.3	Industrialization and integration in the selected Whirpool line												
WP4. PROCESS MONITORING DURING INDUSTRIAL PRODUCTION OF COMPONENTS		1	2	3	4	5	6	7	8	9	10	11	12
T4.1	Definition of the monitoring hardware and data storage protocols												
T4.2	Data storing software and wireless/online communication development												
T4.3	Process monitoring and sensors data storing												
T4.4	Analysis of stored data and validation/optimization of control rules by data mining												
WP5. DISSEMINATION, EXPLOITATION AND MANAGEMENT		1	2	3	4	5	6	7	8	9	10	11	12
T5.1	Project dissemination												
T5.2	Exploitation strategy and plan												
T5.3	Project Management												

WP1: SELECTION OF PRODUCTION LINE

Objectives:

- Define project specifications, select demonstrators and demonstration line.
- Select an active production line, in order to be a use case for the execution of the project.
- Current production variability measurements.



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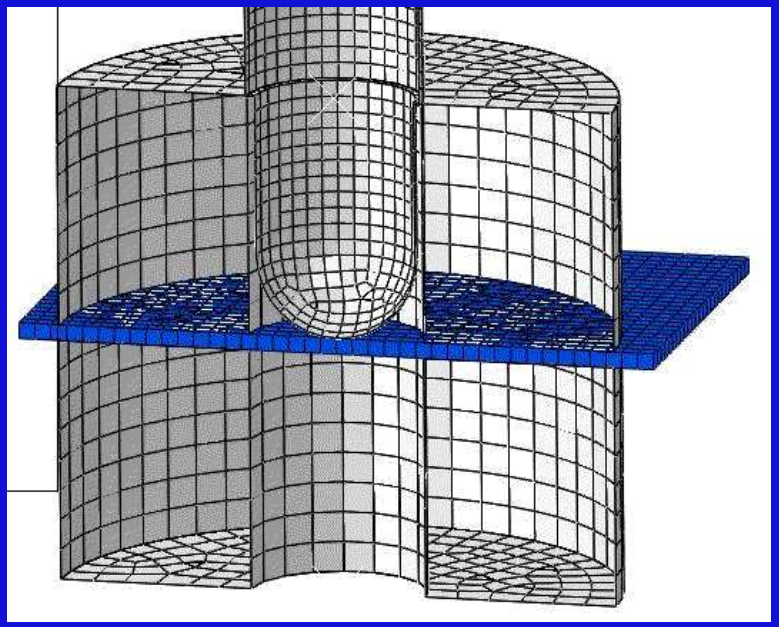
WP1: SELECTION OF PRODUCTION LINE

WP2: MATERIAL PROPERTIES MEASUREMENT

Objectives:

- Development of income material properties measurement sensor based on punching
- Mechanical characterization of selected Materials.
- Design and set-up of a laboratory scale punching operation.
- Industrialization and integration.



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WP2: MATERIAL PROPERTIES MEASUREMENT

SPT (Small Punch Test):

