Modena, March 8th 2016, The Gear Day

MetAGEAR

Integrated framework for industrial gearbox design & manufacturing

A project within POR-FESR 2014-20

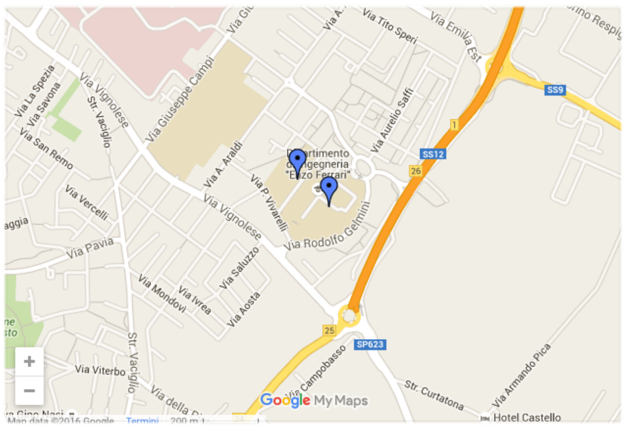
A bit of history…

- 2005 Simech project: “UOR 1.2 Gear transmission”
- 2010 Intermech project: “UOR 1.2 Gearboxes optimization”
- 2016 **MetAGEAR project**: fully focused on gears (1M€)
    - 10 years research experience on gears
    - multidisciplinary approach (thanks to our colleagues in Modena and Ferrara)
    - experimental facilities are available (thanks to the previous projects)

Who is involved?

- Intermech MO.RE.
  - Gear design & optimization - Prof. Francesco Pellicano
  - Archetypal design - Prof. Francesco Leali
  - Material science - Prof. Tiziano Manfredini
  - Manufacturing - Prof. Marcello Pellicciari
- MechLav
  - NVH optimization - Prof. Giorgio Dal Piaz
- Democenter
  - Dissemination

MechLav
Laboratorio per la Meccanica Avanzata



Industrial partners:

BONFIGLIOLI
Power & Control Solutions

SIR
SOLUZIONI INDUSTRIALI ROBOTIZZATE

Intermech Mo.Re.

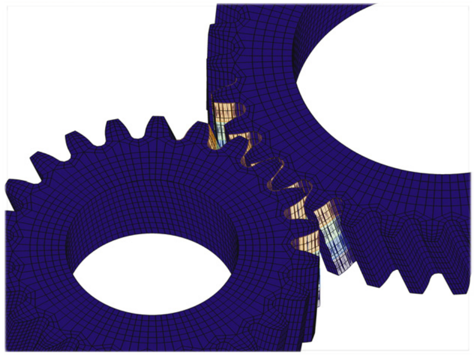
DEMOCENTER

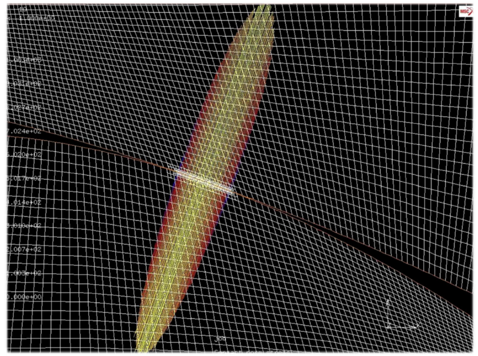
MetAGEAR goals

- In Italy a large number of gear manufacturers is present, but there is not a large research center on gears (handicap with respect to Germany)
- MetAGEAR aims to **collect skills and facilities** shared by the two laboratories Intermech and Mechlav to create a large framework for performing **applied research on gears in Italy**
- In our vision, MetAGEAR will provide **new innovation opportunities and service** for Italian gear manufacturers

