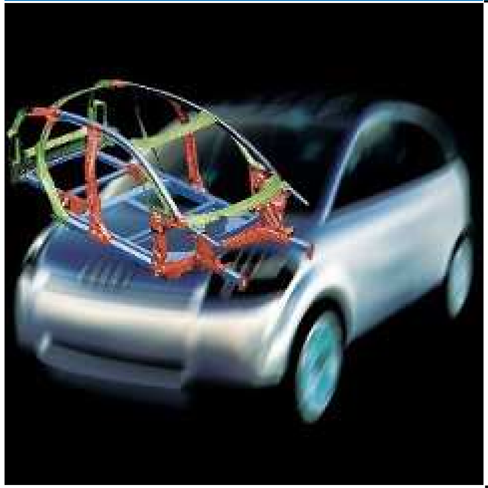
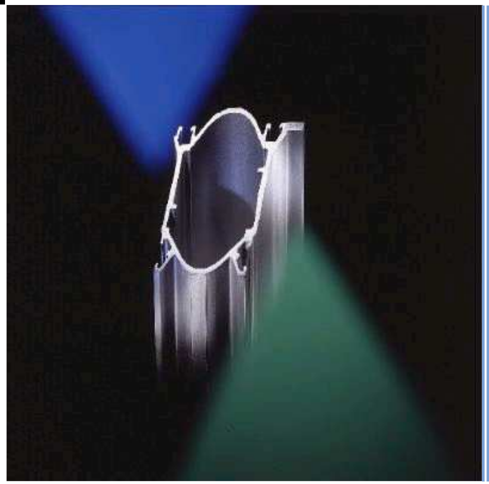
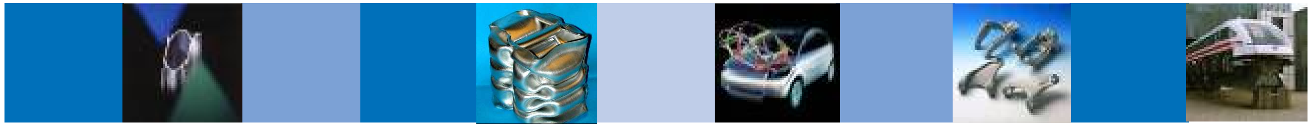


Industrial use of numerical models for the evaluation and improvement of extrusion die designs

Alexis Bacha
Alcan Centre de Recherches de Voreppe
Rio Tinto Alcan, Engineered Products – France

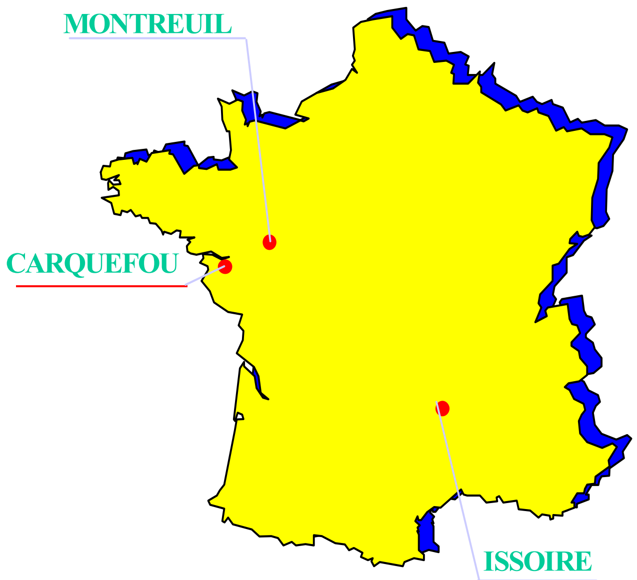
EHTC'08 – October 1st 2008



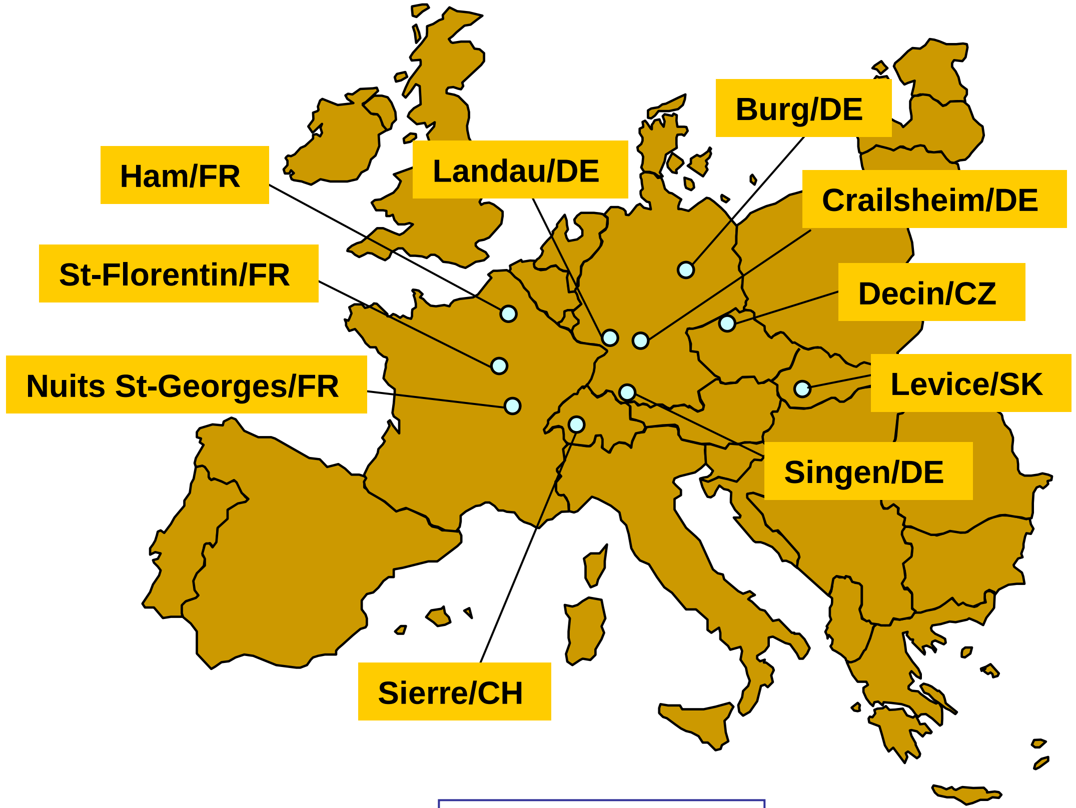


Extrusion business inside ALCAN

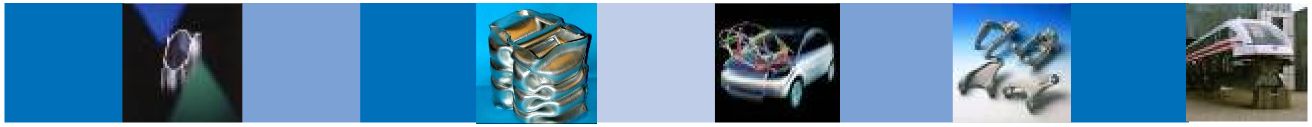
- **2 Business Units:**
  - Aerospace Transport and Industry (ATI)
  - Alcan Extruded Products (AEP)