- Inline test.
- STP test to Tensile test conversion
- Industrialization

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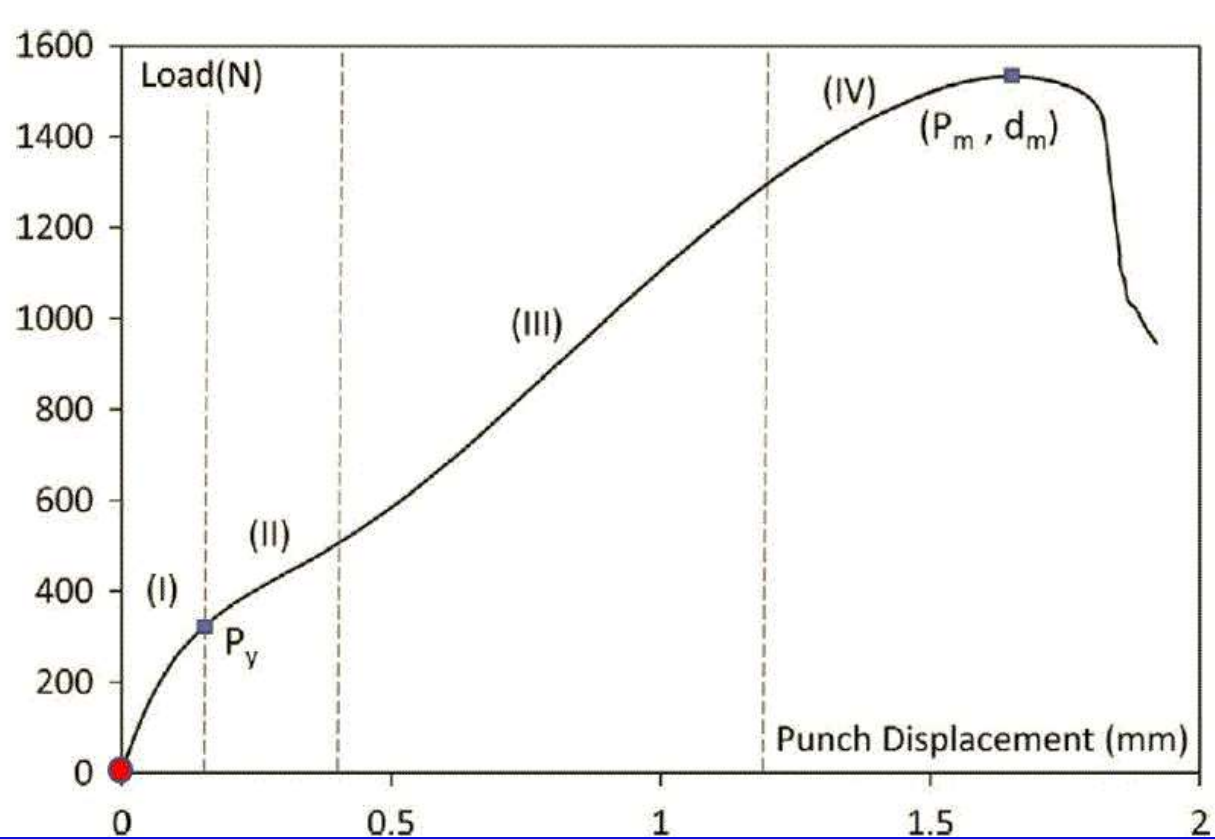
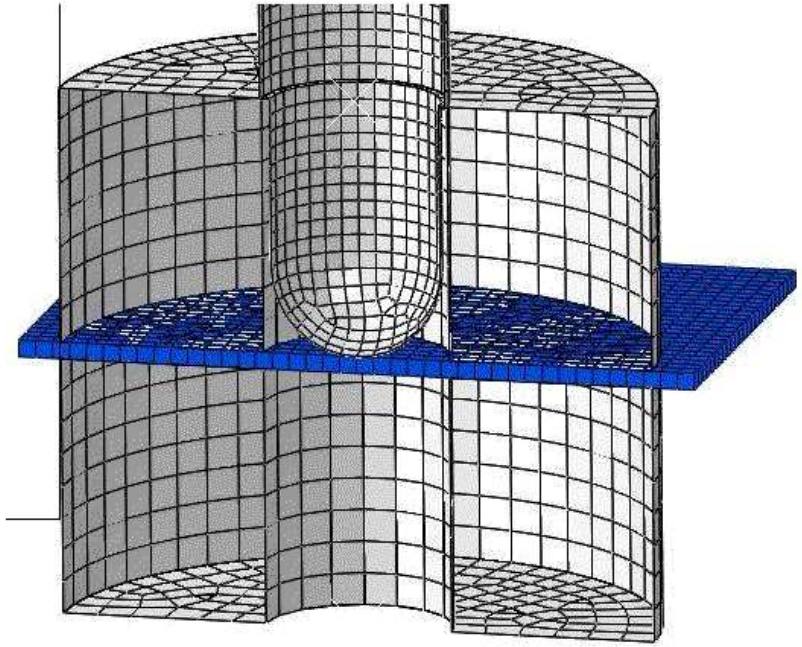
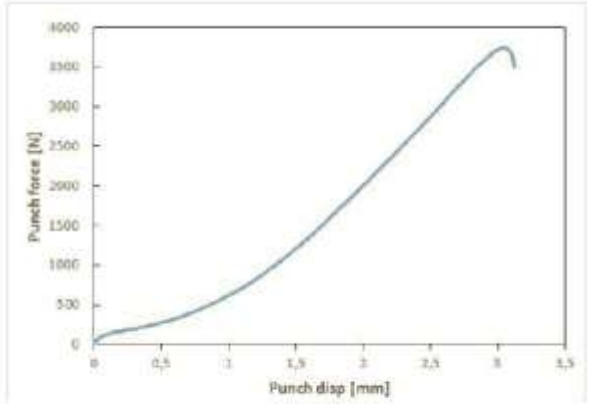
WP2: MATERIAL PROPERTIES MEASUREMENT