OR1 - Gear design, simulation and testing

Prof. Francesco Pellicano



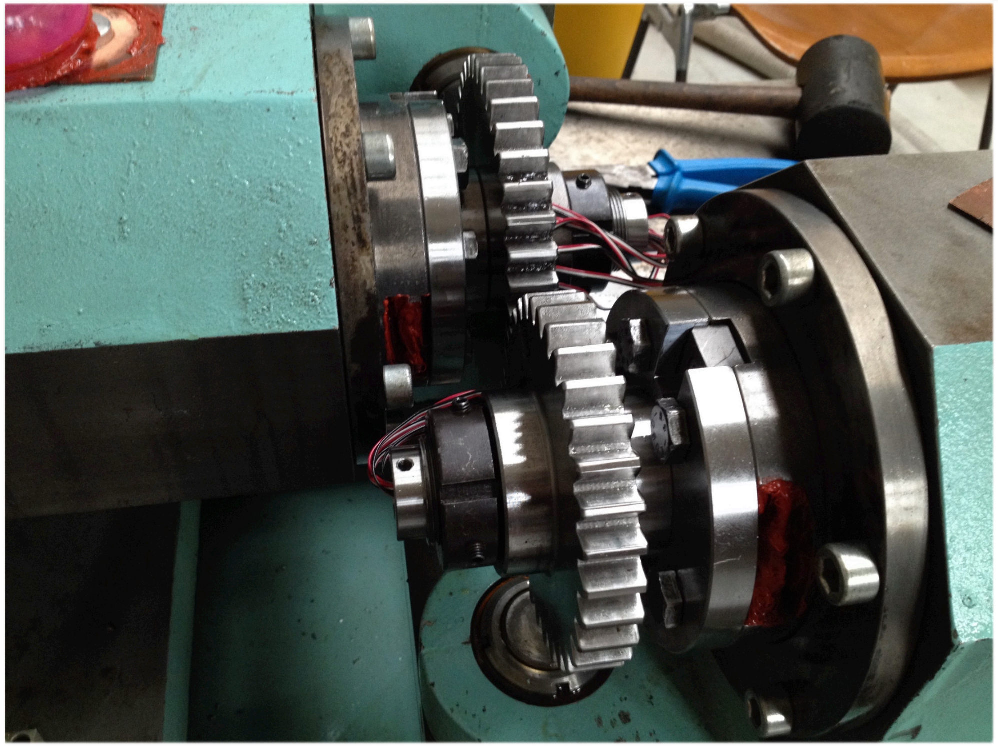


OBJECTIVES

- Developing a **software for analysis and optimization** of gearboxes starting from design parameters and **material properties**
- Developing a **test rig** for experimental validation of models, and for assessment of optimal gear design solutions

ACTIVITIES

- Modelling static and dynamic behavior of gearboxes taking into account for new materials and coatings
- Validations by experiments (with accelerometers / strain gauges)
- The new test rig will be highly flexible / reconfigurable for:
  - model validation;
  - checking the effectiveness of new solutions (e.g. new materials/coatings/treatments OR3);
  - testing for industrial partners (service)

