IZADI-NANO2INDUSTRY

Nanostructured powders for metallic cermet coatings and thermal spray technology for solid state deposition

Speakers

- Maria Parco, TECNALIA
- Riccardo Borghini, Bonfiglioli Riduttori

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"Nanotechnology based solutions for enhanced products and processes in existing industrial manufacturing plants" Workshop

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Horizon 2020

TRIBONANO Pilot

Main features

Technology	Requirements	Sector	IZADI-NANO2INDUSTRY			
			Component	Pilot (TRL7)	Early Adopter	Place
Nano-structured coatings (based on nanostructured powders)	Wear resistance	Construction Agricultural machinery	Valve plate of hydraulic motor	TRIBOnano (Coating by solid state deposition)	Bonfiglioli Riduttori	Emilia-Romagna Region (IT) Basque Region (ES)

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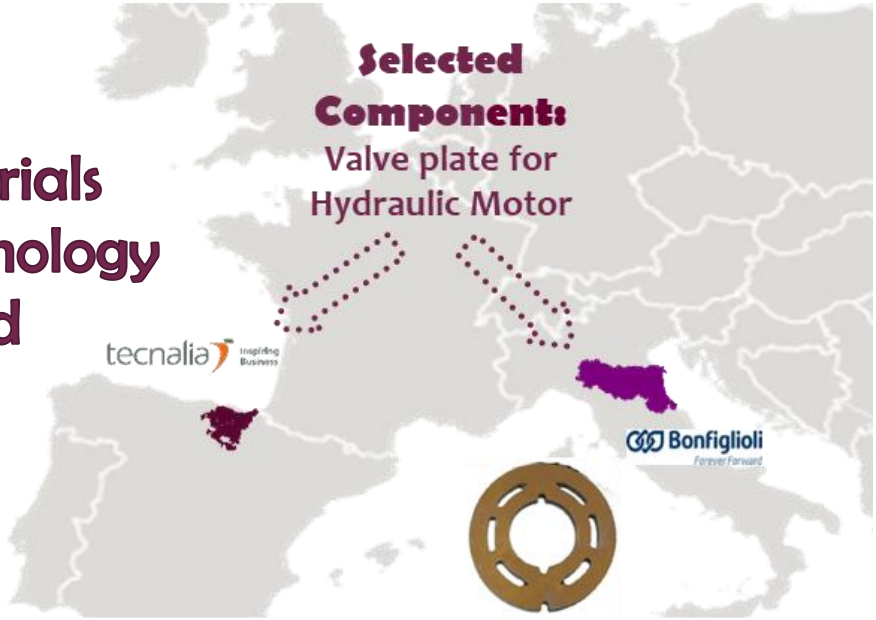
TRIBONANO Pilot

Nanocermet micropowder materials and innovative spray coating technology for metal parts with improved wear resistance



Nanostructured Powders Producer

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Technology Provider

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Early Adopter

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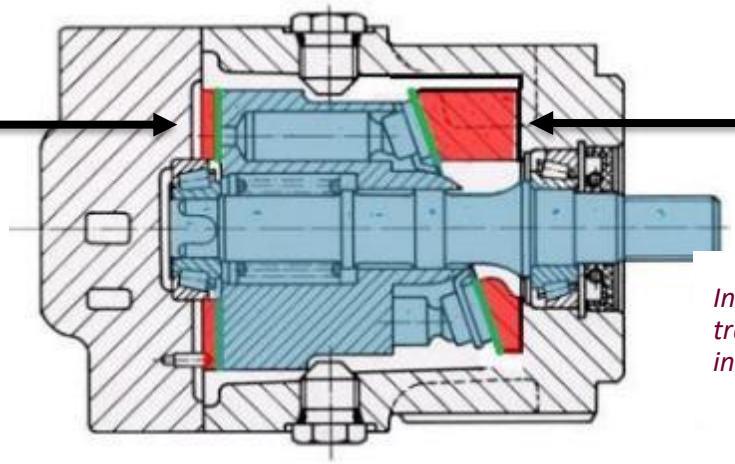
Bonfiglioli as IZADI-NANO2INDUSTRY end-user

In IZADI-NANO2INDUSTRY project we have included **two parts** of our hydraulic motors, which are installed in construction machinery. These two parts are a **valve plate** and a **swash plate**.

Construction machinery
Compact Track Loader

Track Drive
Hydraulic Motorgearbox

Hydraulic Motor



Valve Plate
In a hydraulic motor the valve plate acts as a fix bearing surface.
The rotating kit slides upon it and seals against it

Swash Plate
In a hydraulic motor the swash plate translates the linear motion of the pistons into rotary motion of the rotating kit.