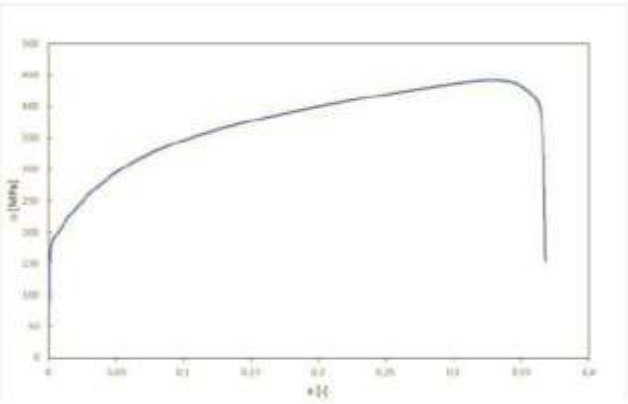


WP2: MATERIAL PROPERTIES MEASUREMENT



Typical SPT curve

Mechanical properties obtained through the SPT

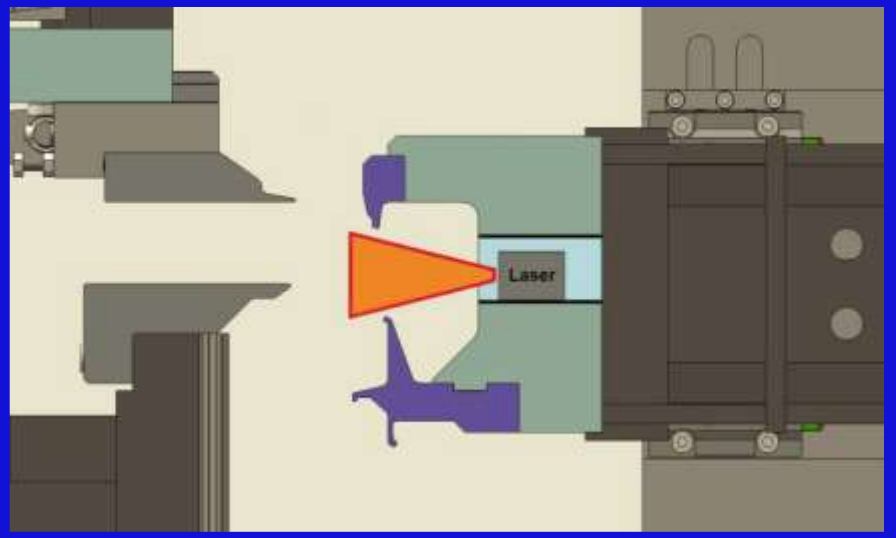


Typical curve of a tensile test

WP3: PRODUCT MEASURING UNIT

Objectives:

- Calibration and optimization of measurement strategy at laboratory and integration.
- Selection of commercial laser sensors.
- Laboratory tests for measurements validation and calibration of sensors.
- Industrialization and integration.