ATI plants



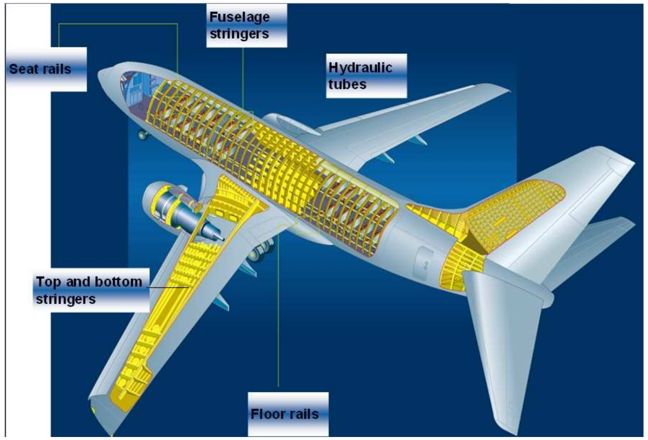
AEP plants



Markets for ALCAN’s extruded products

ATI’s markets

Aerospace

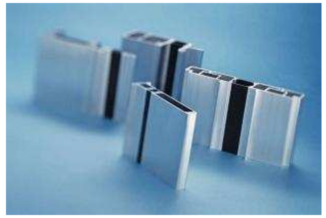


Sport

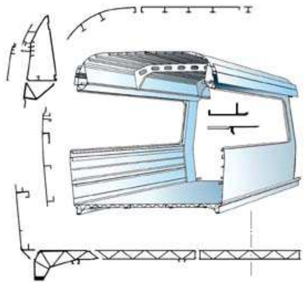
Marine

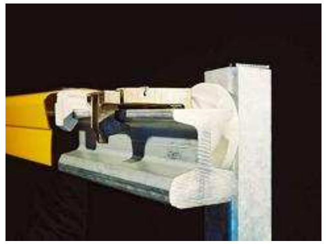
AEP’s markets

Building

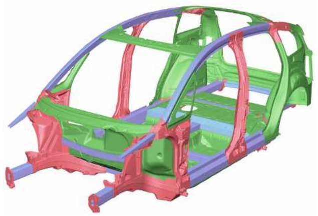


Rail

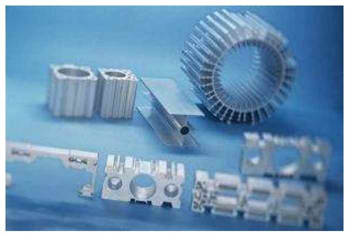


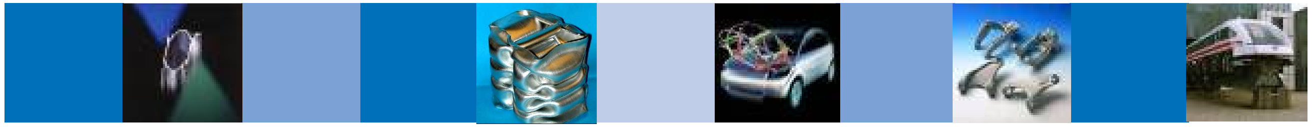


Automotive

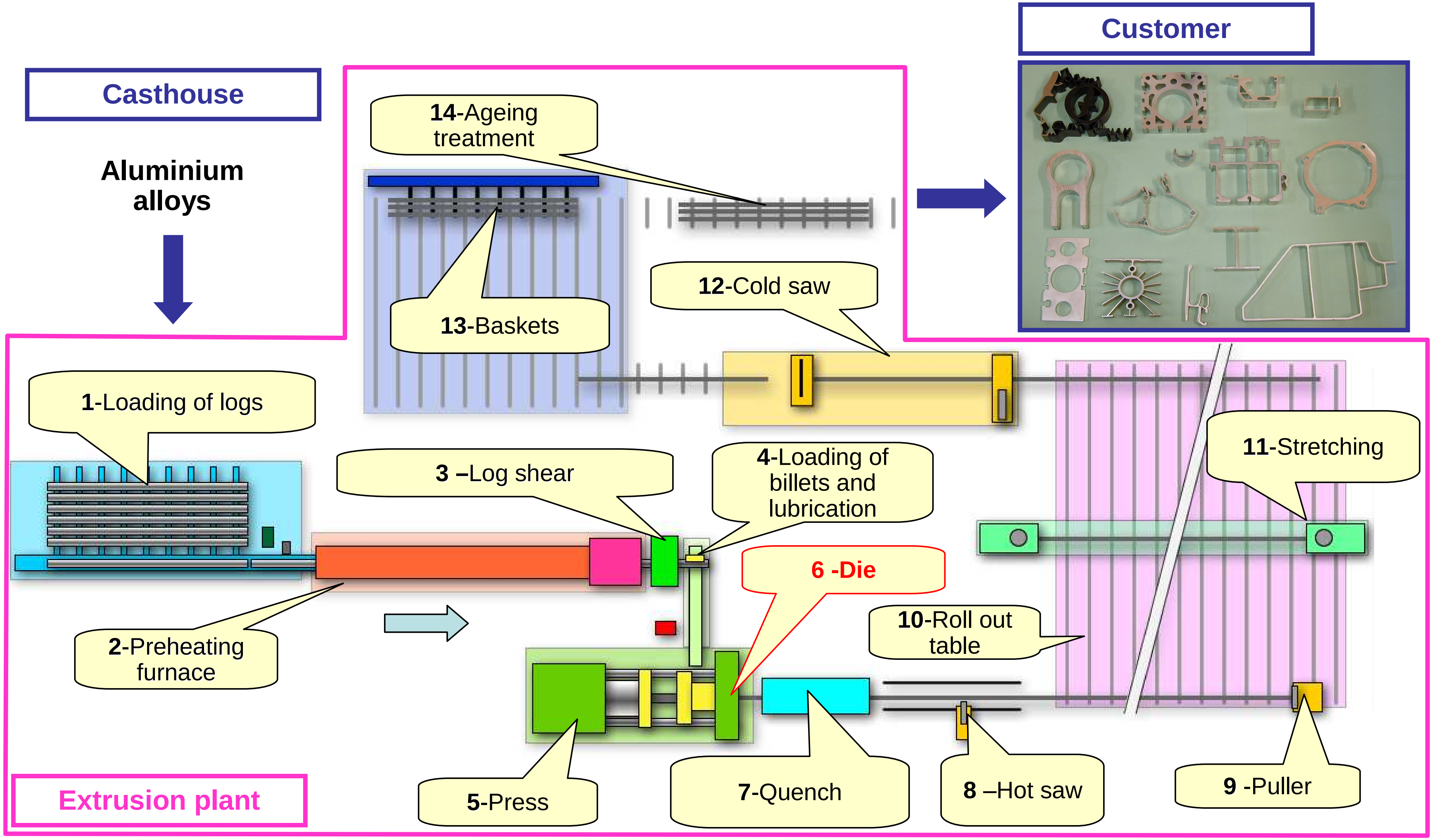


Industry



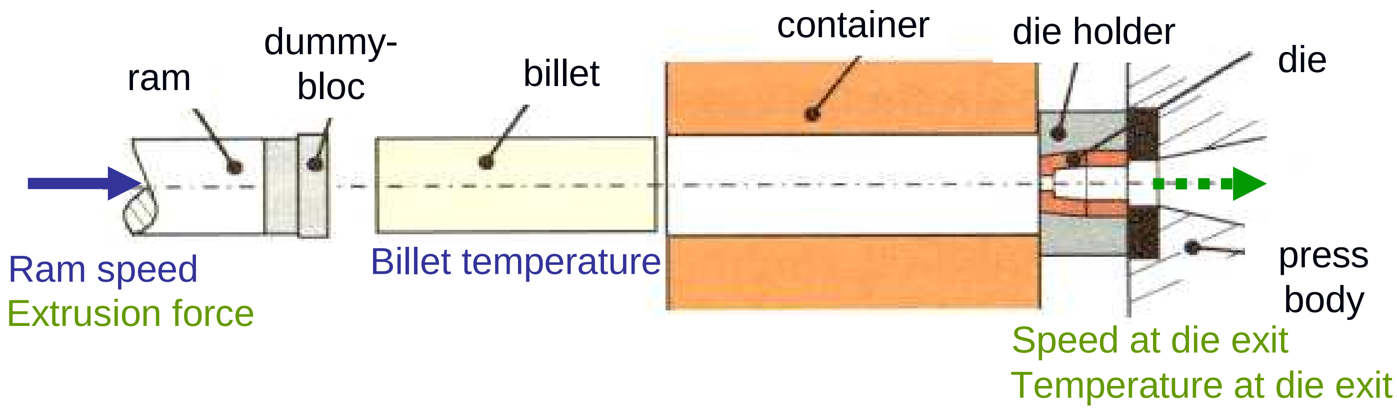


