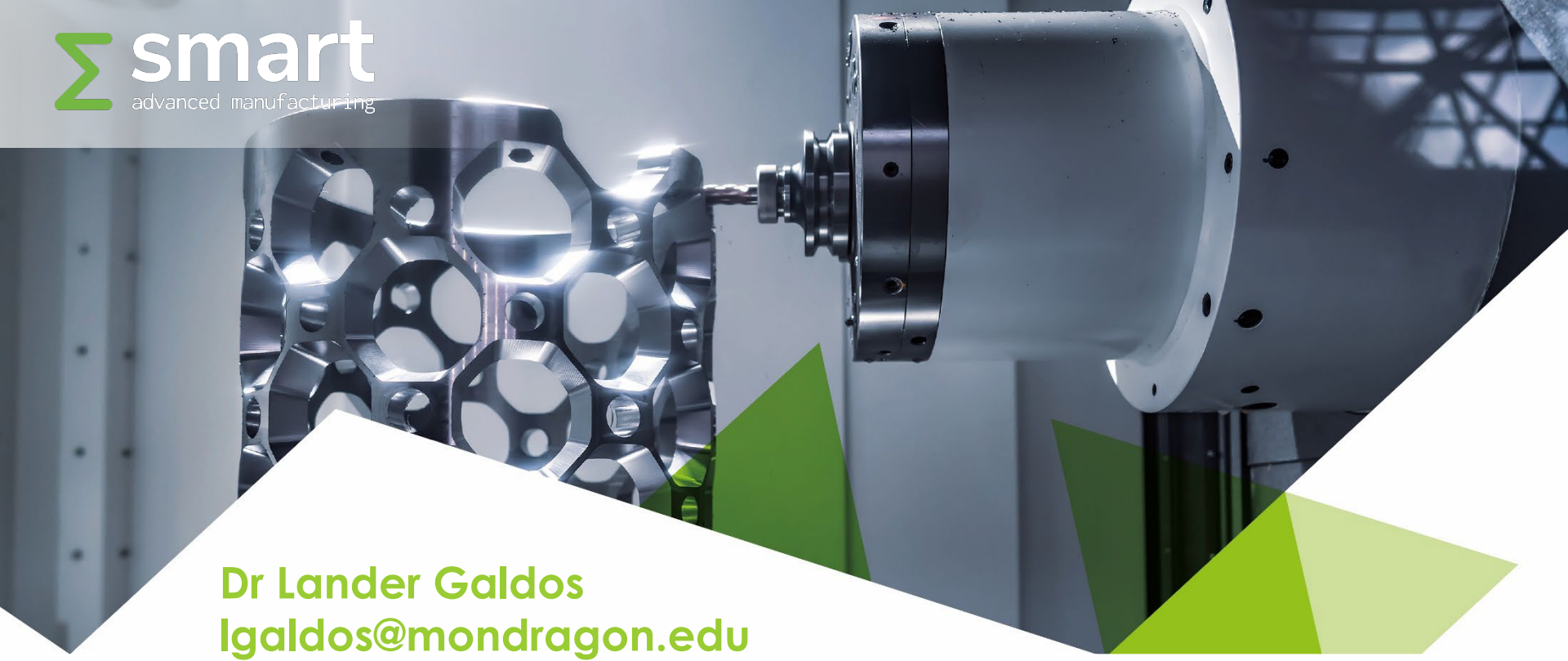

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Improved hot forging processes by advanced numerical modelling of the microstructure, the development of new tooling coatings and the application of AI in forging workshops

ORGANISATION PROFILE

The cooperative company **ULMA Forja, S.Coop.**, under its trade name **ULMA Forged Solutions**, has been a **leading force worldwide in the FORGED STEEL FLANGES and high-spec FORGED COMPONENTS** businesses since it was founded in 1962

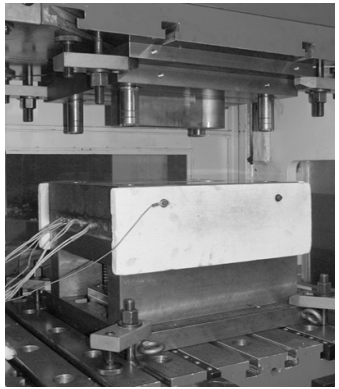
Main **forged products** are:

