

HIGH PRECISION MANUFACTURING

| FR003



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HIGH PRECISION MANUFACTURING

Robotics
Clean Manufacturing
Zero Defect Manufacturing
Maintenance and Support

FR003

FR001
FR002
FR004
FR005

Roadmap

This project has received funding from the European Union Horizon 2020 Programme (H2020) under grant agreement n° 637090.

HORIZON 2020



STATE OF THE ART

01

New Process Chain for Manufacturing

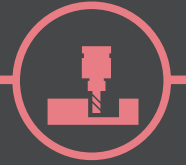
- A typical process chain is composed of: forging/casting, (rough) machining, heat treatment, grinding/hard-turning, fine finishing.
- Not only is this process chain time consuming, the high number of processes keeps production costs high and generates high levels of CO₂ emissions.



02

Precision Finishing

- Fine finishing is defined as a post-grinding/hard-turning process to enhance the surface topography and surface integrity.
- Fine finishing utilizes fixed abrasive tools, ultra-precision grinding, ELID grinding, superfinishing and honing.
- Free abrasive finishing encompasses lapping, polishing, buffing and magnetic abrasive finishing.
- Abrasive media finishing includes vibratory finishing, tumbling, burnishing, barrelling and brushing.
- Abrasive flow media finishing includes abrasive flow finishing, fluid jet finishing, etc.



03

Selective Heat Treatment

Most of the current heat treatment techniques cannot realize selective heat treatment.

1. Annealing
 - 1.1. Normalizing
 - 1.2. Stress relieving
2. Aging
3. Quenching
4. Tempering
5. Selective heat treating
 - 5.1. Differential hardening
 - 5.2. Flame hardening
 - 5.3. Induction hardening
 - 5.4. Case hardening
6. Cold and cryogenic treating
7. Decarburization



04

Low Volume/LOTSIZE 1 Manufacturing

- Mass production, with limited customization, according to the specifications of consumers.



GAP

New Process Chain for Manufacturing

- Precision finishing tools/equipment which can accomplish the manufacturing tasks, such as reach accuracy and material removal, do not exist.
- Post-process quality control is not available to realize 100% quality control/assurance.
- There is no in-process evaluation of material properties to ensure production quality and minimize defects.



Precision Finishing

- Precision finishing tools/equipment that can accomplish the tasks of two processes do not exist.
- Post-process quality control is not available to realize 100% quality control/assurance.
- There is no in-process evaluation of material properties to ensure production quality and control defects.
- It is difficult to carry out in-line validation of surface integrity because suitable technology is not currently available.
- There are currently no suitable technologies for material and workpiece handling for large components.



Selective Heat Treatment

- Most of the current heat treatment techniques, e.g. induction heating, need to be improved to be more flexible and more energy efficient.
- There is no in-process evaluation of material properties such as composition, hardness, strength, tribological properties etc.
- It is difficult to carry out in-line validation of surface integrity because of the efficiency/time limitation and the complexity of the process and lack of suitable equipment.
- Heat treatment needs to be improved to reduce finishing process efforts on machines.



Low Volume/LOTSIZE 1 Manufacturing

- Precision finishing tools/equipment which can accomplish the tasks of two processes do not exist.
- Post-process quality control is not available to realize 100% quality control/assurance.
- There is no in-process evaluation of material properties to ensure the production quality and control defects.
- It is difficult to carry out in-line validation of surface integrity due to the efficiency/time limitations, the complexity of the process and lack of suitable equipment.
- There are currently no suitable technologies for material and workpiece handling for large components.
- Currently, no suitable business model is available for LOTSIZE 1 manufacturing.



CHALLENGE TO FILL THE GAP

New Process Chain for Manufacturing

- Paradigm shift to customized/low volume (LOTSIZE 1) production.
- Machine tools are currently designed for high-volume production. However, it is difficult to develop "ideal" machine tools to meet the requirements of customized small lot production.
- Production equipment for LOTSIZE 1 production.
- CAD/CAM systems and platforms to run on the new production systems for producing customized small-lot-size products.
- Material and workpiece handling in the new process chain to enable first-time-right production, especially for large components.



Precision Finishing

- Development of precision finishing tools/equipment to accomplish the tasks of hard-turning and grinding.
- Methods and technologies to carry out post-process quality control (100% QA).
- Realization of in-process evaluation of material properties.
- Technologies for carrying out in-line validation of surface integrity.
- Novel technologies for material and workpiece handling.



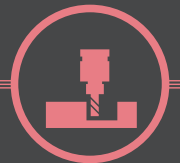
Selective Heat Treatment

- Development of suitable heat treatment techniques and equipment to carry out localized heat treatment and/or surface treatment.
- Suitable technologies (e.g. induction heating and laser hardening) need to be developed.
- In-process evaluation of material properties.
- In-process validation of surface integrity.
- On-machine selective heat treatment.



Low Volume/LOTSIZE 1 Manufacturing

- Development of precision finishing tools/equipment to accomplish the tasks of hard-turning and grinding.
- Methods and technologies to carry out post-process quality control (100% QA).
- Realization of in-process evaluation of material properties.
- Technologies for carrying out in-line validation of surface integrity.
- Novel technologies for material and workpiece handling for LOTSIZE 1 manufacturing.
- Development of new business models that enable the profitability of LOTSIZE 1 manufacturing.



RESEARCH PRIORITIES

New Process Chain for Manufacturing

- Novel precision finishing equipment to LOTSIZE 1 production, e.g. to replace hard-turning and grinding with cost reduction of 30%.



Precision Finishing

- Novel methods and technologies for high-efficiency (e.g. 5 seconds per gear for automotive industry) in-line 100% post-process quality control.
- Novel technologies for in-process evaluation of material properties (e.g. surface roughness, hardness, stress etc.).



Selective Heat Treatment

- Workpiece and material handling technology for large and high-value components in first-time-correct production.



Low Volume/LOTSIZE 1 Manufacturing

- New concepts of business model and supply chain for the LOTSIZE 1 production of high-value products.



FUTURE TRENDS

New Process Chain for Manufacturing

- Global market trends are towards environmentally friendly precision production. At the same time, the market is demanding high-value components with reduced production costs. Current process chains cannot meet these requirements.



Precision Finishing

- The finishing techniques currently implemented in industrial production, such as hard-turning and grinding, account for approximately 40% of the total manufacturing costs in the process chain. Reducing this percentage will require the development of new finishing techniques.



Selective Heat Treatment

- Selective heat treatment can be a more flexible, energy-efficient and cost-effective alternative to traditional heat treatment techniques where the whole component needs to be put into the heat treatment device.



Low Volume/LOTSIZE 1 Manufacturing

- Customized products with tailored functionalities etc. are among the recognized market trends.



Project Partners



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DI MILANO**



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Advanced Manufacturing Research Centre



**UNIVERSITÀ
DEGLI STUDI
DI PADOVA**

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