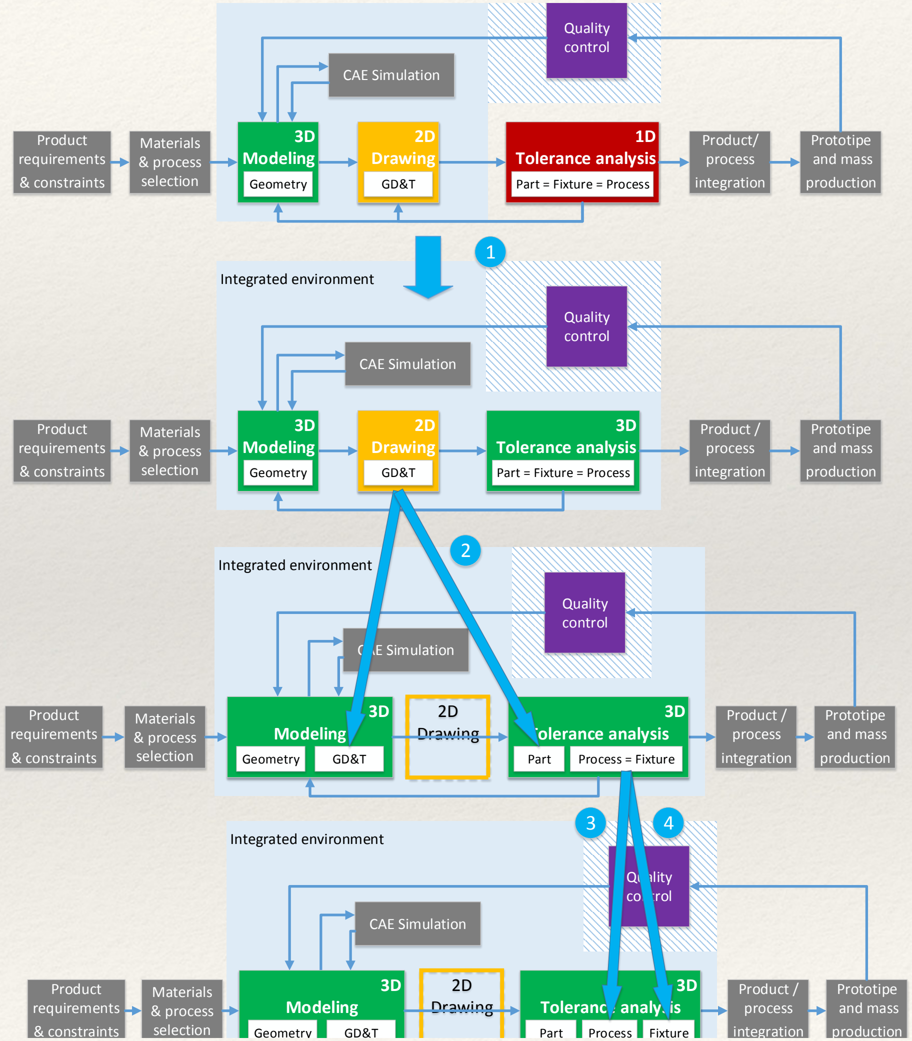


OR1 - Gear design, simulation and testing

Prof. Francesco Leali

OBJECTIVES

- Integrated method to consider geometrical product specification in a 3D environment.
- Dimensioning and tolerancing method directly applied to 3D CAD models
- Description of a FE based simulation method for machining
- Innovative design method for fixture systems



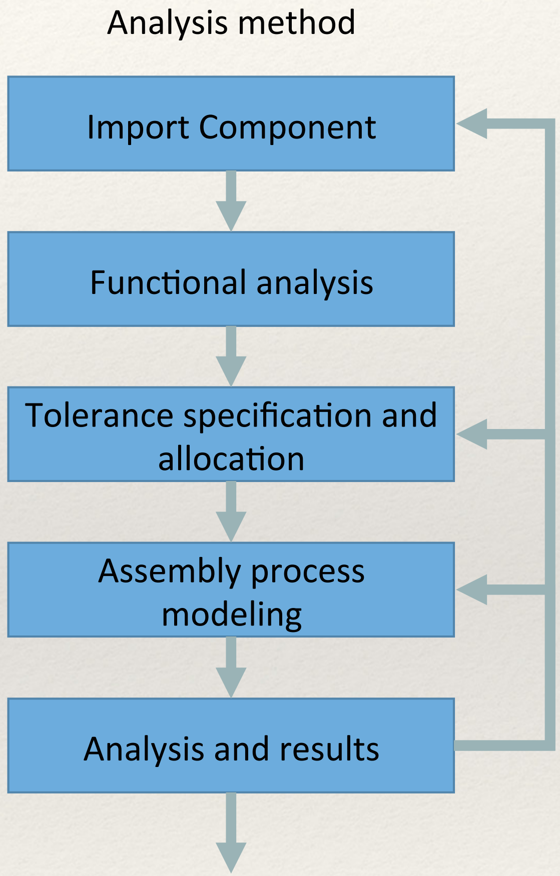
Actions

1	Analysis method
2	Part
3	Assembly process
4	Fixture system

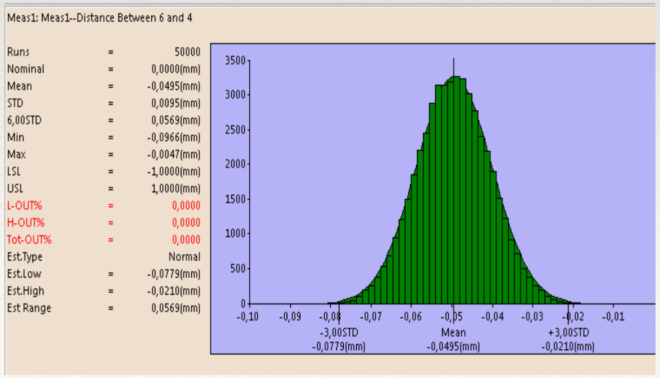
OR1 - Gear design, simulation and testing

Prof. Francesco Leali

- Tridimensional approach – Variational model
- Monte Carlo Analysis method
- Integrated on the design environment
- Implemented in the early design phases
- Identification of the contributors
- Simulation of assembly process point-based
- Fixture system modeling