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Valve plate

Main features

Market needs: improved **DURABILITY** and increased **EFFICIENCY**

Some samples with excessive wear

It's possible to find on the market valve plate for hydraulic motors completely made in **steel** (hardened or nitride and so not suitable for high speed because their high friction), or completely in **copper alloy** (expensive and not suitable for very high load) or, as Bonfiglioli always used to have a good compromise, a **bimetal component.**

Iron or a high-strength iron material is generally used as the base metal with a thin layer of bronze on the sliding face.

STANDARD VALVE PLATE DATA

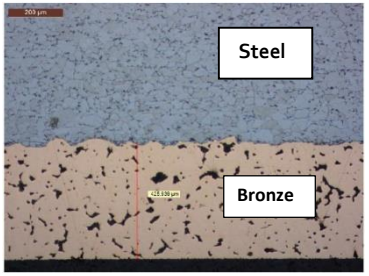
CIL. MAX (44.9 cc)

Mech. Eff. (%)	500 rpm	1000 rpm	1500 rpm	2000 rpm
50 bar	76,7	71,7	69,2	64,4
100 bar	87,7	85,8	84,1	82,7
150 bar	91,1	90,4	89,4	88,0
200 bar	92,5	92,5	91,4	90,7
250 bar	93,2	93,4	93,0	92,1
300 bar	93,6	93,6	93,4	92,7
350 bar	94,2	93,9	94,0	93,5

CIL. MIN (26.9 cc)

Mech. Eff. (%)	500 rpm	1000 rpm	1500 rpm	2000 rpm	2500 rpm	3000 rpm	3500 rpm
50 bar	68,3	63,5	57,4	54,9	47,6	44,8	–
100 bar	85,8	82,1	78,2	78,4	75,6	73,7	–
150 bar	91,0	88,5	87,2	85,7	85,1	82,1	–
200 bar	93,0	91,1	89,8	89,0	87,5	85,7	–
250 bar	93,9	92,8	91,5	90,5	89,5	87,9	–
300 bar	94,5	93,8	93,2	92,0	91,1	90,8	–
350 bar	–	–	–	–	–	–	–

Foto/Photo n°2 100x Nital 3%



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Coating Development – TRIBOnano Pilot

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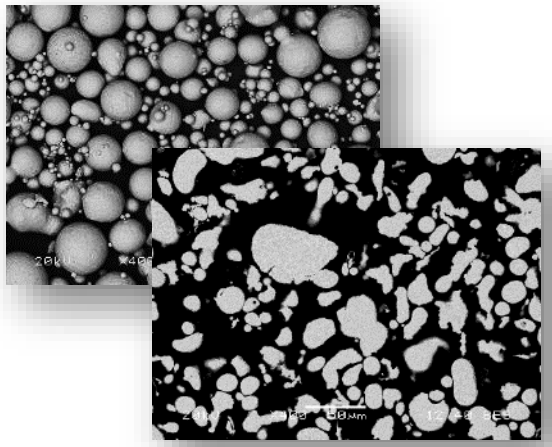
Nanocermet Micropowder Materials

Main features

- First development stage:

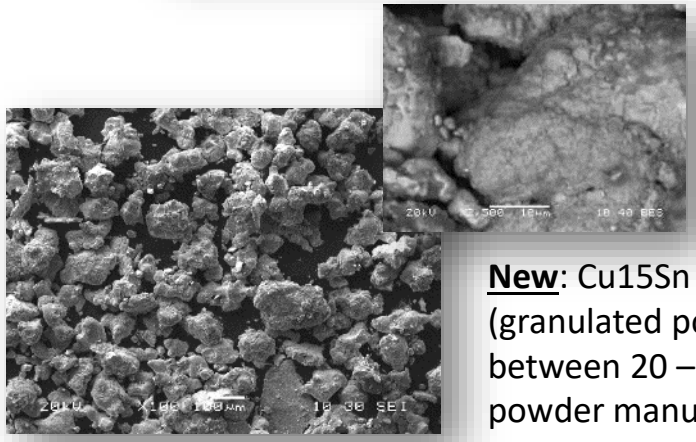
  As a first approach to coating development, bronze powders out of the compositions Cu10Sn and Cu15Sn have been implemented.

- New nano-reinforced powders:
  - Cu15Sn matrix with nano-dispersion of TiC.
  - Feedstock material is shaped in form of irregular microgranules suitable for thermal spray deposition.



