Technology Transfer: paving the way for advanced manufacturing

DYNXPERTS: Orientation to results & Technology Transfer

Dr. Juanan Arrieta
International R&D Projects Director
jarrieta@ideko.es

February 2015
**IK4-IDEKO**: private and independent RTO, skilled in advanced manufacturing & industrial production technologies

IDEKO-IK4 is a Technological Centre specialising in Manufacturing Technologies whose mission is to carry out research in order to provide innovative technologies that translate into competitive advantages for its customers.
Our industrial & corporate face…

… and our scientific & technological face

FINANCE Area

Machine Tools

INDUSTRIAL Area

Industrial Automation

Automotive

Automotive Chassis & Power Train

Components

Construction

Vertical Transport

Equipment

Household

Engineering & Services

Industrial Systems

RETAIL Area

KNOWLEDGE Area

DANOBAT GROUP

Effective MACHINES and efficient SOLUTIONS for component machining

Presentation of my organization (ii)
Plug and Produce Components for Optimum Dynamic Performance Manufacturing

• Topic/Grant number: NMP2-SL-2010-260073
• Project start: July 2010
• Project end: June 2013
• Project coordinator: Dr. Jokin Muñoa (IK4-IDEKO)
• Program Officer (PO): Dr. Ir. Jan Ramboer
• Project Technical Advisor (PTA): Alberto Bellé
Type of consortia/Cooperation approach

Balanced partnership & complementary roles:
- 12 partners & 5 involved countries
- 2 universities
- 3 research agents
- 7 industrial players (5 technology providers, 2 machine-builders)
- Value chain well reflected

European dimension of DYNXPERTS consortium. Industry and SME companies are shown in red colour. Research and academic institutions in blue.
Objective:
To develop a series of portable plug&produce components to improve the overall productivity and process quality of production lines.
## Engagement with project impact & TT among industrial players

<table>
<thead>
<tr>
<th>Plug &amp; Produce Components</th>
<th>Key Technology</th>
<th>Impact</th>
<th>Planned</th>
<th>Achieved</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>5F Active Heavy Duty Spindle</strong></td>
<td>Electromagnetic Inertial actuator</td>
<td>Increase of material removal rate</td>
<td>&gt;300%</td>
<td>200-420%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Improvement of dynamic stiffness</td>
<td>&gt;20%</td>
<td>&gt;150%</td>
</tr>
<tr>
<td><strong>5F Active HSM Spindle</strong></td>
<td>Magnetic bearings</td>
<td>Increase life of spindles</td>
<td>TBD</td>
<td>TBD</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Improvement of damping</td>
<td>40%</td>
<td>40%</td>
</tr>
<tr>
<td><strong>Adaptive Clamping Systems</strong></td>
<td>Magnetorheological materials</td>
<td>Increase of material removal rate</td>
<td>TBD</td>
<td>220%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Improvement of damping</td>
<td>20-80%</td>
<td>100%</td>
</tr>
<tr>
<td><strong>Adaptive solutions for chatter free machining</strong></td>
<td>Piezoelectric and magnetic actuators</td>
<td>Increase of material removal rate</td>
<td>&gt;100%</td>
<td>60%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Surface roughness improvement</td>
<td>10-30%</td>
<td>25%</td>
</tr>
<tr>
<td><strong>Wireless Vibration Monitoring</strong></td>
<td>Wireless communication Magnetic Harvesters</td>
<td>Wireless Sensors</td>
<td>100%</td>
<td>60%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Magnetic Energy Harvesting</td>
<td>100%</td>
<td>75%</td>
</tr>
</tbody>
</table>
Exploitation

DYNXPERTS is very committed with dissemination & exploitation activities (i)

Exploitation:
• ESS Seminar
• Exploitation Plan (25 Exploitable ideas)
• Business Model

Patents & Products:
• 2 patents submitted (more info below).
• 1 patent under study.
• 2 Products already in the market.
• 2 beta users testing results of the project.