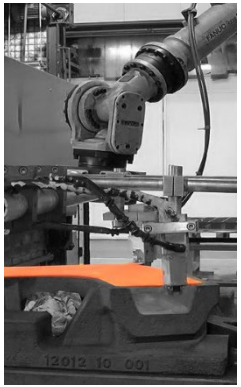
1. Forged Steel Flanges and Spacers (mainly **oil and gas**)
2. Special forged components (forged industrial **valves**, centrifugal **separators**, forged parts for the **aerospace sector**, **blades**, forged parts for the **wind power** industry, **others**

ORGANISATION PROFILE

Mondragon University is a private, non-profit and cooperative university strongly linked to industry and belongs to the **Mondragon Cooperative industrial group** (manpower of 70.000). In our university, being a cooperative, **each worker is owner of the university** and has a vote for decision making

We have a **long-term agreement with Ulma Forged Solutions** for the research in advanced forging processes. The **Advanced Material Forming Processes research group** has the final objective to develop **innovative forming processes** that can produce high added value components and goods



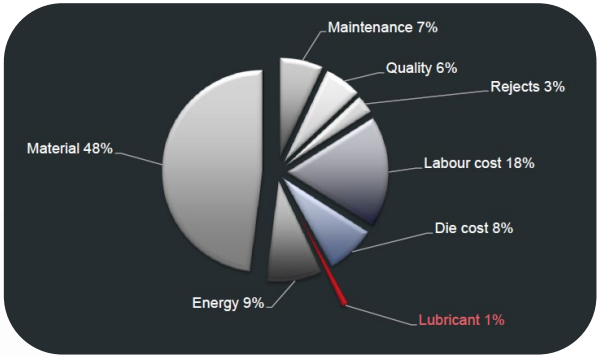


PROPOSAL INTRODUCTION (I)

Motivation

- **Material** cost represents up to the 48% of the forging costs (pre-war data)
- Apart from this cost, the main influencing costs are:

1. **Labour costs** – automation would decrease it to a certain degree
2. **Die costs** and maintenance – tool materials, tool redesing and advanced coatings
3. **Energy** – we all know about it…
4. **Rejects and scrap** – very critical in high added value forgings (Ti, Superalloys)

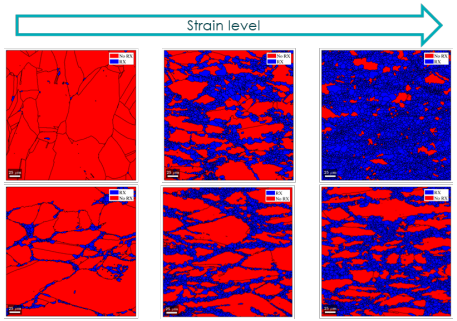


Vision and project idea

- Improve the whole forging process chain inside a forging workshop by:

a) Better **estimating final properties** of components before they are forged (advanced models)
b) The **improvement of tool life and maintenance** (advanced coatings and repair techniques)
c) The use of **process monitoring, advanced reduced models and AI to guarantee process robustness**

PROPOSAL INTRODUCTION (II)



Advanced model for properties estimation

- **Sectors**: Automotive and Aeronautic
- **Materials**: microalloyed steels, aluminium and titanium, superalloys

- **Needed advanced models:**

1. Microstructural evolution models for microalloyed steels (cooling optimization after forging)
2. Mechanical properties estimation models (solution heat treatment and ageing modelling and finite element simulation) of aluminium
3. Grain size evolution of superalloys (mean field and full field models)
4. Phase transformation estimation models of titanium

- **Reduced order models:** for a fast estimation of properties during production using a high ammount of numerical simulations considering different production fluctuations (temperature, times, speed, raw material, cooling, etc.)

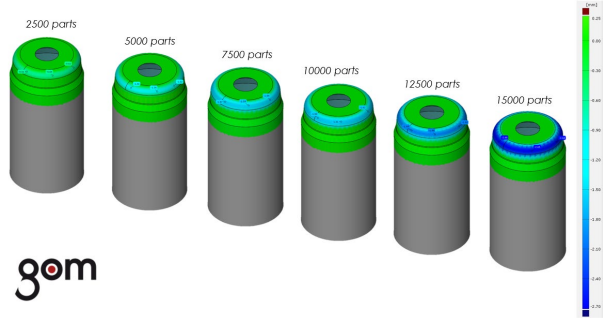
PROPOSAL INTRODUCTION (III)