Overview of the extrusion process

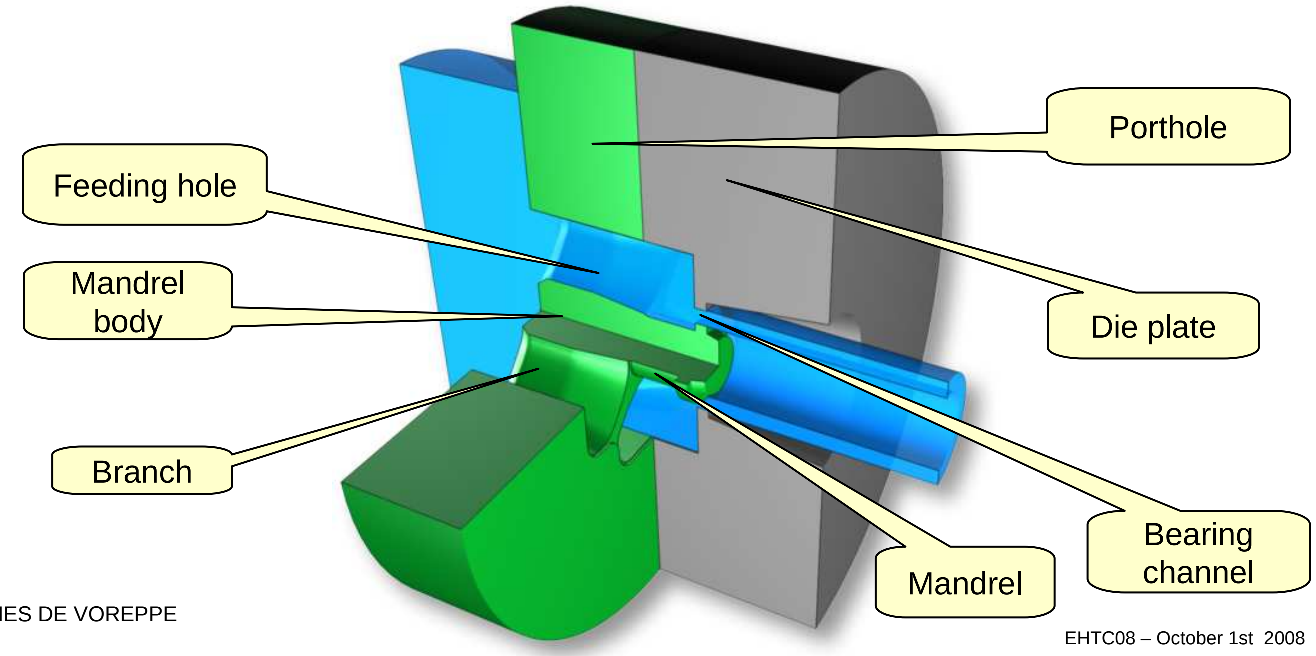


Definitions

- ***Principle of direct extrusion:***



- ***Typical die for hollow sections:***

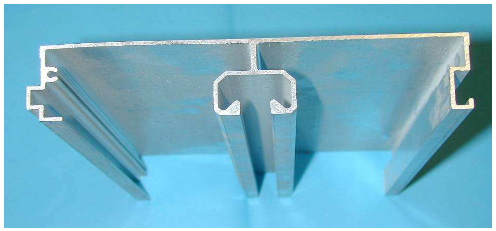


The aims of extrusion modeling

Product feasibility

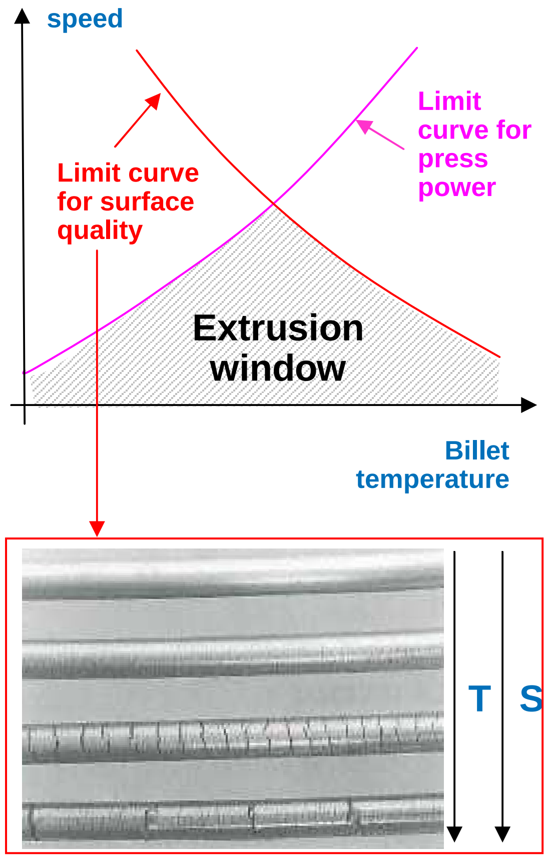
Before die correction

After die correction

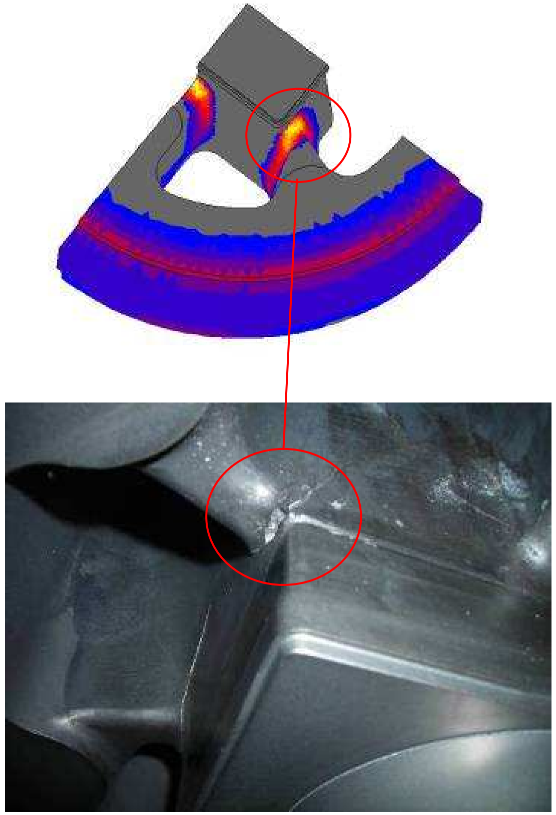


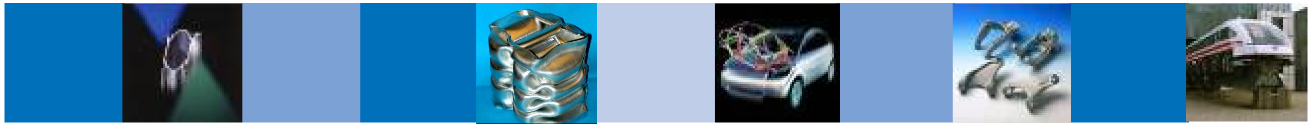
Process productivity

Extrusion diagram



Die lifetime





Methodology for extrusion modeling

1. **Pre-processing (HyperMesh):**