Reference materials:

Cu10Sn and Cu15Sn, With particle size distribution -45+15 µm, gas atomised



New: Cu15Sn – 5wt%nanoTiC, (granulated powder with PSD between 20 – 90 µm, experimental powder manufactured by MARION)

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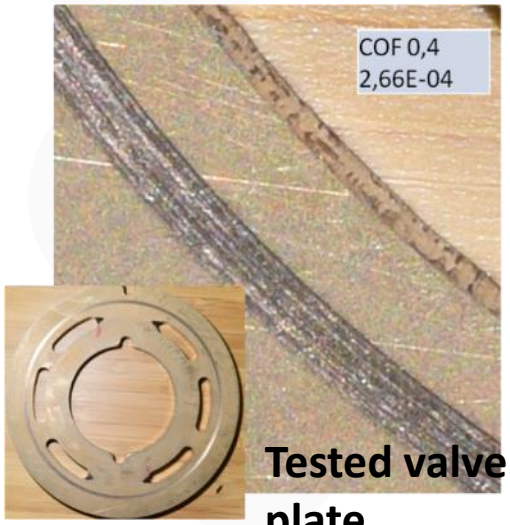
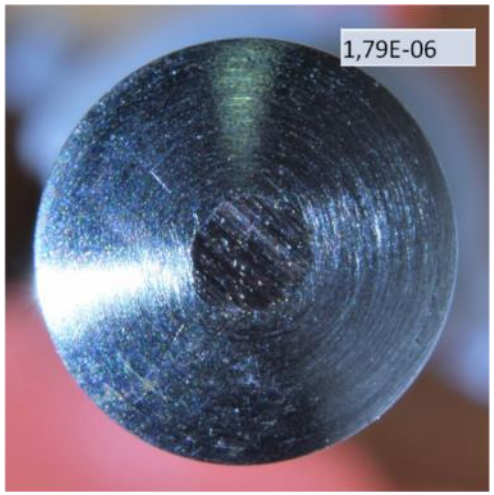
Nanocermet Micropowder Materials

Comparative advantages

Sintered bronze from standard "plate-valve" from Bonfiglioli ***CURRENTPLATE***



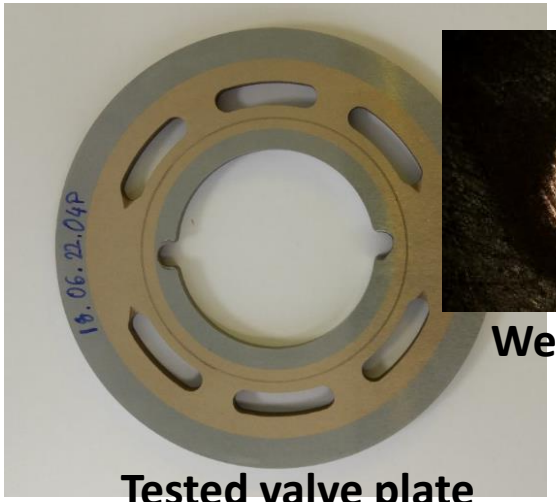
Tested valve plate



Wear on the pin

Friction, **COF**	**0,4**
Wear of the disc	**26,6E-05 mm³/Nm**
Wear of the pin	**K=17,9E-07 mm³/Nm**

Cu15Sn + 5% nanoTiC APS - *Pins on cast iron (from the hydraulic motor body)*



Tested valve plate

Wear on the pin

Friction coefficient, CoF	**0,13**
Wear of the disc	**Non measurable**
Wear of the pin	**K=4,41E-08 mm³/Nm**

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Qualitative comparison at lab. scale

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HVOAF Thermal Spray Technology

Main features

High velocity combustion spraying with controlled temperature (HVOAF process)

- The system is operated with mixtures of natural gas, compressed air and oxygen.
- Low process temperatures, covering the gap between conventional High Velocity Oxy-Fuel (HVOF) and Cold Spraying:

  → **Warm spray concept!**
- Solid/semi-solid state deposition of materials, achieving highly dense and high quality metal and cermet type coatings.

