Production and Materials Engineering, Lund University
Research group in:
Machining and Manufacturing Systems, MMS

Professor Jan-Eric Ståhl, PI

Manufacturing processes
Materials engineering
Manufacturing systems

Lund September 2016

Project: Flintstone, Next generation of superhard non-CRM materials and solutions in tooling.

Objectives: Developing of innovative alternative solutions for tooling operating under extreme conditions in order to provide a perspective for the replacement of tungsten and cobalt - Two critical raw materials.

Project leader and researchers:
Jan-Eric Ståhl
Volodymyr Bushlya
Fredrik Schultheiss
Oleksandr Gutnichenko
Daniel Johansson
Aynil Ahadi
Mathias Agnell

Addressed area:

Partners:
ISM, Kiev, Ukraine
LSPM, CNRS, France
TUBAF, Freiberg, Germany
Bifa GMBH, Germany
SECO TOOLS, Sweden
Element Six Ltd, UK
Sandvik Mining & Construction Tools
BCC BV, Netherlands

Funding:
Horizon 2020 Programme, European Commission,

Selected publication:


Potential for high performance cutting tools based on superhard phases

Potential application areas for high performance cutting tools:
1. Machining ferritic and perlitic materials, carbon steels P (a) and irons K (b).
2. Machining austenitic materials, stainless steels M (c, d) and superalloys S (e).
3. Machining titanium alloys S (h) and other special materials such as composite materials and aluminum and copper alloys N (i).
4. Machining martensitic materials and hardened steels H (g).
5. Cutting and processing rock, minerals and concrete (j).

Material, material structure and application examples

<table>
<thead>
<tr>
<th>(Ferritic) and perlitic, P, K</th>
<th>(Ferritic) – austenitic, M</th>
<th>Austenitic and super alloys, M, S</th>
<th>Martensitic materials, M</th>
<th>Titanium alloys S and composites</th>
<th>Rock and minerals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon steel (a), cast iron, ductile cast iron (b).</td>
<td>Duplex stainless steels (c).</td>
<td>Stainless steel 316L (d) and Alloy 718 (e).</td>
<td>Toughened steels (f) and tool steel M2 (g).</td>
<td>Titanium alloy Ti6Al4V (h) and Al-based MMC (i).</td>
<td>Minerals (j) as Quartz, mica, feldspar, etc.</td>
</tr>
</tbody>
</table>

Basic use for CRM in tooling applications

Project: Diffusion and chemical wear of advanced tooling materials simulated in a high pressure cell, HPC.
Objectives: Identification and prediction of diffusion and chemical wear mechanisms in machining operations.

Project leader and researchers:
Volodymyr Bushlya
Jan Eriq Ståhl
Vladimir Turkevich
(Igor Petrusha)
(Vladimir Solozhenko)

Addressed area:
Extending the life of advanced tooling through understanding and prediction.

Partners:
IBM, Kiev, Ukraine
LSPM, CNRS, France
SECO TOOLS

Funding:
SPI (VINNOVA)
Lund University
IBM, Kiev, Ukraine

Selected publications:
Diffusion and chemical wear of advanced tooling materials simulated in a high pressure cell

Design and development of specialized experimental setups and routines for characterization of physics of cutting and tool wear

<table>
<thead>
<tr>
<th>Sample</th>
<th>Width</th>
<th>Material</th>
<th>Density</th>
<th>Mach.</th>
<th>Feed</th>
<th>Time</th>
<th>Pressure</th>
<th>Microscope</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>Steel</td>
<td>7.80</td>
<td>10</td>
<td>1</td>
<td>0.5</td>
<td>10</td>
<td>HR-SEM/TEM</td>
</tr>
<tr>
<td>2</td>
<td>1.5</td>
<td>Stainless</td>
<td>7.93</td>
<td>20</td>
<td>1.5</td>
<td>1</td>
<td>30</td>
<td>HR-S/TEM</td>
</tr>
</tbody>
</table>

Examples of challenges:
- Materials with one or several extreme principal machining properties
- Nuclear waste and accelerator components
- Hard and hardened components
- Ceramic and carbide components
- Engine and turbine components
- Mod-Tec and turbine components
- Transmission components
- Tool life modeling and prediction of deterioration behavior

Addressed area:
- Tool life modeling and prediction of deterioration behavior

Selected publications:
Workpiece material properties – Potential machinability not accounting chemical loads

Material factors in a polar diagram for comparing potential machinability

1. **Hardness** and deformation resistance.
2. **Abrasiveness** and proneness to wear.
3. **Ductility**.
4. **Strain hardening**, i.e. increase in yield strength during deformation.
5. **Low thermal conductivity** and/or low specific heat.

An example of a polar diagram describing how strong an effect each of the material factors has on the potential machinability of material X compared with the reference material, shown by the thick black line, Andersson et al.

**Polar diagram for Alloy 718**

Relative variation of potential machinability properties of parts (Alloy 718) from different batches and turbine discs and the range of each property value for the 223 individual parts considered, according to Avdovic et al.

**The abrasiveness factor in a machinability polar diagram**

Examples of modeled distributions of micro-hardness (nano-hardness) for various selected steels.


The 66th Diamond Conference, Warwick University 2016
Project: LFB, Machining of components based on Lead free brass.

Objectives: Development of production technologies for competitiveness production of lead-free brass component.

Project leader and researchers:
Kurt Nilsson, MMA
Jan-Eric Ståhl
Volodymyr Bushlya
Fredrik Schultheiss
Kathrine Spang
Daniel Johanson

Addressed area:

Partners:
MMA, Markaryd
Sandvik Balzers
Chalmers
Högskolan Halmstad

Funding:
Mistra Innovation

Selected publication:

State of the art in brass-based home products.

