

MetAGEAR

**Integrated framework for industrial
gearbox design & manufacturing**

OVERVIEW

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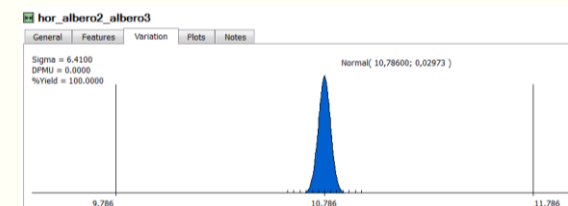
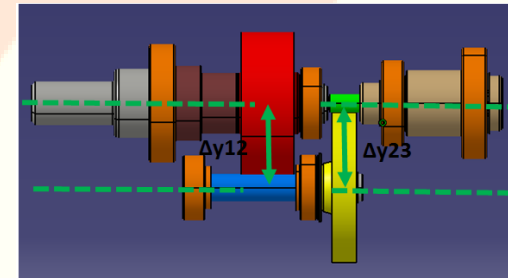
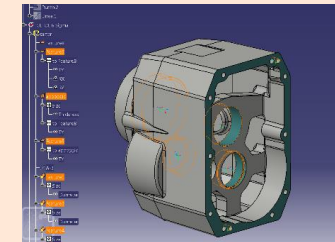
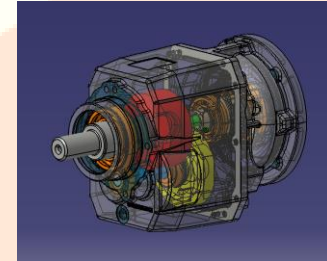
The origins

- 2004 Gear Design Project with CNH SpA: Nonlinear Parametric FEA
- 2005 Simech: Gear dynamic models
- 2007 Helical-pair project with CNH SpA: New Nonlinear Parametric FEA, Test-Rig
- 2010 Intermech: Gearboxes optimization
- 2013 INDGEAR project: Condition Monitoring, Diagnostics, Prognostic
- 2014 FORTISSIMO project: Supercomputing applications
- **2016 MetAGEAR project with Bonfiglioli SpA and SIR SpA:**
 - **Technologies for gearboxes**
 - **Design, Simulation, Testing, Materials, Production**

Over 10 years research on gears, gearboxes and the like
Undergraduate, Graduate and PhD students specialized on gears

3D Tolerance design

- **Methodological approach for the 3D tolerance analysis in gearboxes**
 - Dimensional, geometric and general tolerances
 - Functional analysis of the assembly
 - Identification of the main contributors to the 3D tolerance stack
- **Methodological approach for the synthesis of tolerances :**
 - Definition of a Datum Reference Frame
 - Allocation of tolerances on functional dimensions and geometrical features
 - Knowledge-based approach
 - Revision of the dimensional and tolerances values in accordance with the results of tolerance simulations



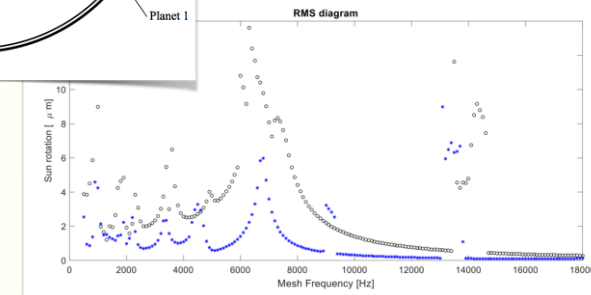
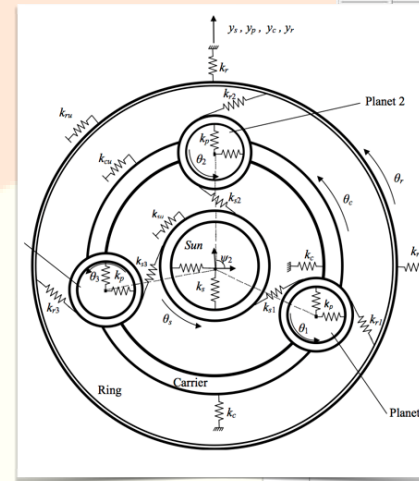
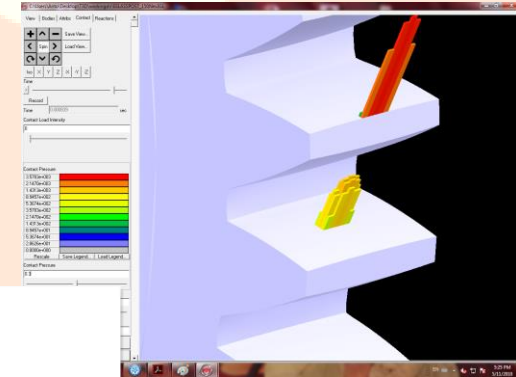
SIMULATION