   - *Meshing*
   - *Boundary Conditions*
   - *Morphing*

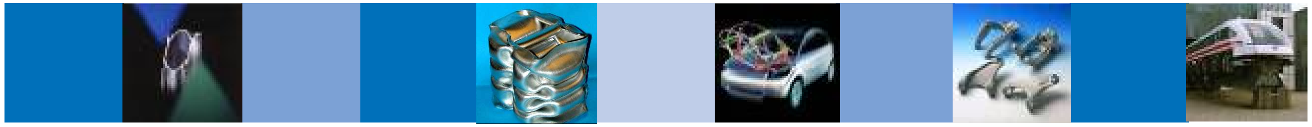
2. **Computation (HX solver) :**
   - *Steady state*
   - *Transient*

3. **Post-processing (HyperView):**
   - *Results fields (P, T, S)*
   - *First step of fields transfer (HX → MARC)*

4. **Pre-processing (HyperMesh & Mentat):**
   - *Meshing*
   - *Field transfer and mapping*
   - *Boundary Conditions*

5. **Computation (MARC):**

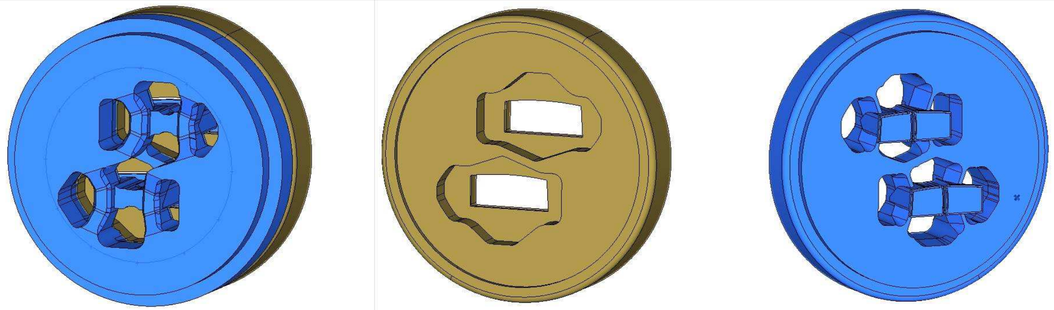
6. **Post-processing (MARC):**
   - *Stress field*
   - *Displacements*