	Dettaglio catena tolleranze	Tol.	Range	Range2	Distr.	G	U	Note
T1	Tolleranza attrezzatura (maschera elemento)	+ 0,10 / - 0,10	0,20	0,04	G	0,04		
T2	Tolleranza posizione + ripetibilità attrezzatura	+ 0,20 / - 0,20	0,40	0,16	G	0,16		
T3	Tolleranza tassello fisso su elemento	+ 0,20 / - 0,20	0,40	0,16	G	0,16		
T4	Tolleranza tassello mobile su elemento	+ 0,35 / - 0,35	0,70	0,49	G	0,49		
T5	Tolleranza Gioco perno-foro rif. (da STD 0,13)	+ 0,15 / - 0,15	0,30	0,09	G	0,09		
T6	Tolleranza SLD (Punti)	+ 0,20 / - 0,20	0,40	0,16	G	0,16		
T7	Tolleranza di SLD (MIG)	+ 0,40 / - 0,40	0,8	0,64	G	0,64		
T8	Tolleranza di Chiodatura	+ 0,30 / - 0,30	0,6	0,36	G	0,36		
T9	Tolleranze di Stampaggio	+ 0,50 / - 0,50	1,0	1,00	G	1,00		
T10	Tolleranza Attrezzatura (perno mobile MP telaio)	+ 0,30 / - 0,30	0,6	0,36	G	0,36		Per Pallet Mobili
T11	Tolleranza Attrezzatura (perno fisso MP telaio)	+ 0,15 / - 0,15	0,3	0,09	G	0,09		Per Pallet Fissi
T12	Tolleranza Perno-Foro MP Telaio	+ 0,20 / - 0,20	0,4	0,16	G	0,16		FORO Lavorato di macchina H7
T13	Tolleranza forature di macchina post-welding telaio	+ 0,75 / - 0,75	1,5	2,25	G	2,25		Viene dichiarato anche toll. ±0,3
T14	Svergolatura su Profilo Estruso (mm/M per largh. 50mm)	+ 1,50 / - 1,50	3,0	9,00	G	9,00		Tab. UNI EN755/9
T15	Tolleranza Cancavità e Convessità (sp. ≤5mm Largh. Fino a 60mm)	+ 0,40 / - 0,40	0,8	0,64	G	0,64		Tab. UNI EN755/9
	QUADRATIC EQUATION		15,60					
	RANGE		3,95					
		+ 1,97						
		- 1,97						

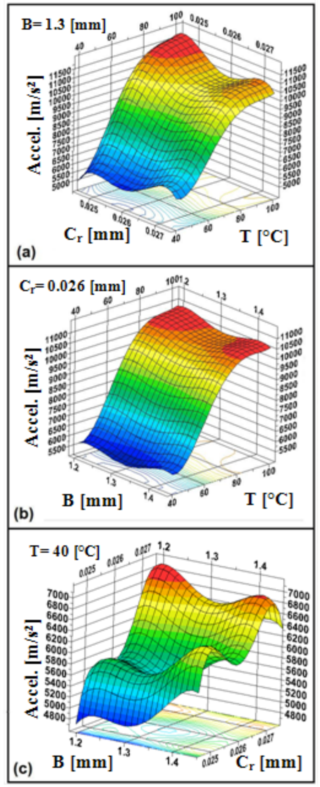


OR2 - NVH optimization of gearboxes

Prof. Giorgio Dal Piaz

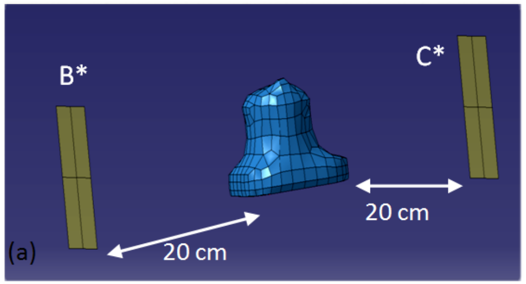
OBJECTIVES

- Developing a software instrument for **optimizing NVH** (Noise Vibration and Harshness) behavior of gearboxes
- Useful framework for gear design
- Developing a **suite of virtual instruments** to assess vibration and noise level in operating conditions
- Integration of models:
  - Lumped parameters LP
  - Finite elements FE
  - Boundary elements BE
- **Psycho-acoustic** models and **sound quality** measurements
- Statistical **modelling of tolerances** and their effect on vibration and noise