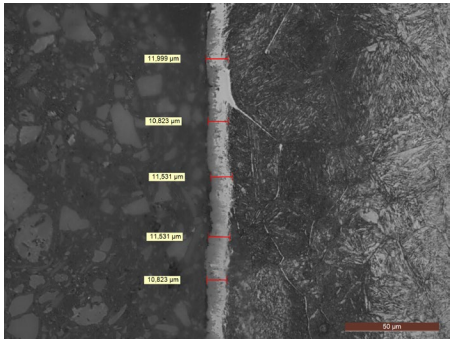
Advanced tool solution and coatings

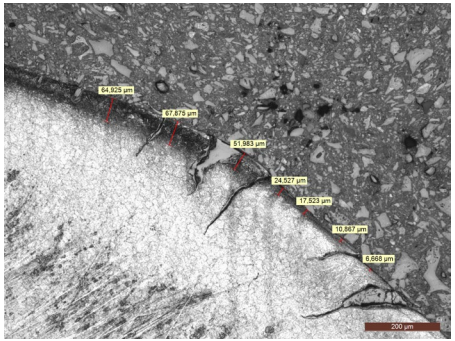
- **Needed tool solutions**: Adhesive tool wear (aluminium and titanium), abrasive tool wear (steels), plastic deformation and abrasive wear (superalloys)

- **Project solutions**

1. Wear protective coatings (i.e. boriding) – high production rates in steel
2. Self-lubricant coatings that decrease the friction and allow a better filling – aluminium and titaniums
3. Tool steel, heat treatments and tool repair techniques for plastic deformations - Inconel







PROPOSAL INTRODUCTION (IV)

Reduced order models, experimental testing + AI for process surveillance

- **Needed solution:** a production surveillance system that will inform the operator if the production is not running correctly (very critical for titanium and Inconel for there high price but also for the automotive productions)

- **Project solution:**
- At least a press line and a hammer forging line will be monitored using advanced sensors (high speed, laser measuring scanner at high temperatures, press force transducers, furnace temperatures and times, cooling curves, etc.)
- Production data will be stored and data analytics, Artificial Intelligence and the reduced order models will be used to calculate the final properties of the forged components
- Turnkey solutions and new production surveillance systems will be developed for each demonstrator line and component

PROPOSAL INTRODUCTION (V)

Vision and project idea

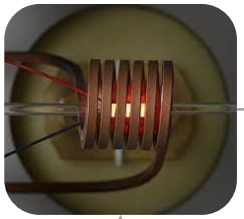
Advanced models for final properties estimation + Reduced order models (ROM)

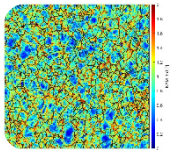
Surveillance system (data analytics + ROM + AI)

warnings

Industrial comm.

Final testing

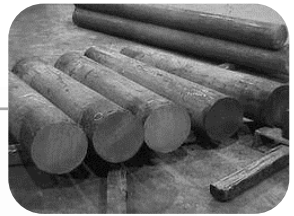




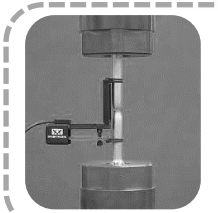
Testing at laboratory cond.

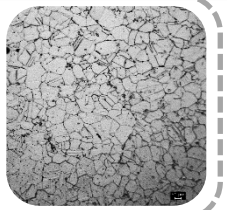
Sensors

Workshop



Raw material





Final forging

PROPOSAL INTRODUCTION (VI)

Expected outcome and impact

- **Advanced numerical models for final properties** estimation and advanced process design of high added value forging processes
- **Fast reduced models using metamodeling techniques**
- **Innovative monitoring sensors** and solutions **for the hot forging industry** and high-speed forging facilities
- **New solutions for tool wear and tool repair**
- **Non existing surveillance systems for high added value forging** process chains
- **Application** of all of them in **at least two forging lines**

Schedule:

- The total duration of the project will be of 2.5-3 years
- Starting will depend on final partners and their national conditions

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PARTNERS

Consortium: not fully confirmed yet

Fraunhofer IST

ULMA Advanced Forged Solutions

WYMAN GORDON

SAFRAN

ODTÜ METU

TIMET

SAT Since 1966

Mondragon Unibertsitatea

ROLLS ROYCE

AFRC ADVANCED FORMING RESEARCH CENTRE UNIVERSITY OF STRATHCLYDE

ALTEKA ALUMINIUM FORGING

Cemef CENTRE DE MISE EN FORME DES MATERIAUX

TEKNOROT STEERING & SUSPENSION PARTS

Partner search: the following company profiles may be interesting for the project linked to own resources/funding

- **High temperature forging component measuring system developer** (laser triangulation technique, flash contour by AV)
- Companies with **forging lines monitoring experience** (sensors, industrial communications, data treating and storing)

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CONTACT INFO

Contact info: Technical coordinator of the proposal
Contact me if you are interested!

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