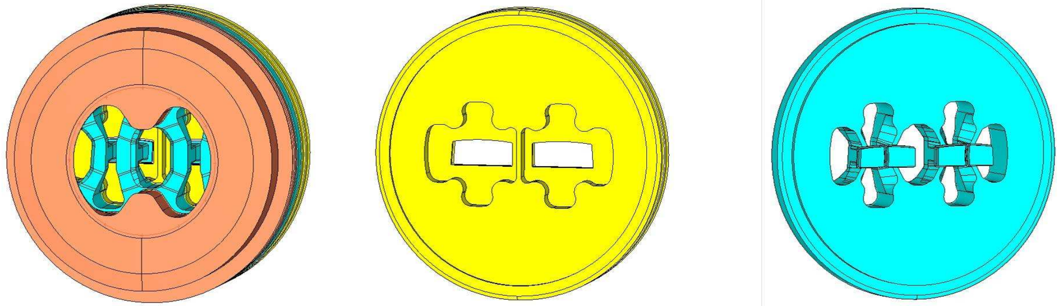
Example of die design optimization

Die geometries

A - Current die design

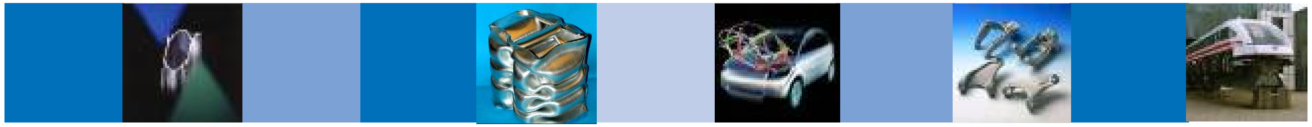


B - Proposed die design



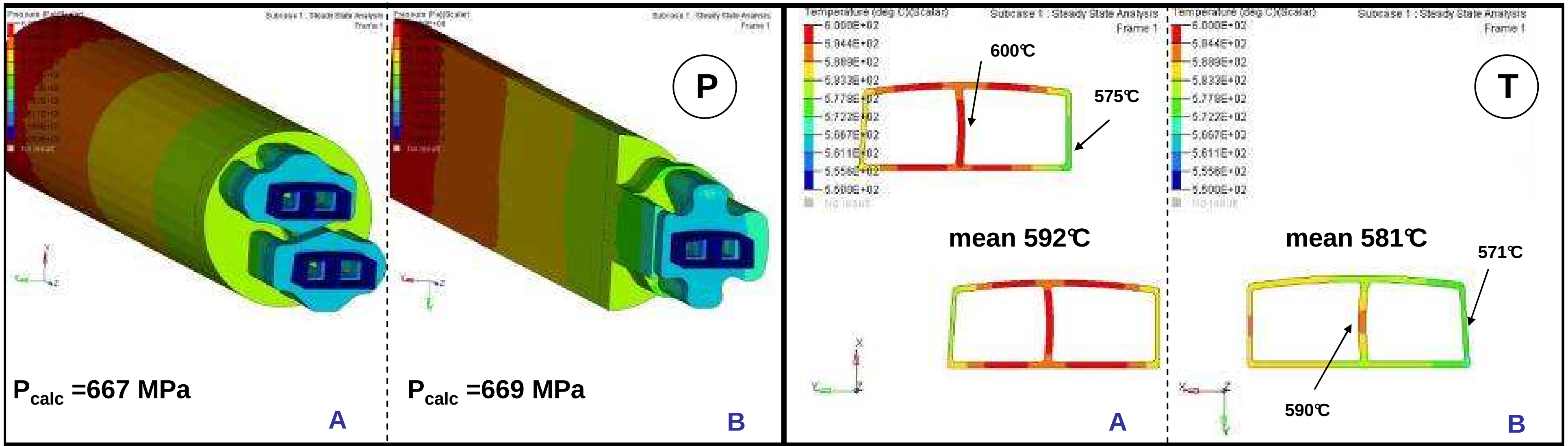
Objectives: Compare the flow and the behavior of the tool in terms of:

- **Productivity / Feasibility:**
  - increase the extrusion speed through a reduction of extrusion pressure or outlet temperature
  - be compatible with the power of the press
- **Product quality**
  - avoid distortion at die exit
  - ensure a good surface quality
  - reduce scrap due to transverse welds
- **Die lifetime**
  - increase the number of extruded billets before the failure of the die