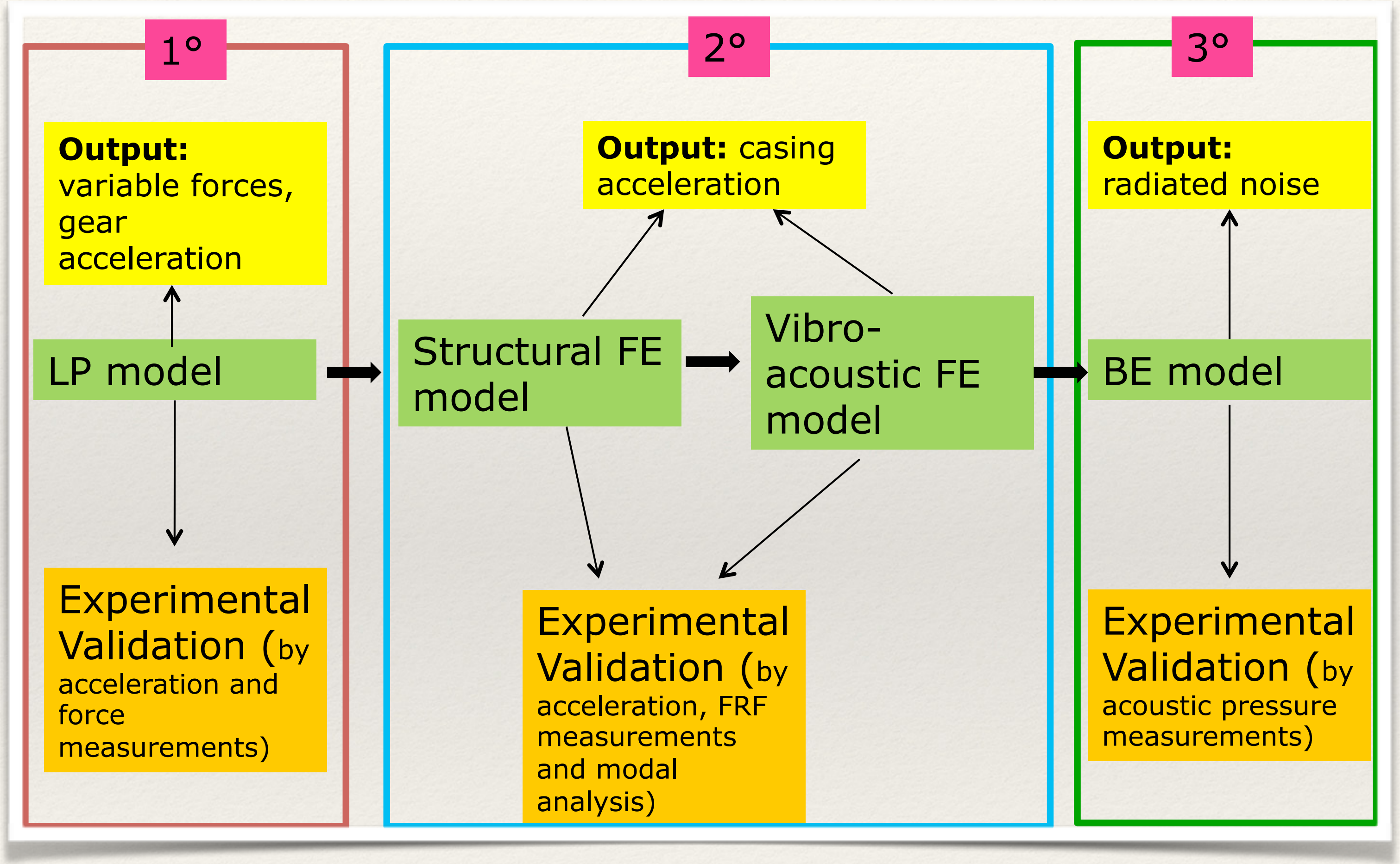
EXPECTED RESULTS

- Tolerance estimate
- Reduced time to market
- Lower vibration and better sound quality