Patents (2)
"Inertia damper for suppressing vibrations in machine tool", European Patent 12380046.8 (submitted)
The present invention relates to suppressing or attenuating the vibrations produced in machine tools during machining processes, such as for example turning, milling, boring or grinding, a tuneable inertia damper which is coupled to the machine tool for modifying the dynamics of one of its specific vibration modes being proposed to that end. IK4-Ideko has submitted this European patent proposal to the Spanish Patent Office on 13 September 2012.

"Antichatter Spindle Head", Spanish Patent P201330810 (submitted)
The present invention proposes a new spindle head with an integrated inertial actuator and accelerometer. The vibrations produced in machine tools during machining processes can be damped using an active damping strategy. SORALUCE has submitted this patent proposal to the Spanish Patent Office on 3 June 2013.

<table>
<thead>
<tr>
<th>Machine Tool Components</th>
<th>Vendor</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active Heavy Duty Spindle</td>
<td>SORALUCE</td>
<td>Patent</td>
</tr>
<tr>
<td>Active High Speed Spindle</td>
<td>GOIALDE HIGH SPEED</td>
<td>Prototype</td>
</tr>
<tr>
<td>Self-Tuning Damper</td>
<td>SORALUCE</td>
<td>Patent</td>
</tr>
<tr>
<td>Adaptive fixture</td>
<td>Matzat</td>
<td>Prototype</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Software Product</th>
<th>Vendor</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active Damping Function</td>
<td>SORALUCE</td>
<td>Beta User</td>
</tr>
<tr>
<td>MUTE II Anti chatter System</td>
<td>SORALUCE</td>
<td>Beta User</td>
</tr>
<tr>
<td>Wireless Monitoring System</td>
<td>GOIALDE HIGH SPEED</td>
<td>Prototype</td>
</tr>
<tr>
<td>Chatter Prediction Function</td>
<td>FIDIA</td>
<td>Prototype</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sensor /Actuator Product</th>
<th>Vendor</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Force MICA Actuator</td>
<td>CEDRAT</td>
<td>Catalogue</td>
</tr>
<tr>
<td>Dynamic Calibrator</td>
<td>planlauf</td>
<td>Prototype</td>
</tr>
<tr>
<td>UC65 Digital Controller</td>
<td>CEDRAT</td>
<td>Catalogue</td>
</tr>
<tr>
<td>Energy Harvester</td>
<td>CEDRAT</td>
<td>Prototype</td>
</tr>
</tbody>
</table>
DYNXPERTS is very committed with dissemination & exploitation activities (ii)

Dissemination

General Dissemination:
• Webpage: www.dynxperts.eu.
• Youtube channel: www.youtube.com/user/dynxperts

Publications:
• 1 book published (Springer).
• 11 Publications on scientific journals
• 6 Publications in industrial journals

Conferences:
• Participation in 17 conferences.

Industrial Dissemination:
• 10 presence at fairtrades, exhibitions & workshops.
• 6 industrial newsletters

EFFRA Innovation Portal
• Detailed technical information
• 12 key project results
• 9 demonstrators
EFFRA Innovation Portal:
More efficient diss&expl, higher impact!!
EFFRA Innovation Portal

Addressed fields for each project

Collecting from each project:
- The addressed challenges (cfr. FoF 2020 roadmap)
- The addressed technologies (cfr. FoF 2020 roadmap)
- For each exploitable result and demonstrator:
  - The application area, for example automotive, aerospace, food industry, textile industry, etc (using the NACE code structure)
  - An indication on how close the result/demonstrator is to industrial deployment
  - The involved organisations and locations
1. **General information**: acronym, title, duration, budget/funding, nº of partners, website, description, call topic, topic title, instrument, project officer.