All core components of the pilot plant developed by TECNALIA (TRL7)

Own control software

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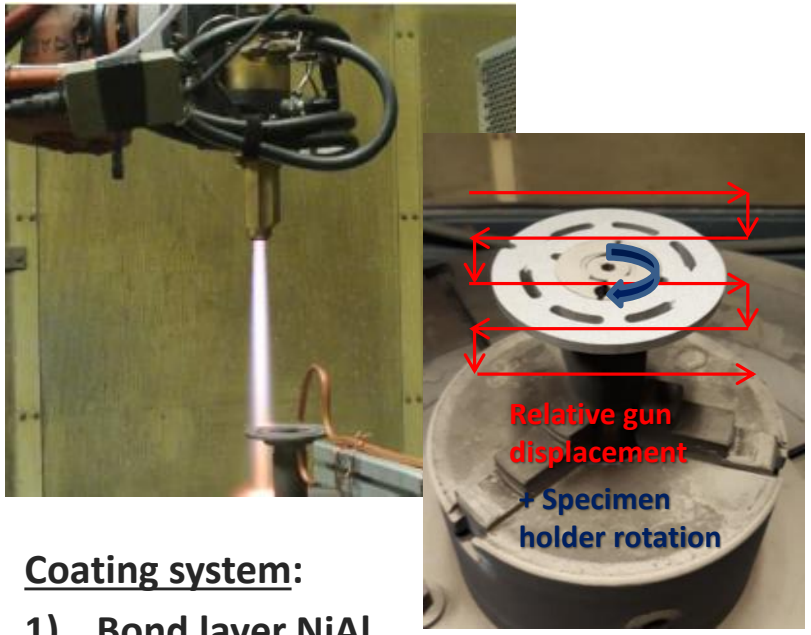
HVOAF Thermal Spray Technology

Comparative advantages

- Spray of thermally sensitive materials (eg. Nano-reinforced materials).
- Limited oxidation of the feedstock material and interaction with environment.
- High process stability and reproducibility.
- Low process costs (fuel: natural gas).
- Dense, hard, cold worked microstructure.
- Reduced thermal heating and residual stresses in the valve plate.
- High process flexibility (processing of metal and cermet type materials).

Valve coating application in two steps..



Coating system:

1) **Bond layer NiAl**
2) **Top functional layer (CuSn-TiC)**

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Nano-improved Coated Parts for Construction and Agricultural Machinery – Valve Plate of the Hydraulic Motor

Main features

- Valve manufacturing process can fully automated: Valve plate machining Degreasing → grit blasting → Fixing in holder → Coating deposition → Final lapping step.
- No distortions and/or detrimental effects induced on the valve plate!
- Cost competitive solution: 17,72 €/part

Optimized valve design to integrate the coating

As-sprayed coating

After finishing (Ra < 0.4 µm)

- Reduction in material consumption in comparison to current manufacturing procedure: approx. 78% less tribomaterial on the plate valve.

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Performance validation - TRIBOnano

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Valve Plate of the Hydraulic Motor

Comparative Advantages

1) Result achieved: Increase of the **mechanical efficiency** of the motor

Increase of MECH.EFF. with IZADI PLATE (motor at max displacement)

Mech. Eff. (%)	500 rpm	1000 rpm	1500 rpm	2000 rpm
50 bar	6,5	7,6	6,3	5,4
100 bar	2,9	3,4	3,3	2,2
150 bar	2,3	2,2	1,7	1,2
200 bar	2,0	2,3	2,8	2,3
250 bar	1,3	1,4	1,3	1,0
300 bar	1,2	1,3	1,3	1,0
350 bar	1,1	1,1	0,7	0,7

Increase of MECH.EFF. with IZADI PLATE (motor at min displacement)

Mech. Eff. (%)	500 rpm	1000 rpm	1500 rpm	2000 rpm	2500 rpm	3000 rpm
50 bar	12,8	11,6	11,3	9,4	14,0	10,0
100 bar	5,2	5,9	7,2	4,7	5,2	2,9
150 bar	2,9	3,0	3,6	2,8	2,4	3,6
200 bar	1,8	1,8	1,9	2,2	1,5	2,0
250 bar	1,1	1,1	2,0	1,8	1,4	1,6
300 bar	0,8	0,8	0,1	0,9	1,2	0,5
350 bar	--	--	--	--	--	--

Mechanical efficiency:

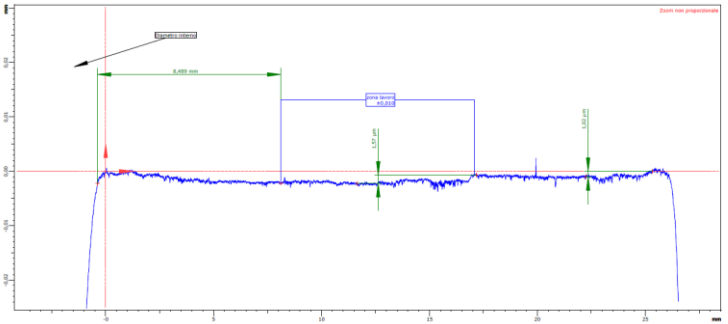
Max. increase at max displ. 7,6%

Max. increase at min displ. 12,8%

Considering the standard working points (circled above in red) the efficiency increase is around 3%.