OR2 - NVH optimization of gearboxes

Prof. Giorgio Dal Piaz

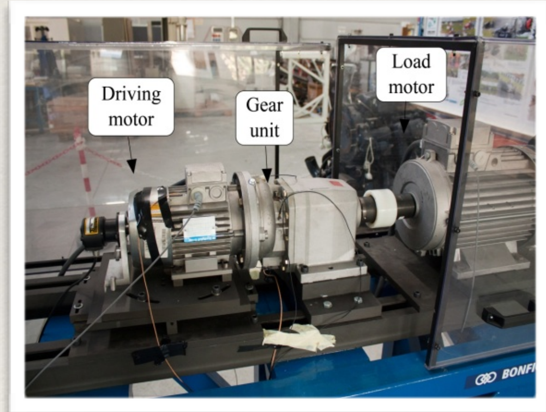


OR2 - NVH optimization of gearboxes

Prof. Giorgio Dal Piaz

FACILITIES

- Anechoic and hemi-anechoic chamber (50 Hz cut-off frequency)
- Complete instrumentation for acoustic and vibration measurements and modal analysis
- Test bench for rotating components (gears, bearings, joints)
- 3-Axis Electro-Dynamic Vibration System
- Contactless sensors: Laser Doppler vibrometers, Microflown
- Software MB, FEM, BEM, psycoacoustic for simulation and optimization

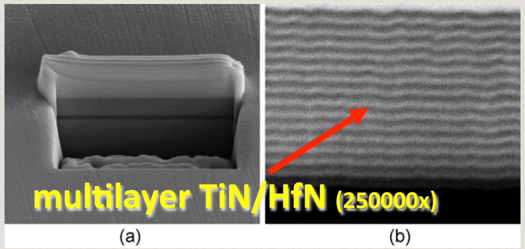


OR3 - Surface coatings and treatments for gears

Prof. Tiziano Manfredini

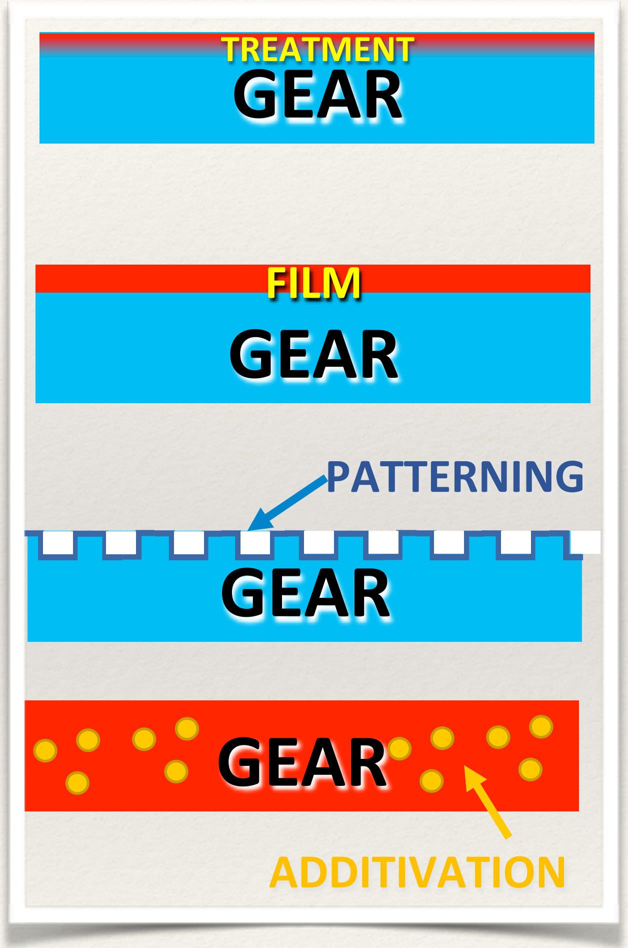
OBJECTIVES

- Developing/**optimizing thermochemical treatments and tempering** for optimal tribological performance
- Developing/optimizing Physical Vapor Deposition (**PVD**) and **Plasma Enhanced CVD films** to increase wear resistance and to reduce friction



binary or ternary nitrides PVD coatings
wear ⬇⬇

- **Surface patterning** to enhance tribological behavior
- Developing **polymeric reinforced materials** for optimal tribo-mechanical performance