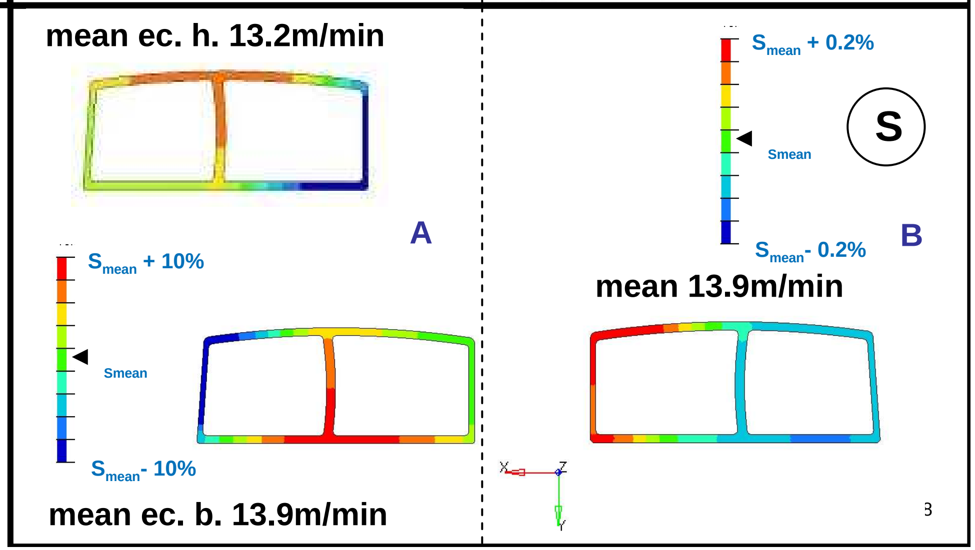


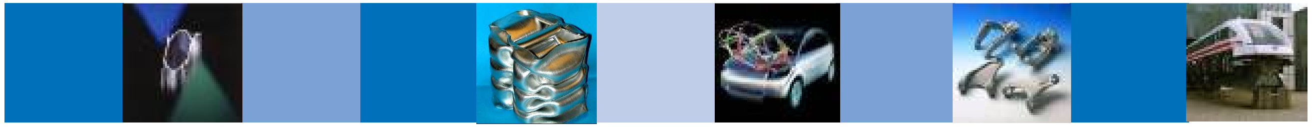
Example: Modeling of flow

- **Complex flow simulations (steady state)**



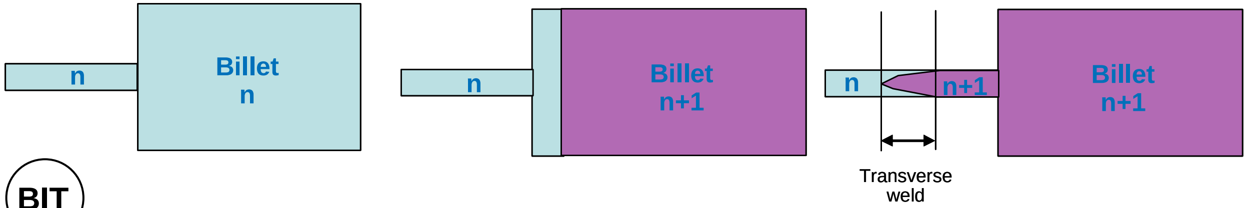
- **(P) Pressure at the rear side of the billet** ⇒ **Feasibility** - **Productivity** ⇒ decrease beneficial
- **(T) Temperature at die exit** ⇒ **Productivity - Product quality** ⇒ decrease of the mean temperature and local hot spots beneficial
- **(S) Speed at die exit** ⇒ **Feasibility - Productivity – Product quality** ⇒ decrease the gradient inside a same hole and decrease the difference of mean speeds between holes beneficial

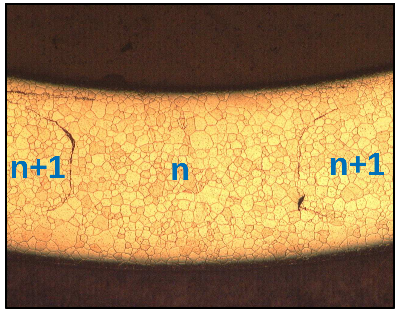


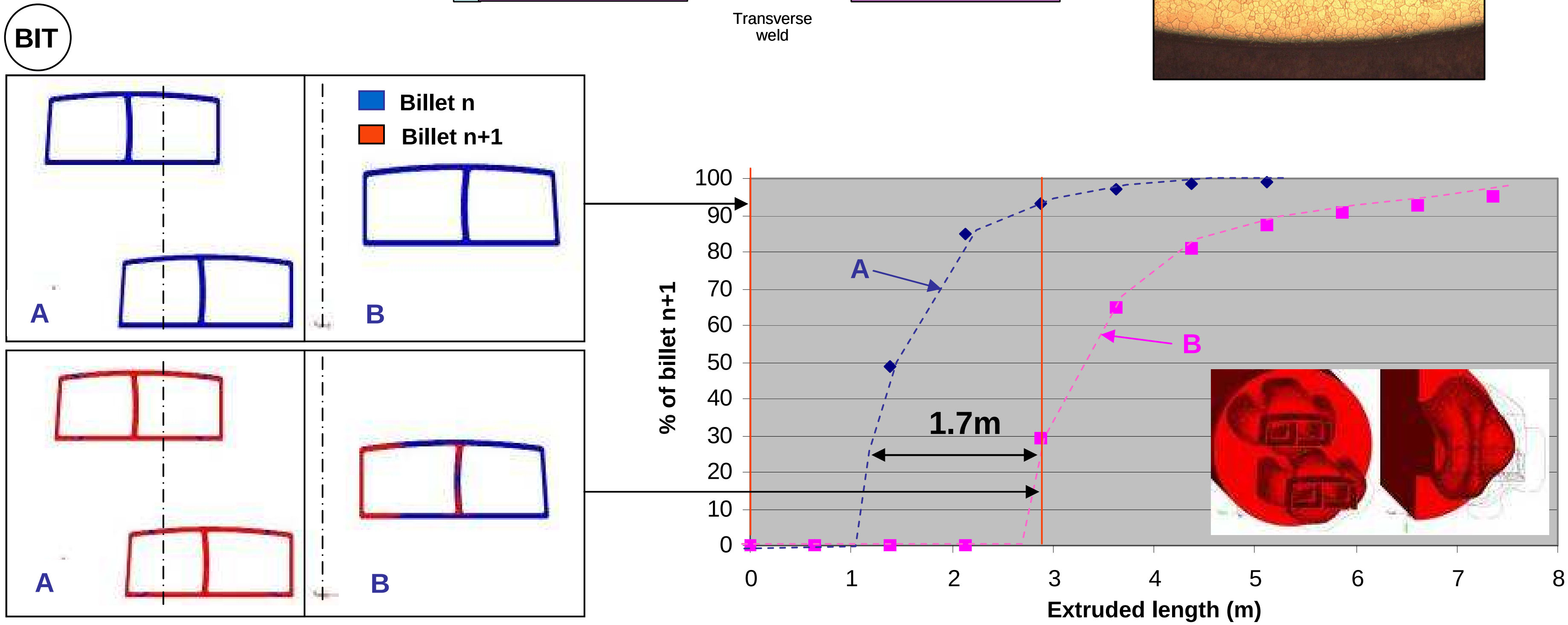


Example: Modeling of flow

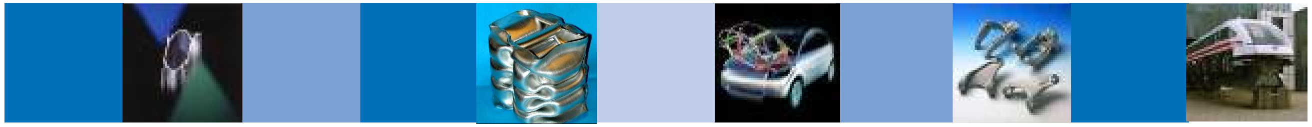
- **Complex flow simulations (transient)**
  - **(BIT) Billet interface tracking** ⇒ **Product quality** ⇒ decrease of the length affected by the transverse weld beneficial (scrap reduction)







