
DURALDUR
LEONARDO
Engineers for Integration
TORINO
An Automatic procedure for the optimization of the pin bore profile for highly loaded pistons

Company Introduction

- Duraldur is a small-medium company located in the north of Italy, on the Garda Lake
- Duraldur specialized in the productions of casted and forged pistons, air-cooled cylinder, centrifugated liners and made of alluminium forged liners mainly for internal combustion engines
- The company was estabilished in 1951 and is family-run business

Summary

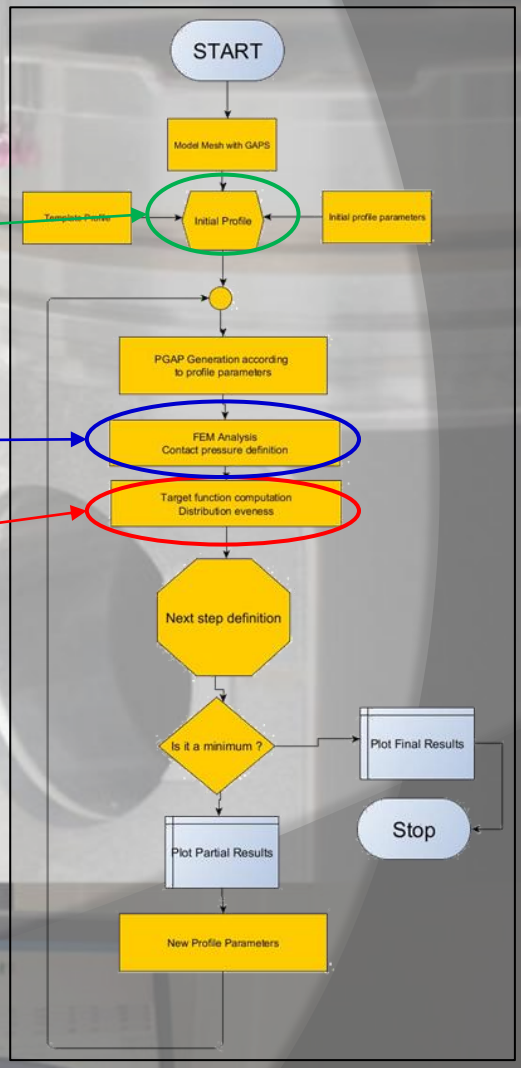
- Pistons are key component of engines
- Nowadays the OEM are adopting exclusively four stroke engine to fulfill requirements in gaseous emissions
- This lead to a potential loss of power density that is compensated thanks to a painful increasing of combustion pressure and the adoption of turbocharging;

GREAT IMPACT ON PISTON – PIN CONTACT

HOW ACHIEVE THE BEST SOLUTION????

Optimization strategy

- Thanks to a strict cooperation with Leonardo Engineering we developed a fully automatic tool to get the best piston-pin contact
- The target of this automatic tool is to define the best pin bore profile to level out the contact presure
- Starting point for simulation
  - Based on previous experience
  - May influnce search result
- Gap contact force
  - Requires computation of average pressure
  - Specific Python script available
- Target function:
  - Max predicted value of contact pressure not reliable, because it may be influenced by numerical oscillation
  - Max quadratic variance of pressure
  - Two options, both tested:
    - Computed on the upper half of the pin bore
    - Computed only in contact areas
    - Computed only in contact areas