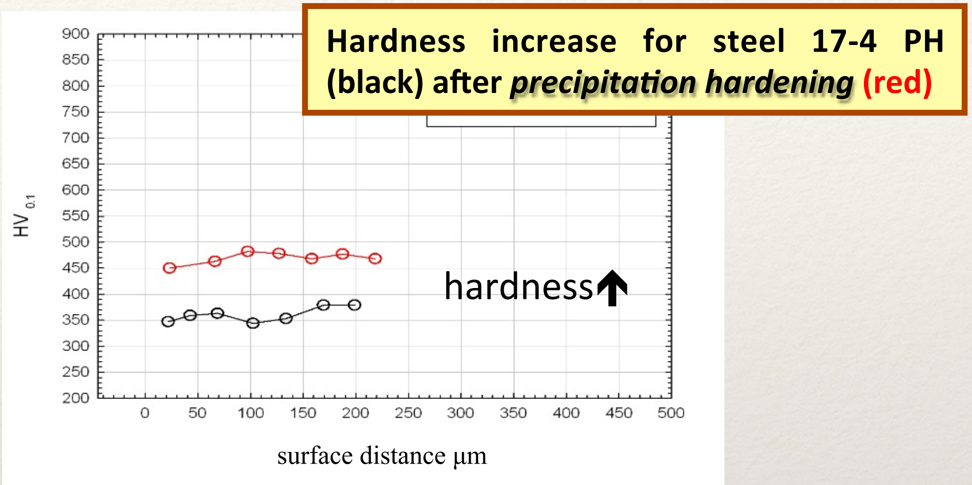


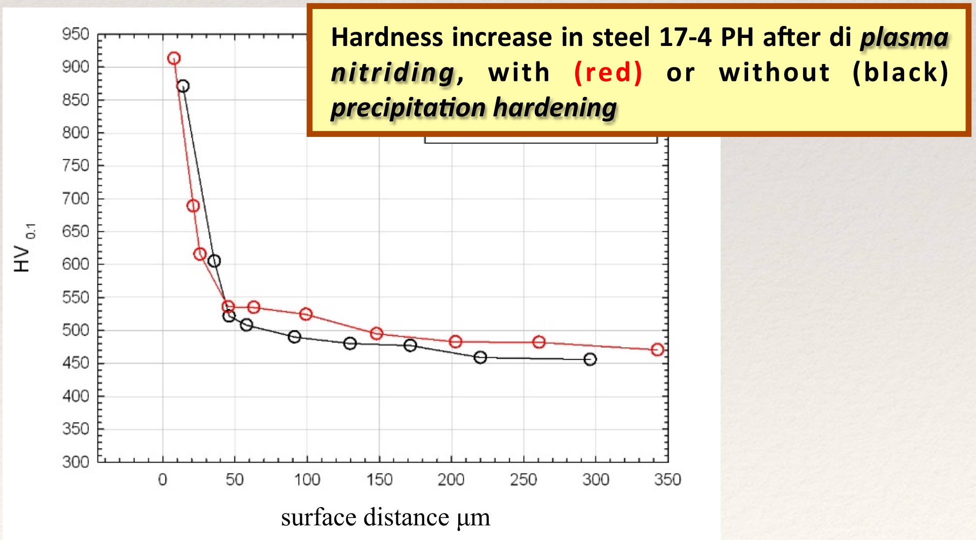
OR3 - Surface coatings and treatments for gears

Prof. Tiziano Manfredini

ACTIVITIES

- Use of special steel "**precipitation hardening**" for gears: inox steel reinforced by means of precipitation hardening
- **Unconventional nitriding/carburizing/ tempering** to increase surface hardness (without reducing oxidation protection)
- **Micro/nano reinforced polymers** for reducing mass, costs and vibrations





10%
Portland cement
(low cost reinforced
polymeric material)

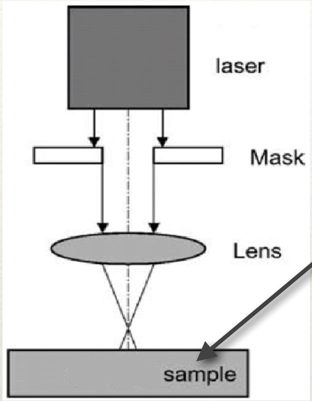
J Polym Eng 2014;
34(8): 775–786

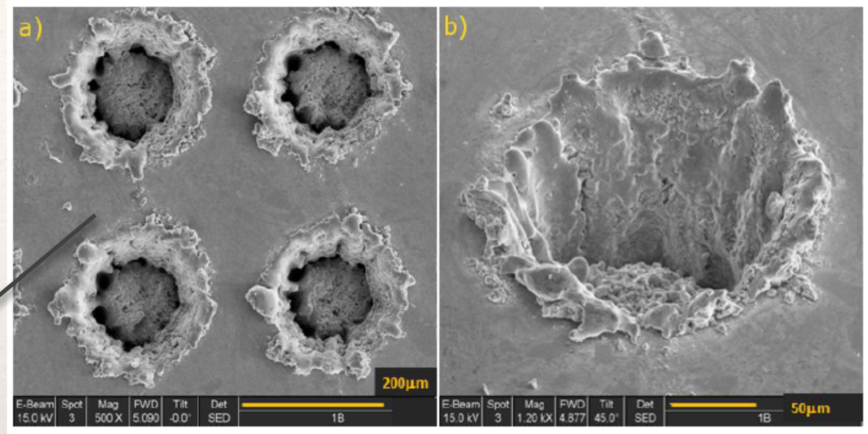
OR3 - Surface coatings and treatments for gears