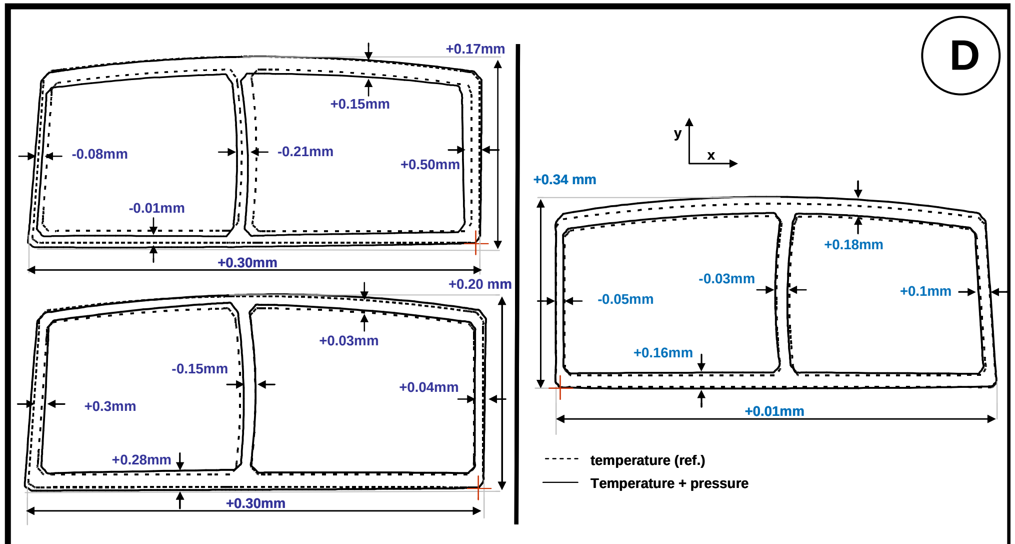
Low scrap High scrap

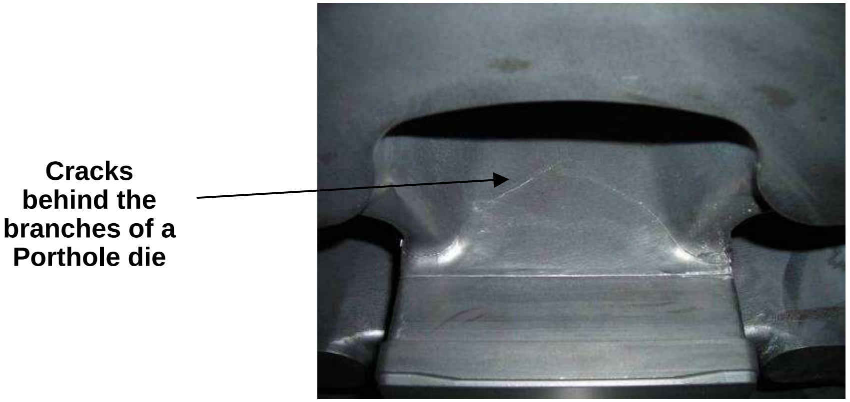


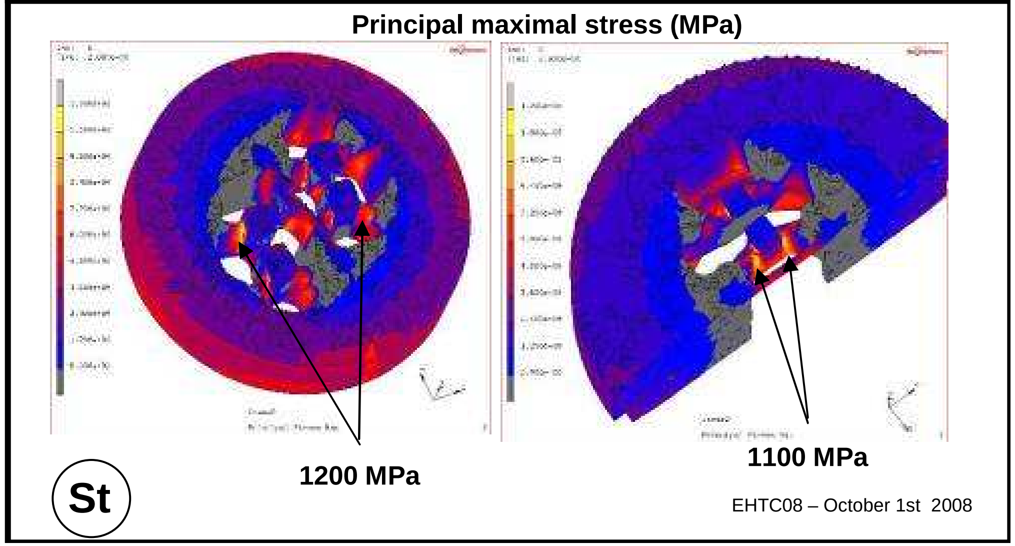
Example: Modeling of dies

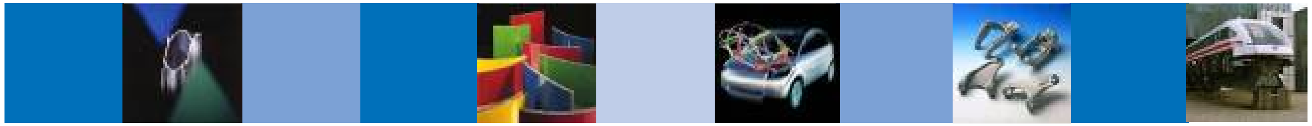
Thermomechanical analysis of die behaviours

- **(D) Displacement of mandrels ⇒ Product quality** ⇒ decrease of deflection beneficial
- **(St) Stresses inside the dies ⇒ Die lifetime ⇒** decrease of principal maximal stress beneficial









Example: Synthesis of the comparison

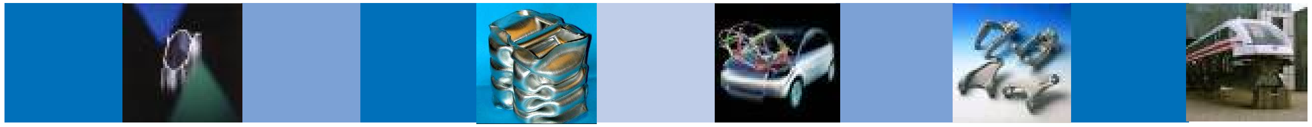
Calculation outputs	Effect of the new design
Pressure	=
Outlet temperature	+++
Speed at die exit	+++++
Transverse weld behavior	-
Geometrical tolerances	+++
Stresses inside the die	+

Productivity/feasibility (Pressure, Outlet temperature, Speed at die exit)

Product quality (Speed at die exit, Transverse weld behavior, Geometrical tolerances)