2. **12 key project results** (further details and contact person for each result)

3. **9 project demonstrators** (further details and contact person for each demonstrator)

4. **Related challenges & technologies** (traceability according to FoF Roadmap 2020)

5. **Relevant FoF research domains & priorities** (traceability according to FoF Roadmap 2020)

6. **12 participants** (further info on other FoF for each participant)
DYNXPERTS at EFFRA Innovation Portal (i): Project search & identification at the portal

Page dimensions: 720.0x540.0

DYNXPERTS
Plug and Produce Components for Optimum Dynamic Performance Manufacturing Systems

FoF.NMP2010-1 2013-06-30 www.dynxperts.eu

Duration 36
# DYNXPERTS at EFFRA Innovation Portal (ii):
## General information

<table>
<thead>
<tr>
<th>RESEARCH &amp; INNOVATION PROJECT</th>
<th>[edit general information!]</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Acronym</strong></td>
<td>DYNXPERTS</td>
</tr>
<tr>
<td><strong>Title</strong></td>
<td>Plug and Produce Components for Optimum Dynamic Performance Manufacturing Systems</td>
</tr>
<tr>
<td><strong>Registration code</strong></td>
<td>953-415762 (this code is only visible to project participants)</td>
</tr>
<tr>
<td><strong>Website</strong></td>
<td><a href="http://www.dynxperts.eu">www.dynxperts.eu</a></td>
</tr>
<tr>
<td><strong>Project duration</strong></td>
<td>36 months (2010-07-01 until 2013-06-30)</td>
</tr>
<tr>
<td><strong>Number of participants</strong></td>
<td>12 participants</td>
</tr>
<tr>
<td><strong>Total budget - EC contribution</strong></td>
<td>5,251,444 Euro - 3,449,198 Euro</td>
</tr>
<tr>
<td><strong>Description</strong></td>
<td>Current machine tools are complex mechatronic structures full of sensors and drives where control laws are implemented. However, in these systems, the measurement and action points are usually far from the cutting zone and frequently the actuation bandwidth is not wide enough to avoid self-excited vibrations and assure a proper dynamic behavior. DYNXPERTS project has overcome these limitations introducing actuators and sensors as close as possible to the machining point. With this objective in mind, DYNXPERTS project has focused on the development of a new generation of plug and produce adaptive components. These components are able to improve the dynamic behavior of machine tools in several aspects and increase their productivity introducing new features in existing machines. A new concept of spindle head for heavy roughing operations: &quot;The 5F Active Inertial Spindle Head&quot;. With this head it is possible to obtain the dynamic properties of the machine in all working area, to monitor the state of the mechanical components of the head, to change the spindle speed to avoid unstable cutting conditions, to introduce active damping using an inertial drive, and improve the motion control introducing adaptation signals in the control loops. The dynamic stiffness has been increased 150% applying smart functions and the material removal rate has been quadrupled with this new spindle head. A patent has been submitted protecting the concept. An innovative spindle head for High Speed Machining: &quot;The 5F Magnetic Active Spindle Head&quot;. It makes use of magnetic bearing technology and features the aforementioned 5 functionalities of the new roughing head. In this component the actuation to calibrate the machine and to avoid self-excited vibrations have been made using the capability of the magnetic bearings to induce a force in the shaft. The damping ratio has increased more than 40% and the material removal rate has increased 8 times taking advantage of the new five functions. The spindle head has been presented in a workshop to important aerospace aluminum part manufacturers. New smart fixtures devices have been developed in the project based on an active damper and advanced damping system. This damping has been implemented with magnetorheological elastomers and damping elements which are able to adapt to the dynamics of different large and flexible work pieces. A big improvement of more than 50% has been measured in the cutting test performed by the consortium. The concept of the adaptive dampers is in pending process. A new component has been created to introduce the stability charts into the production lines in an automatic way. This device measures the critical dynamic of the tool, generating the stability charts and providing automatically the best process parameters to guarantee optimal machining and chatter free cutting conditions. The system has been able to increase the material removal rate more than three times and the surface roughness has decreased 55%. To reinforce the self-sufficiency, portability and plug and produce features the project focuses on energy harvesting devices and wireless communication bridges. The energy harvesting functionality has allowed locating numerous monitoring sensors in positions extremely close to the points where the action takes place during a machining operation: the interior of the head and the clamps of the fixture. The wireless bridge is used to transmit the information monitored by these sensors to the control units of each of the components, but also to link the new plug and produce devices to the machine’s control. A wireless monitored high speed spindle has been developed during the project.</td>
</tr>
<tr>
<td><strong>Call topic</strong></td>
<td>FP7-NMP-2010-7</td>
</tr>
<tr>
<td><strong>Call topic title</strong></td>
<td>Plug-and-Produce components for adaptive control</td>
</tr>
<tr>
<td><strong>Instrument</strong></td>
<td>Small or medium-scale focused research project</td>
</tr>
</tbody>
</table>
DYNXPERTS at EFFRA Innovation Portal (iii): Project results

PROJECT RESULTS

(Note: The information in this section is being collected. Information may therefore be incomplete.)