Prof. Sergio Valeri

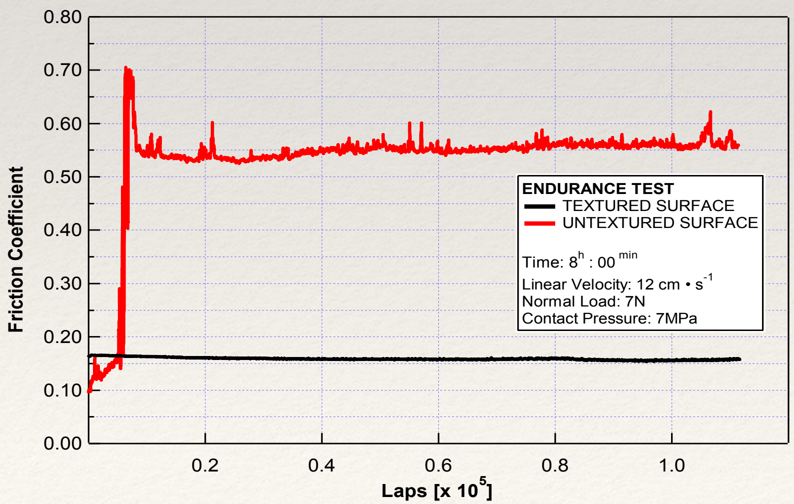
ACTIVITIES

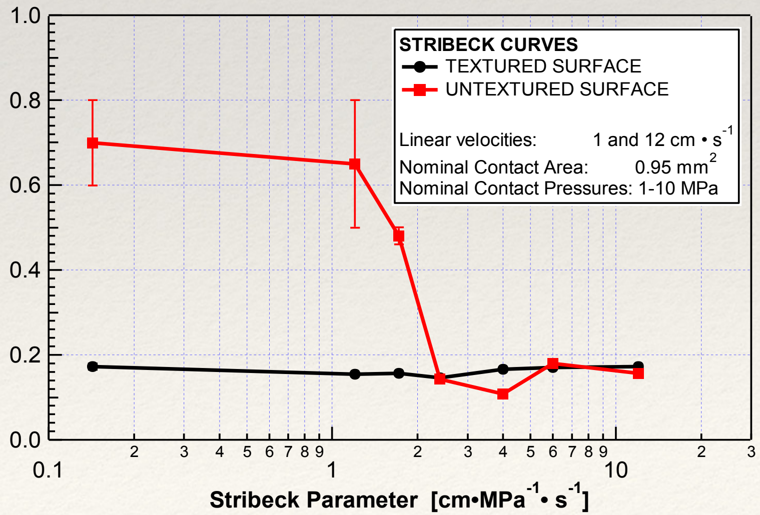
- Surface patterning reduces the coefficient of friction 4 times when lubricant is present
- Friction coefficient is low even for low values of the Stribeck parameter





Laser patterning





OR4 - Reconfigurable Manufacturing Systems for gearboxes

Prof. Marcello Pellicciari

CHALLENGE

- Gearboxes demand for careful and precise assembly; assembly should be automated to ensure optimal process control and efficiency

OBJECTIVES

- **Automated assembly** of gearboxes by means of force feedback
- Optimal process precision and quality (**customized** and flexible)

PARTNERS

- Intermech Mo.Re.
- SIR S.p.A.
- Bonfiglioli S.p.A.

OR4 - Reconfigurable Manufacturing Systems for gearboxes

Prof. Marcello Pellicciari

ACTIVITIES

- “**Zero-defect**” automatic assembly by force feedback
- New generation of **robotic cells**, scalable and reconfigurable
- “**One-piece-flow**” production in a large product mix
- Process analysis and data management to monitor production quality (**smart factory**)

Modena, March 8th 2016, The Gear Day

MetAGEAR

Integrated framework for industrial gearbox design & manufacturing

A project within POR-FESR 2014-20