Search Method

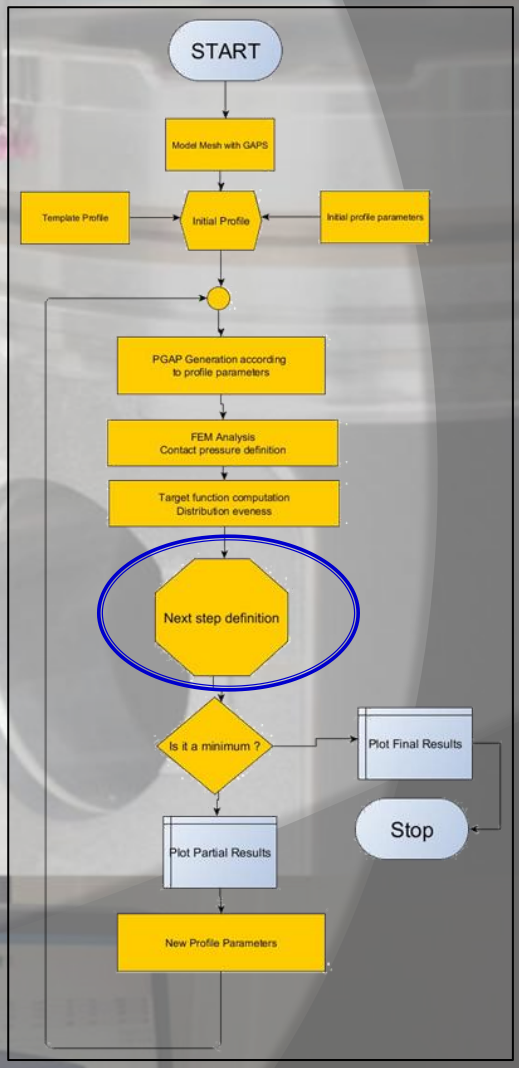
- **Two areas of choice**

  - *Derivative-based* (Jacobian & Hessian matrix)
    - Faster but sensible to noise (numerical or measured)
    - May be locked into local minimum
    - Two methods tested

  - *Non Derivative-based* (s.c. Global search)
    - Much stabler but slower
    - May not converge in reasonable time
    - Two methods tested

- **Both types of methods tested**

  - *Derivative based* converged to probable absolute minimum with both options for target functions
  - *Non-derivative based* were slower and remained far from best options found by derivative based ones.



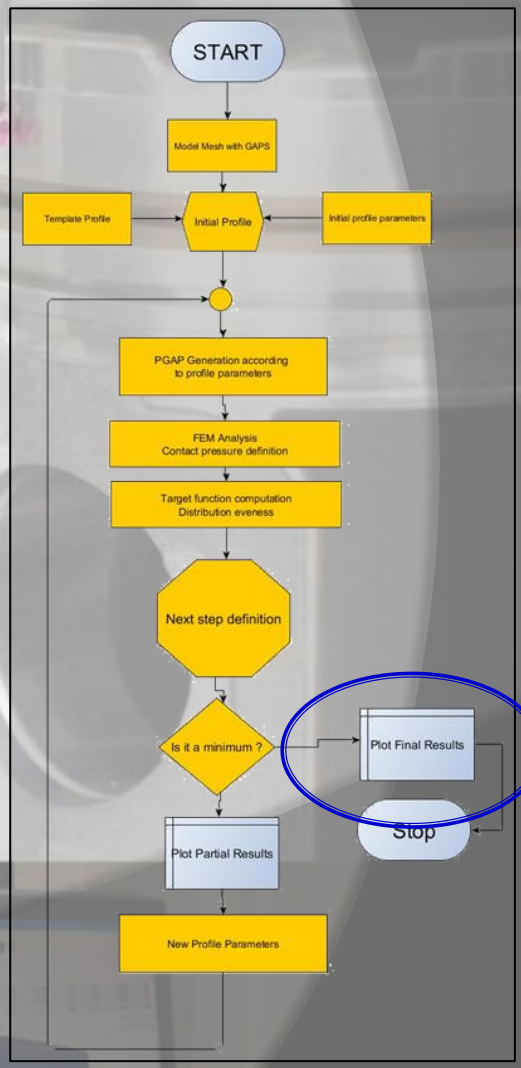
Optimization Strategy

- **Output**

  - Value of the parameters corresponding to Best Found Value (BFV)