Examples of processing chains used in the manufacture of components made of brass. Operations with reed border need to be developed if lead-free brass should be a competitive alternative.

Complex Tooling, new tool for hot forging and brass properties.

Sawing Forging Welding Machining

Project: LFC, Machining of Lead free copper alloys.

Objectives: Development of production technologies for competitiveness production of lead-free copper based component.

Project leader and researchers:
Fredrik Schultheiss
Mike Olsson
Volodymyr Bushlya

Addressed area:

Partners:
MMA, Markaryd
Sandvik RS, Svedala
SKB, Oskarshamn
RFR Solutions, Landskrona
Produktionsteknik i Lund AB
Examec Group AB
Maskinteknik AB, Oskarshamn
SECO TOOLS
Chalmers
Högskolan Halmstad

Funding:
Produktion2030
VINNOVA

Selected publication:
Project: MMC based product realization.

Objectives: Development of production technologies for competitive production of components based on MMC for automotive industry and consumer products.

Project leader and researchers:
Jan-Eric Ståhl
Lanny Kirkholm
Volodymyr Bushlya
Jinming Zhou
Fredrik Schultheiss
Daniel Johanson

Addressed area:
MMC based automotive and consumer products.

Partners:
Amtek Sweden, Floby
SECO TOOLS

Funding:
VINNOVA, LIGHTer
VINNOVA, SCALight II
Volvo Cars, cash funding

Selected publication:

Clustering of particles (left) and crashed particles in machined surface (right).

Project: Intermittent machining of manganese steels, martensitic and carbide steels.

Objectives: Establishing of optimum conditions for heavy interrupted hard machining with existing and novel tool materials.

Project leader and researchers:
Volodymyr Bushlya
Jan-Eric Ståhl
Oleksandr Gutnichenko
Fredrik Schultheiss

Addressed area:

Partners:
Xylem Water Solutions, Lindås
Sandvik RP, Sweden

Funding:
SPI (VINNOVA)
Lund University

Selected publication:

Dynamic cutting forces for 3 different tool geometries in entry phase of a slotted workpiece.

Examples of different standard tool micro geometry's.

Damage to a polycrystalline diamond tool initiated primarily on the clearance face during intermittent machining of martensitic steel.

Example of a workpiece with intermittent combined with a part continuous cutting.
Project: Machinability of grey cast iron with respect to cold aging and optimal process conditions.

Objectives: Develop a strategy to handle variation of the machinability of grey cast iron.

Project leader and researchers:
Jan-Eric Ståhl
Daniel Johansson
Volodymyr Bushlya
Jinming Zhou
Oleksandr Gutnichenko

Addressed area:
Work material properties and process conditions in relation to tool wear and production costs.

Partners:
Volvo Cars, Floby and Skövde

Funding:
Volvo Car, cash funding
Lund University
SPI (VINNOVA)

Selected publications:

There is a possibility that dynamic force measurements can be used to investigate the machinability of cast iron and can be used to analyse the ageing process.

Nano hardness measurements can be used as a very powerful method to measure both expected differences in machinability and the changing in GCI when ageing over time.

The distributions of normalized dynamic cutting forces $F_c$ and the normalized nano hardness, measured after aging of the work material.

Improved machinability

Nano graphite used in environmental friendly ultra-high pressure lubrication (UHP-MQL) in discrete part manufacturing.

Objectives: Development of environmental friendly effective lubricants with modified carbon-based nano-fillers primarily for machining and forging operations.

Project leader and researchers:
Oleksandr Gutnichenko
Volodymyr Bushlya
Jan-Eric Ståhl
Lanny Kirkhorn

Addressed area:
Possible lubrication mechanisms of nanoparticles as friction modifiers.

Partners:
ISM, Kiev Ukraine

Funding:
Mistra Innovation

Selected publications:

Influence of GNP on friction coefficient

Ultra-high pressure setup, maximum 2210 bar

Onion-like carbon with amorphous structures

SEM images of synthesized GNP
Project: Burr formation, geometry related tolerances and surface defects in metal cutting.

Objectives: Develop a strategy to minimize burr formation and the related effects in metal cutting.

Project leader and researchers:
Ian-Eric Sihn
Hemrik Persson
Patrick de Voo, SECO TOOLS
Hans-Börjo Oskarson, Chalmers

Funding:
FFI/MSU (VINNOVA)
SECO
Volvo

Addressed area:
Volvo Cars, Skövde
Volvo Laxvångar, Skövde
SECO TOOLS, Fagersta
Chalmers, MCR

Partners:
Volvo Cars, Skövde
Volvo Laxvångar, Skövde
SECO TOOLS, Fagersta
Chalmers, MCR

Selected publications: -

Contents – Work packages
1. Introduction to burr formation and related problems.
2. Principle definition and description of burr formation and related problems
3. Examples from different applications.
4. Materials, geometry and cutting conditions.
5. Recommendation in general.
7. Deburring methods.

Burr formation in shearing operation (left) compared with burr formation in metal cutting (right).

Burr formation in metal cutting in a ductile material (left) and a brittle material (right) with an exit surface breakage.

High seed Camera images.

Source: Persson H. and Agmell M.
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Keywords: Metal cutting, tool life modelling, machining tests and process measurement.

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PhD – student in production and materials engineering, member of MMS.
Keywords: Metal cutting, exotic materials, research infrastructure.

Dr. Lanny Kirkhorn
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Expert in tribology and engineering materials, member of MMS.
Keywords: Tribology, materials selection, metal matrix composites (MMC), metal cutting.

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Thank you and Questions

Acknowledgement

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