Machine Tool Component 1: Roughing 5F Milling Head - | Manufacturing | Manufacture of machinery and equipment n.e.c. | Manufacture of other transport equipment | Manufacture of railway system components - More...

Software Result 1: Adaptive Fixturing Device - | Manufacturing | Manufacture of railway system components | Manufacture of machinery and equipment n.e.c. | Manufacture of other transport equipment | Manufacture of railway system components - More...

Software Result 2: Adaptive System for Chatter Free High Speed Machining - | Manufacture of railway system components | Manufacture of machinery and equipment n.e.c. | Manufacture of other transport equipment | Manufacture of railway system components - More...

Sensor/Actuator/Hardware Result 1: High Force MICA Actuator - | Other services activities | Manufacturing | Manufacture of fabricated metal products, except machinery and equipment | Manufacture of motor vehicles, trailers and semi-trailers - More...

Machine Tool Component 2: 5F Magnetically Levitated High Speed Milling Head - | Manufacturing | Manufacture of railway system components - More...

Machine Tool Component 3: Magnetorheological Damper - | Manufacturing | Manufacture of railway system components | Manufacture of fabricated metal products, except machinery and equipment - More...

Machine Tool Component 4: Eddy Current Damper - | Manufacturing | Manufacture of railway system components | Manufacture of fabricated metal products, except machinery and equipment | Manufacture of other transport equipment | Manufacture of railway system components - More...

Sensor/Actuator/Hardware Result 2: UHCR5 Controller - | Manufacturing | Manufacture of railway system components | Manufacture of machinery and equipment n.e.c. - More...

Machine Tool Component 5: Adaptive Fixturing Device - | Manufacturing | Manufacture of railway system components | Manufacture of machinery and equipment n.e.c. | Manufacture of other transport equipment | Manufacture of railway system components - More...

Machine Tool Component 6: Adaptive System for Chatter Free High Speed Machining - | Manufacturing | Manufacture of railway system components | Manufacture of machinery and equipment n.e.c. | Manufacture of other transport equipment | Manufacture of railway system components - More...

Sensor/Actuator/Hardware Result 3: HPC Absolute Dynamic Calibration - | Manufacturing | Manufacture of railway system components | Manufacture of machinery and equipment n.e.c. | Manufacture of other transport equipment | Manufacture of railway system components - More...

Machine Tool Component 7: Wireless Monitored High Speed Spindle - | Manufacturing | Manufacture of railway system components | Manufacture of machinery and equipment n.e.c. | Manufacture of other transport equipment - More...
## Project Demonstrators

**Demonstrator 1: 5F Heavy Duty Spindle Head Installed In SORALUCE FL-6000 Milling Machine Machining Steel C45 Parts** - Manufacture of aero components | Manufacture of railway system components | Manufacturing | Manufacture of fabricated metal products, except machinery and equipment | Manufacture of machinery and equipment n.e.c. | Manufacture of motor vehicles, trailers and semi-trailers | Manufacture of other transport equipment | More...

**Demonstrator 2: Advance Control Loop Demonstrate** - Transporting and storage | Manufacturing | Manufacture of fabricated metal products, except machinery and equipment | Manufacture of machinery and equipment n.e.c. | Manufacture of motor vehicles, trailers and semi-trailers | Manufacture of other transport equipment | More...

**Demonstrator 3: 5F High Speed Spindle Head Installed in BUKKOR Machining Center Machining T7075-T6 Aluminium Parts** - Manufacture of railway system components | Manufacturing | Manufacture of fabricated metal products, except machinery and equipment | Manufacture of machinery and equipment n.e.c. | Manufacture of motor vehicles, trailers and semi-trailers | Manufacture of other transport equipment | Manufacture of aero components | More...