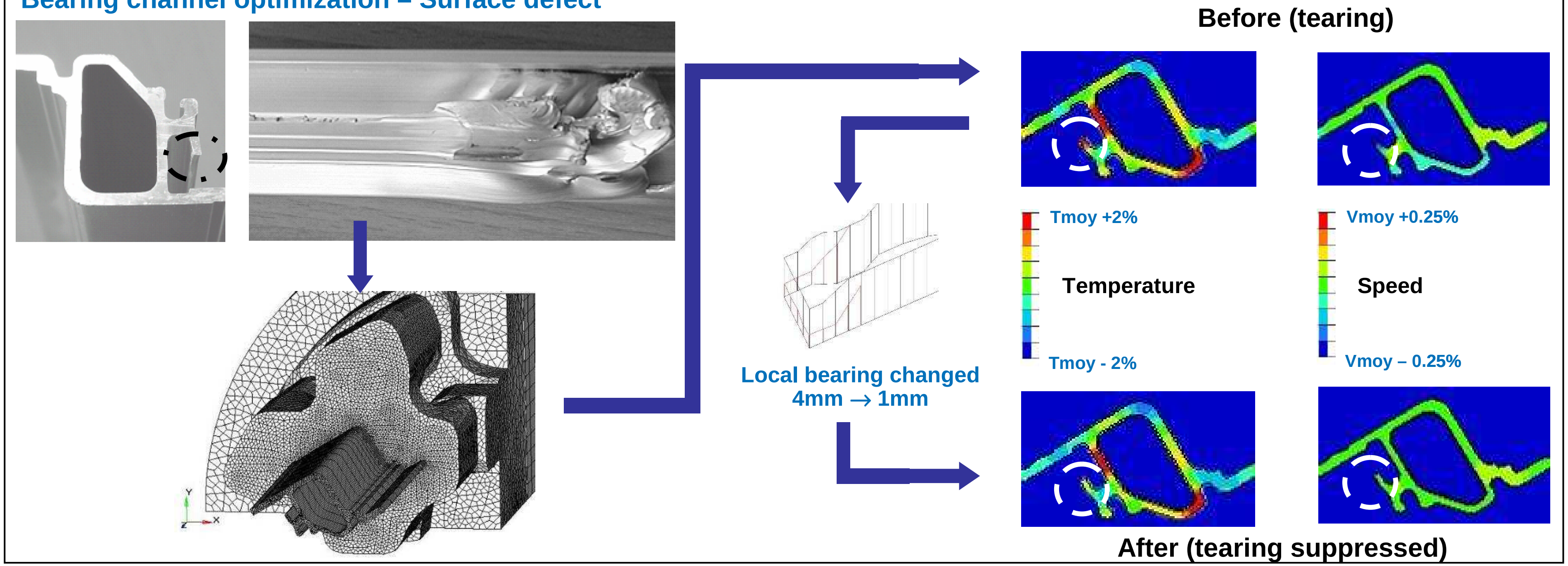
Die lifetime (Stresses inside the die)

Easier decision

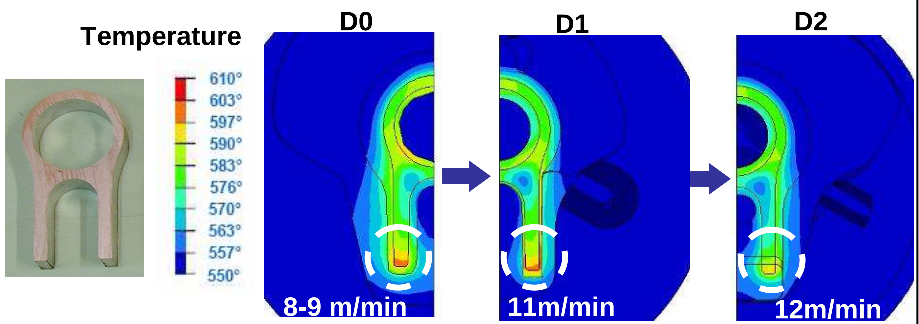


Some cases solved by numerical calculations

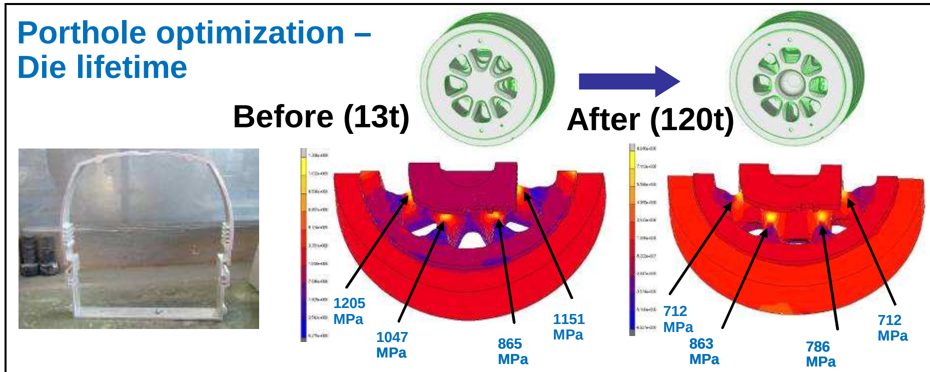
Bearing channel optimization – Surface defect

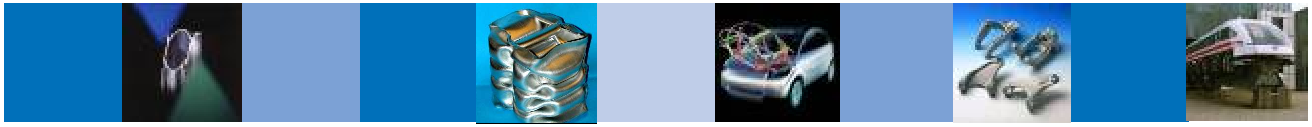


Global die design optimization – Productivity



Porthole optimization – Die lifetime





Conclusions

- Numerical modeling of extrusion is currently used to ensure optimal die design and relevant correcting operations carried out in Alcan Extruded Products' die shops. It is also a way to rationalize our know-how in die design.
- The main industrial objectives reachable thanks to numerical simulations are:
  - Reduction of the number of trials
  - Improvement of die lifetime
  - Increase of extrusion speed
  - Implementation of new dies for novel applications
- Alcan is satisfied with Hyperworks and continues to collaborate closely with Altair to implement the necessary new functionalities for complex extrusion cases.
- Outlook concerning the software:
  - Reduction of calculation times (parallel calculations)
  - Improvement of the accuracy of the basic features
    - Skin tracking
    - Multiple cycle
  - More flexibility for advanced users (user subroutines, etc…)