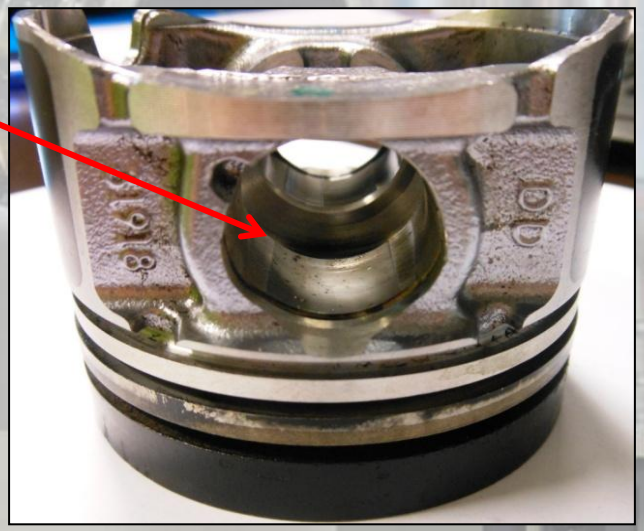
  - Plot file for visualization
  - Target function at BFV

  - FME model (rough mesh, with BFV gap configuration) and result



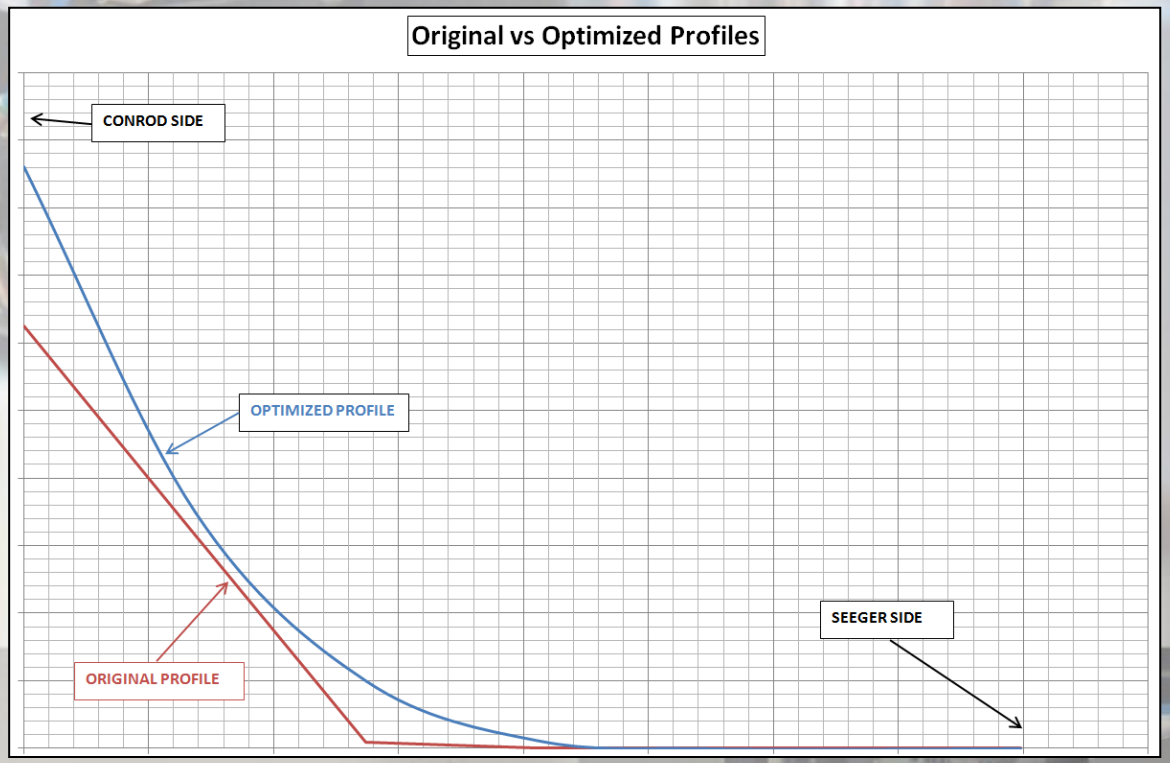
Analysis Case

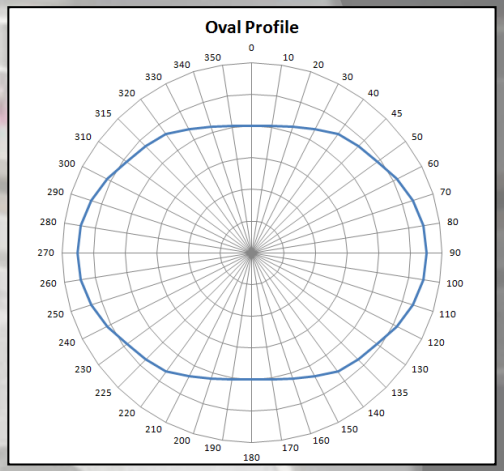
- In the last two years we designed and developed, in partnership with KOHLER ENGINES Reggio Emilia, a new piston for a diesel engine with increased power and torque.
- Following the first test phase, we stated that the piston–pin contact was ok, anyway an improvement was possible.
- For this reason we performed an optimization assessment to improve the actual situation.

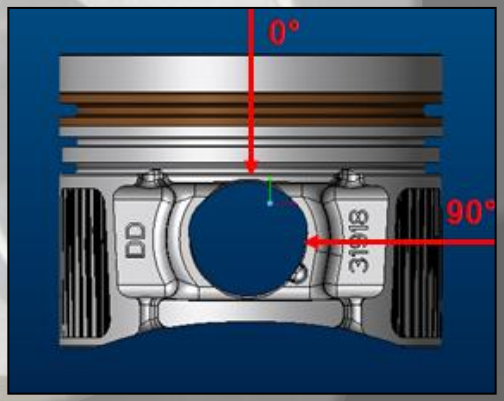


Analysis Case

- At the first step we checked the existing situation
- Hereafter we perform an optimization analysis
- Finally we compared the different output (profile and stress)