2) Result achieved: Improve of **durability** (anti-wear properties)

Max. wear depth on sliding surface: 0,0015 mm



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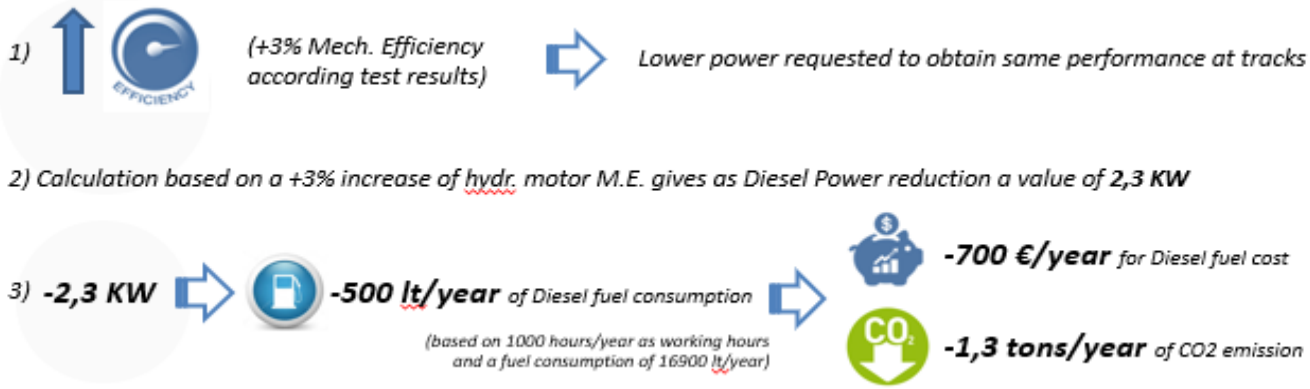
Valve Plate of the Hydraulic Motor

Exploitation Routes

Producing a valve plate with the innovative technology of TRIBONANO pilots, will allow us to propose to the market an hydraulic motor with **increased mechanical efficiency** and **improved durability.**

These benefit are really appreciated by our target customer, because:

- the increase of mechanical efficiency can be converted in a **reduction of fuel consumption**



- the increase of durability means a **lower maintenance cost**

The **industrial cost** of the IZADI valve plate is comparable with the current valve plate

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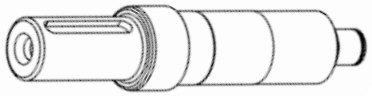
Valve Plate of the Hydraulic Motor

Exploitation out of IZADI-NANO2INDUSTRY

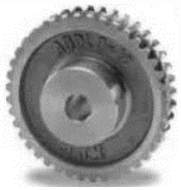
TRIBONANO pilot technology can be applied on **several other components** that need the same improvement in term of **durability** and that now are thermal treated or coated in a more expensive way (as the chromium plating)

- Valve plates
  (for different sizes of hydraulic motors – downscale and upscale)

- Rotating shaft
  (where induction hardening is used to solve wear problem)



- Worm gear
  (currently steel with carburizing-hardening-tempering & shot peening)



- Plain bearing

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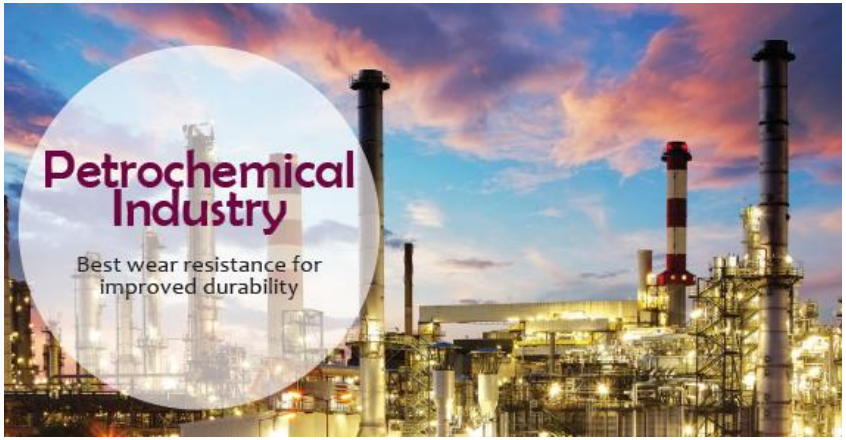
Nano-improved Coated Parts for Other Market Sectors and Customer Segments

Exploitation out of IZADI-NANO2INDUSTRY



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