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WP3: PRODUCT MEASURING UNIT

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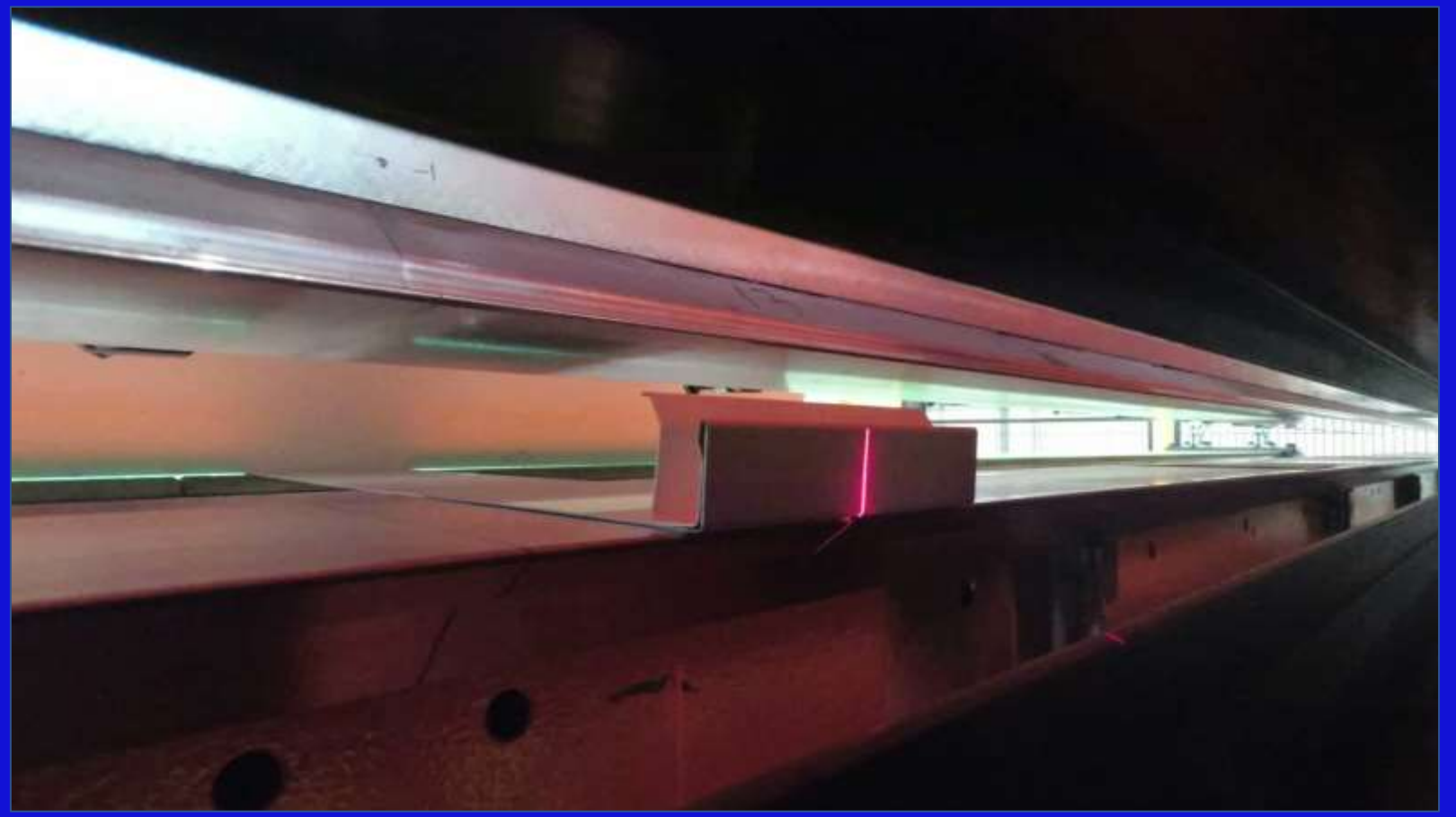
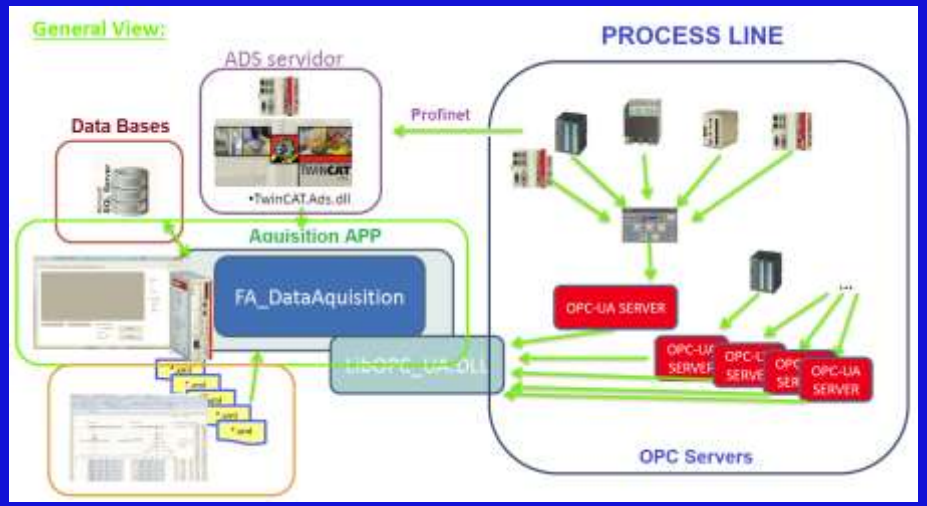