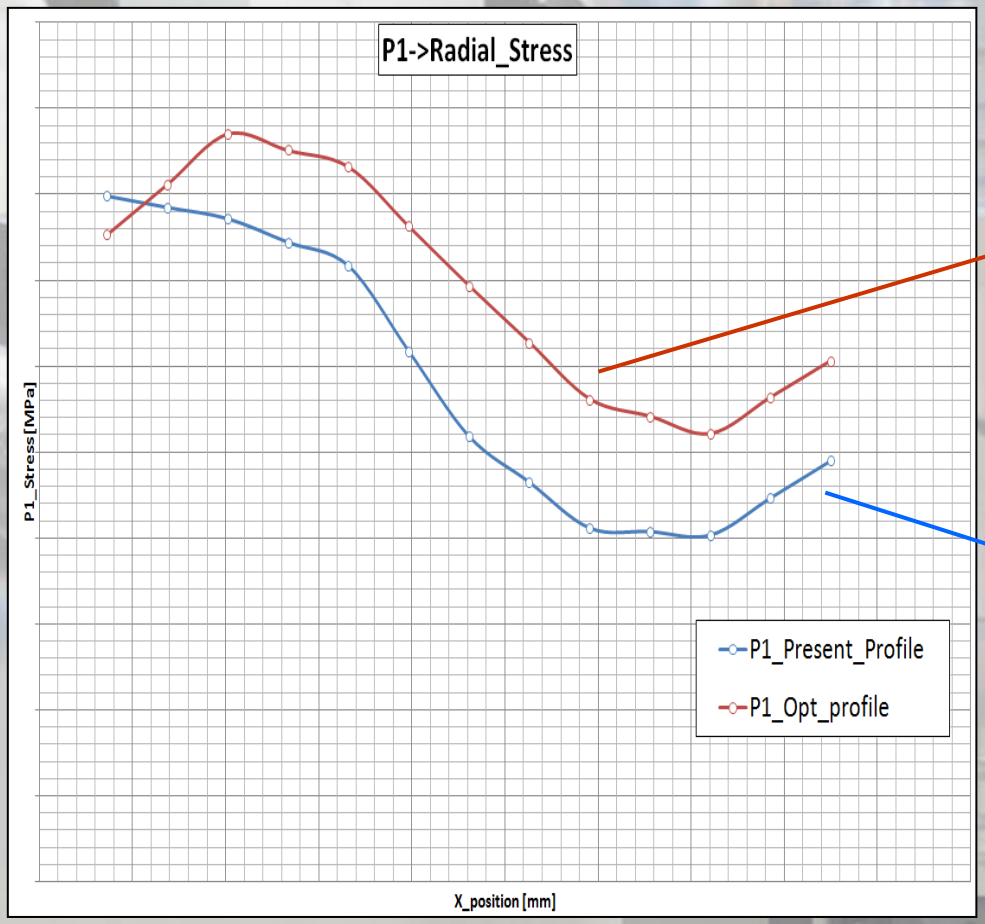


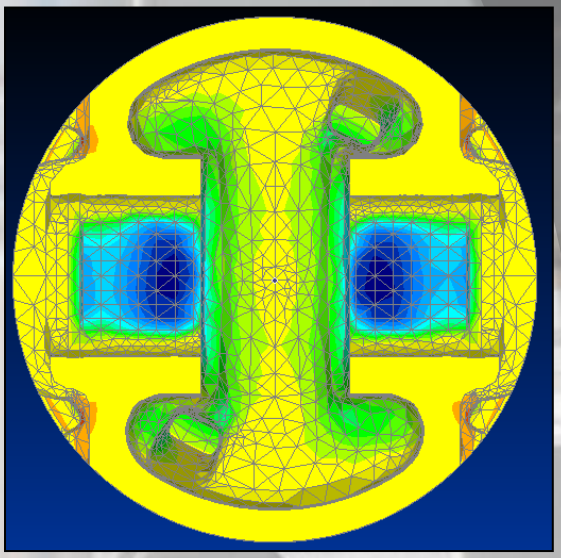


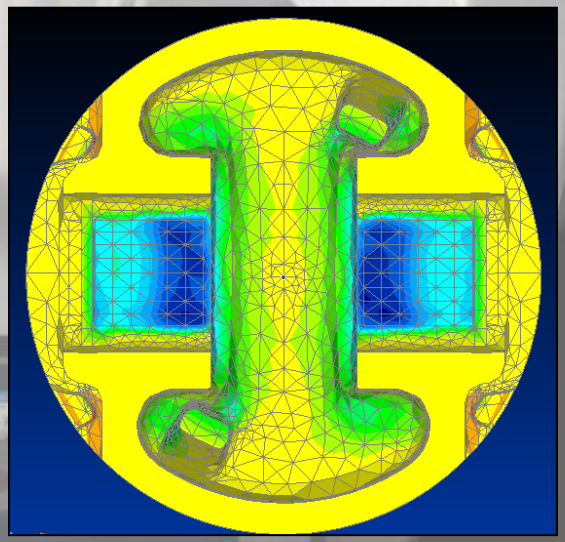


- The optimized profile requires an oval development @90°

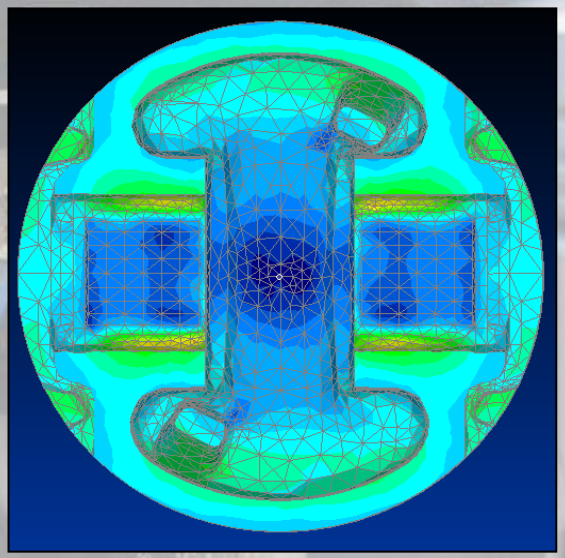
Analysis Case

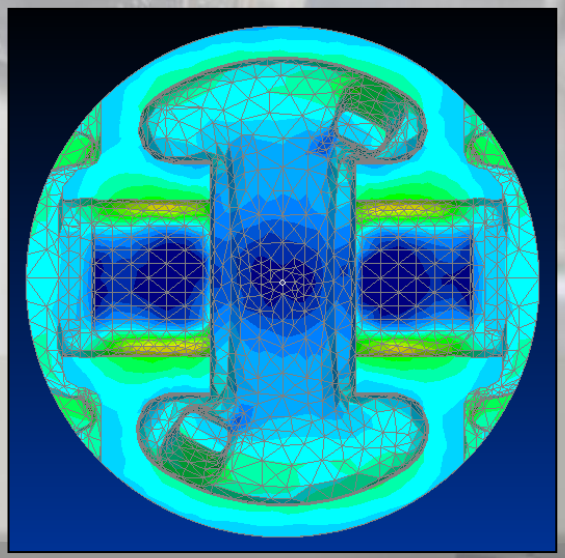