- **Nonlinear Modelling**

- Nonlinear FEA (Commercial and in-house software)
- Lumped parameters modelling
- Loaded Tooth Contact Analysis
- Misalignments
- Dynamic loads
- Linear and nonlinear resonances

- **Optimization**

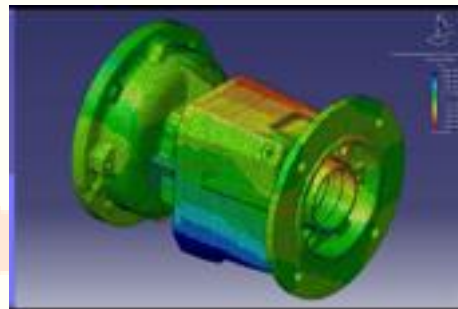
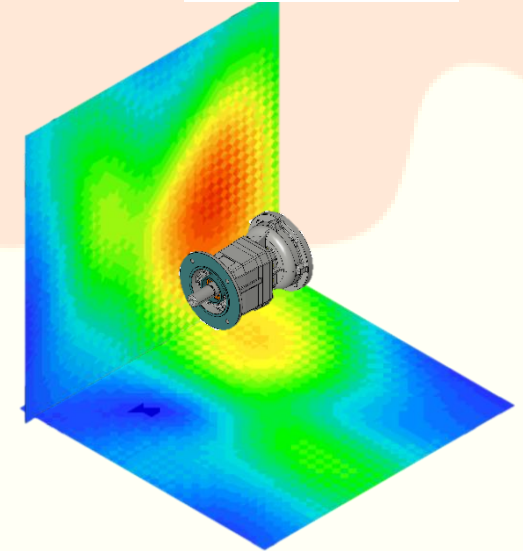
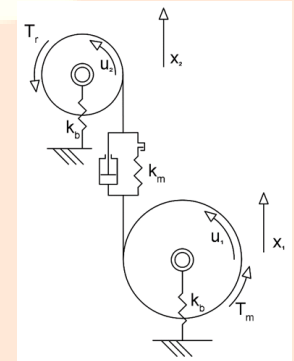
- Simple and complex gear-trains
- Micro-geometry optimization
- Static and dynamic optimization



SIMULATION

- **NVH optimization of gearboxes**

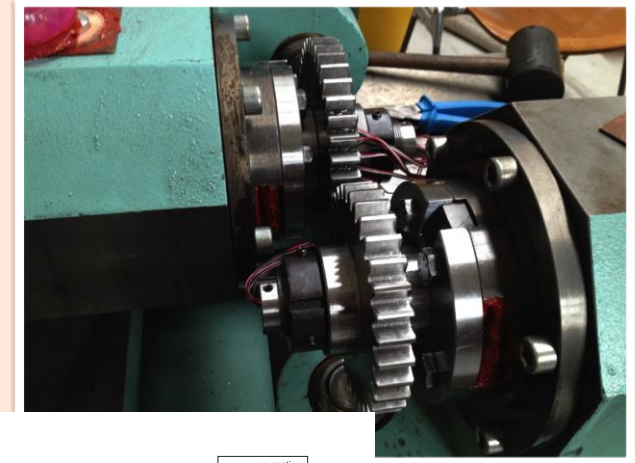
- Parametric LP model of gearboxes
- Gear vibration/variable forces on bearings and casing
- Parametric FE model of gearboxes
- Natural frequency of casing/ casing vibration
- BE model of gearboxes
- Acoustic radiation
- Sound Quality Analysis of gearboxes
- acoustic comfort/metrics