**Demonstrator 4: Magnetorheological Damper Integrated with a Swivel Type Fixturing System for Automotive Applications** - Manufacture of railway system components | Manufacturing | Manufacture of fabricated metal products, except machinery and equipment | Manufacture of machinery and equipment n.e.c. | Manufacture of motor vehicles, trailers and semi-trailers | Manufacture of other transport equipment | Manufacture of aero components | More...

**Demonstrator 5: One Station Fixture with an Integrated Self-Tailing Eddy-Current Damper Installed in SORALUCE SV/6000 Milling Machine Machining Steel C45 Parts** - Manufacture of railway system components | Manufacturing | Manufacture of machinery and equipment n.e.c. | Manufacture of motor vehicles, trailers and semi-trailers | Manufacture of other transport equipment | Manufacture of aero components | More...

**Demonstrator 6: Adaptive Fixturing Device** - Manufacture of railway system components | Manufacturing | Manufacture of machinery and equipment n.e.c. | Manufacture of motor vehicles, trailers and semi-trailers | Manufacture of other transport equipment | Manufacture of aero components | More...

**Demonstrator 7: Adaptive Solution for Chatter Free Machining** - Manufacturing | Manufacture of machinery and equipment n.e.c. | Manufacture of motor vehicles, trailers and semi-trailers | Manufacture of other transport equipment | Manufacture of aero components | More...

**Demonstrator 8: HPC Absolute Calibrator Demonstrator** - Manufacture of aero components | Manufacture of railway system components | Manufacturing | Manufacture of fabricated metal products, except machinery and equipment | Manufacture of machinery and equipment n.e.c. | Manufacture of motor vehicles, trailers and semi-trailers | Manufacture of other transport equipment | Manufacture of aero components | More...

**Demonstrator 9: Wireless Communicated High-Speed Spindle** - Manufacturing | Manufacture of machinery and equipment n.e.c. | Manufacture of other transport equipment | Manufacture of aero components | More...
### RELATED CHALLENGES AND TECHNOLOGIES

**CHALLENGES**

1. Economic sustainability
   - 1.1. High performance production, combining flexibility, productivity, precision and zero-defect while remaining energy-efficient
      - Rating: 100/100

**TECHNOLOGIES**

1. Mechatronics for advanced manufacturing systems
   - 1.1. Control technologies
      - Rating: 100/100
   - 1.2. Cognition-based intelligent features within machinery and robots
      - Rating: 100/100
   - 1.3. Condition and performance monitoring
      - Rating: 100/100
   - 1.4. Intelligent machinery components, actuators and end-effectors
      - Rating: 100/100

### RELEVANT FACTORIES OF THE FUTURE RESEARCH DOMAINS AND PRIORITIES

**Domain 2: Adaptive and smart manufacturing systems**

1. 1. Sub-Domain 2.1 Adaptive and smart manufacturing devices, components and machines
   - 1.1.1. Embedded cognitive functions for supporting the use of machinery and robot systems in changing shop floor environments
      - Rating: 100/100
   - 1.1.2. Mechatronics and new machine architectures for high performance and resource-efficient manufacturing equipment
      - Rating: 80/100
Critical success factors:

• The project MUST address **real market needs and industrial problems** from the beginning (pathway to market)
• It MUST aim at an **“impact oriented” research** (avoid “research by research”)
• Addressing an **ambitious knowledge generation**
• **Bridging the gap** between research results and innovations to the market (death valley).
• **Developing attractive & ambitious results** both for technology providers as well as machine builders.
• **Orientation to results:**
  • Increasing product portfolio with high added-value products (technology providers)
  • Developing machine options that bring worldwide competitive advantage.
• **Involvement & proactive attitude of industrial partners & value chain** from the beginning is critical!!
• The coordinator MUST keep it always in mind, when carrying out the project management and governance!!
THANK YOU
VERY MUCH!!

Dr.-Ing. JUANAN ARRIETA
International R&D Projects Manager
IK4-IDEKO
jarrieta@ideko.es