WP4: PROCESS MONITORING

Objectives:

- Data storing in serial production. Data mining and control rules validation and optimization.
- Definition of monitoring hardware and data storage protocols.
- Process monitoring and sensors data storing.
- Analysis of stored data and validation.
- Development of a new machine learning iterative control strategy.



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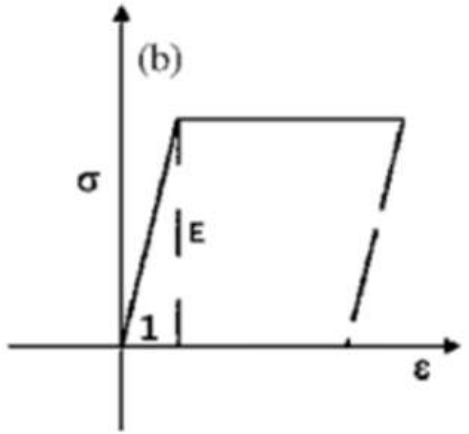
WP4: PROCESS MONITORING

Due to SPT or product measurement, it is possible to improve the bending process by modeling the spring back: **elastic, perfectly plastic.**



$$\frac{1}{R}-\frac{1}{r}=\frac{12M/w}{E't^3}=\frac{12}{E't^3}\left[\frac{\sigma_0't^2}{4}-\frac{\sigma_0'^3R^2}{3E'^2}\right]$$

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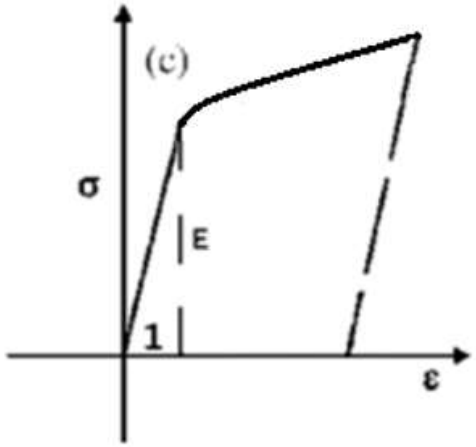
WP4: PROCESS MONITORING

Due to SPT or product measurement, it is possible to improve the bending process by modeling the spring back: **elastic plastic with hardening.**



$$\frac{M}{w} = \frac{\sigma_0 t^2}{4} - \frac{\sigma_0^3 R^2}{3E^2} + \frac{2K}{R^n(n+2)}\left(\frac{t}{2} - z^*\right)^{n+2} + \frac{2Kz^*}{R^n(n+1)}\left(\frac{t}{2} - z^*\right)^{n+1}$$

WP5: DISSEMINATION

Objectives:

Dissemination of results, protection of developments and management.

- Project dissemination.
- Feasibility study, Exploitation and go-to-market strategy.
- Project Management
- Digital Transformation Strategy.

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Manufacturing matters!

FAGOR ARRASATE achieved one of its main objectives: the adequacy of their equipment to the latest ICT technologies:

Inline Material properties measurements.

Inline product measuring unit.
Process Monitoring.

Process Monitoring.

Global market of bending lines are 230M €.

FAGOR ARRASATE represents the 6,5% .

This project will boost FAGOR to 7,5%

Manufacturing matters!

WHIRLPOOL is characterized by the ambition of process optimization and increase of the produced parts quality. WHIRLPOOL line's overall equipment effectiveness is increased thanks to the following factors:

- Reduction in defective parts. With a smart database adapting process parameters to the product specifications: from 4-6 defective parts in the set-up to 1-2.
- Reduced time for set-up. More flexibility and shorter batches avoid stocks and reduce lead times to market. A proper monitoring of process information and the self-learning bending controller would mean an improvement of machine availability: from 20-25 minutes of actual set-up to less than 5 minutes.
- Work-force expertise: from needing a specialized operator to a non-specialized one.

THANK YOU

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