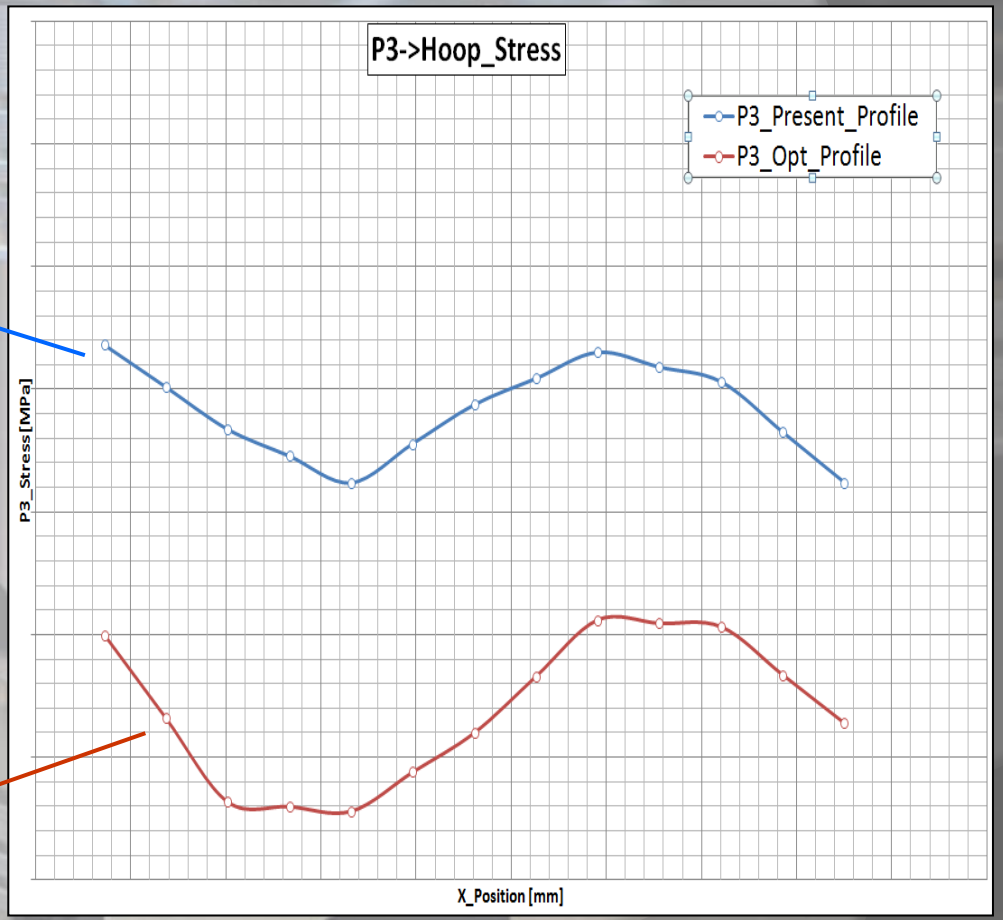




Analysis Case







Future Development

- **Process**
  - Review parameters definition
  - Add version with conical taper
  - Add conrod profile to optimization procedure
  - Generate interface GUI for non-python users
  - Develop python script to view results in FEARCE
  - Other optimization criteria (stresses, fatigue life)
- **Product**
  - Review analysis with finer mesh as original one
  - Check cold piston pressure distribution (with reasonable cyclinder pressure!!)