TESTING

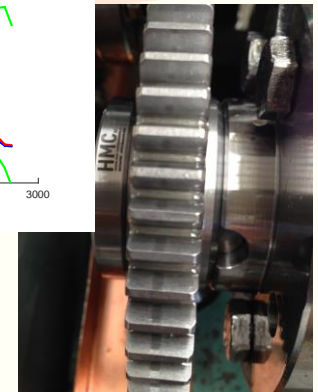
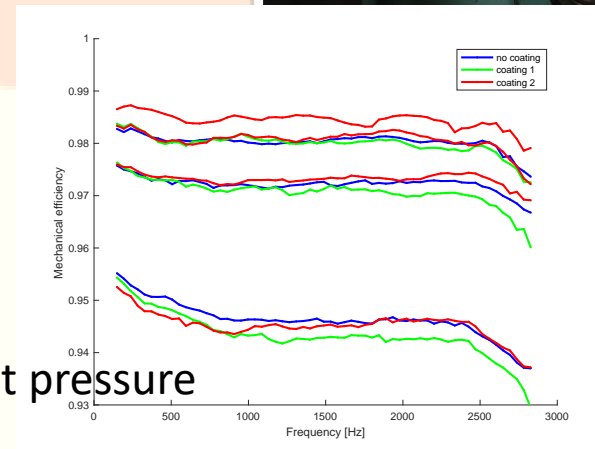
• Test Rig

- Test rig for single pair analysis
 - » variable centerdistance
 - » controlled misalignments
 - » computerized speed/torque control
- Sensors: torque-meters, strain-gauges, accelerometers



• Testing program

- Efficiency direct measurement
- Vibration and sound measurement
- Endurance accelerated test
 - » special gear design for high contact pressure

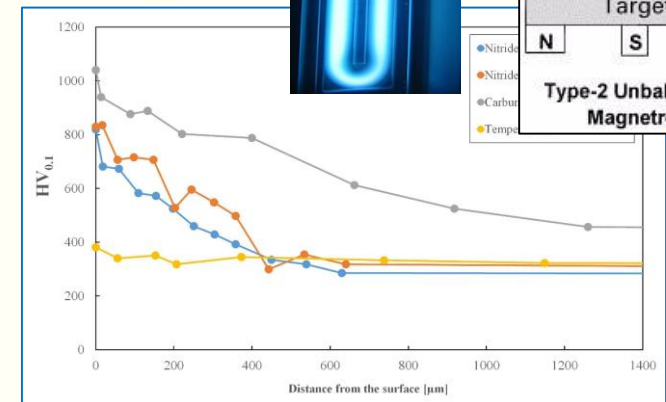
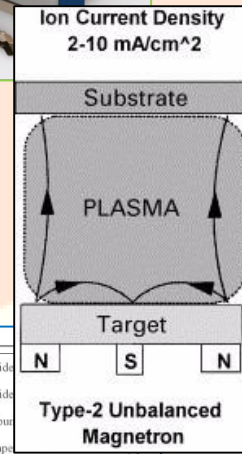


• Goal

- Final assessment on materials, coatings, surface treatments

MATERIALS

- **THERMOCHEMICAL TREATMENTS**
 - *LOW PRESSURE CARBURIZING*
 - ZeroFlow® GAS NITRIDING
- **FILM DEPOSITION**
 - Physical Vapour Deposition (PVD)
 - Plasma Enhanced Chemical Vapour Deposition (PECVD)
- **QUALITY CHECK: HARDNESS AND ROUGHNESS**
 - TRIBOLOGICAL TEST
 - PARAMETER SELECTION
 - Stribeck curve
 - pin-on-disk set up



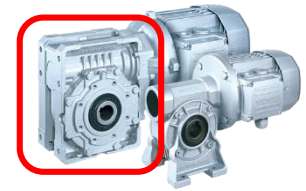
High accuracy and reconfigurability robotic system

New architecture of reconfigurable robotic assembly cells:

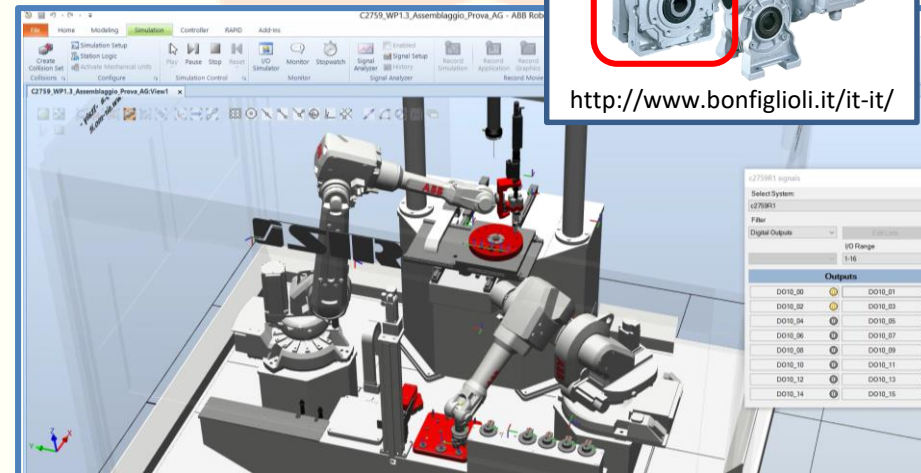
- **Different control architecture needed** to improve and re-adapt existing plants, and to develop high reconfigurable robotic cells: **PC based and Structured Text** instead of PLC & AVL

Operating modules and their behavioral models, product configuration, tests:

- **Identified the case study** and variances for robotized assembly
- **re-adapting robotic assembly democell**
- analysing case study for preliminary assembly **simulation tests**



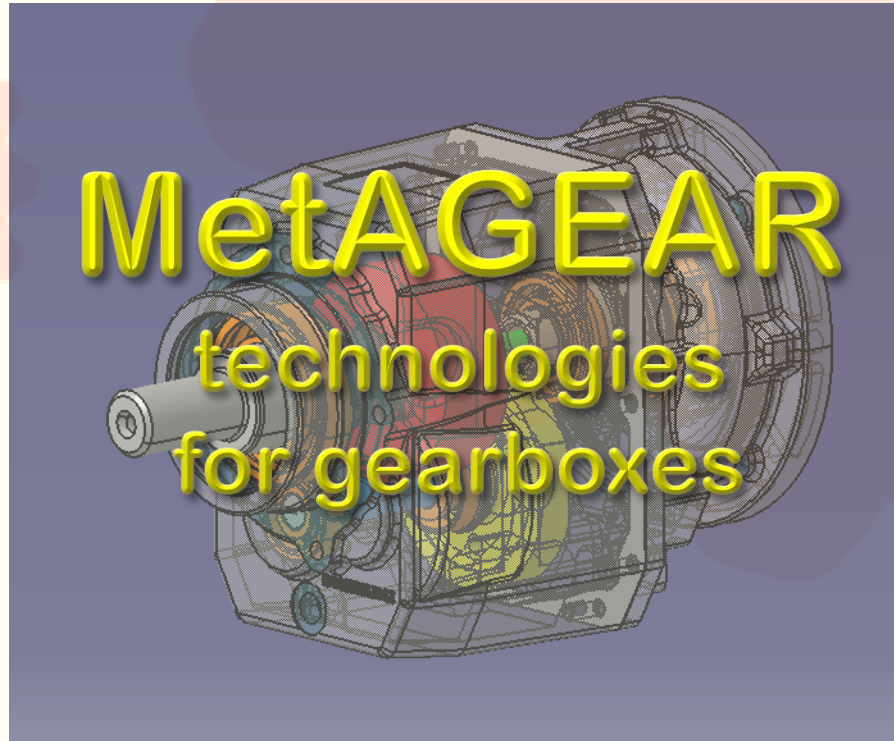
<http://www.bonfiglioli.it/it-it/>



SIMULATION

TESTING

MATERIALS



DESIGN

PRODUCTION