Cutting edge laser shock peening

Intertwining industrial practice and academic simulation

The Industrial Problem

Lower production costs by applying the Laser Shock Peening (LSP) to improve lifespan of a cutting edge made of tooling steel. Prove that LSP complements the main company business – PVD coatings.

Mechanics and Mechatronics

Research group

Laboratory of Technical Mathematics

texMathGroup

Research group focused on providing suitable computational approaches to specific application-driven problems

Company

SHM, s.r.o.

SHM SUPER HARD MATERIALS | INDUSTRIAL PVD COATINGS

Czech company dealing with industrial applications of PVD coatings since 1993. Its business comprises PVD Coatings, Surface Technologies, Services, and Research

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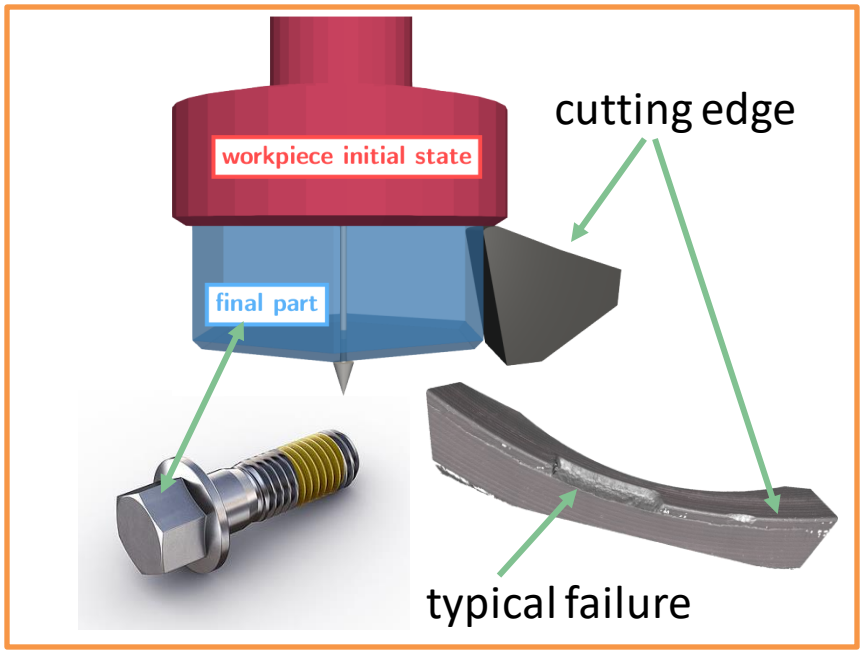
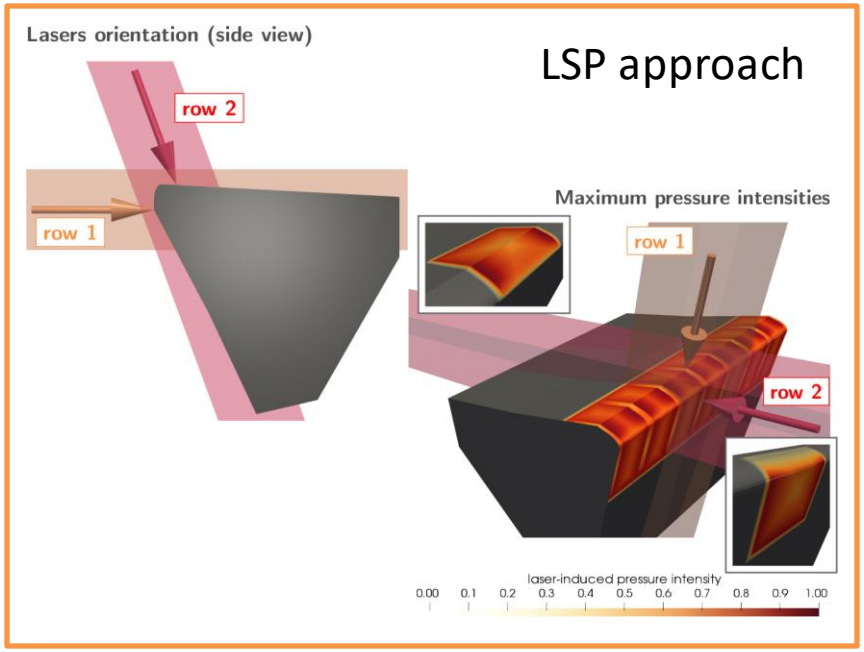
eu-maths-in.cz
Czech Network for Mathematics in Industry

Mechanics and Mechatronics

Challenges & Goals

- Use numerical simulation to improve LSP treatment of a cutting edge
- To develop a simulation framework for LSP
- To ensure the framework industrial applicability
- To improve explainability of experimental results
- To increase the cutting edge lifespan





(left) Solved problem illustration (right) considered variants of LSP treatment

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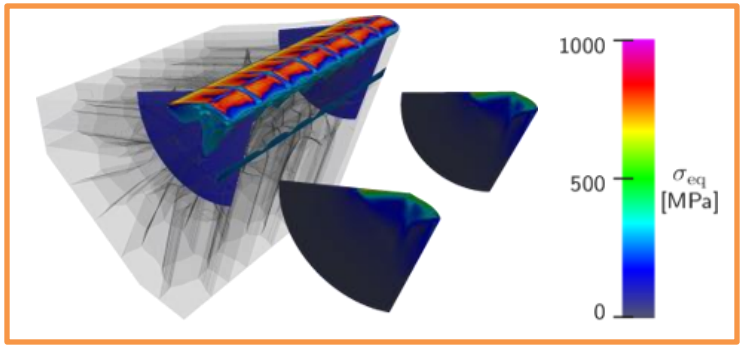
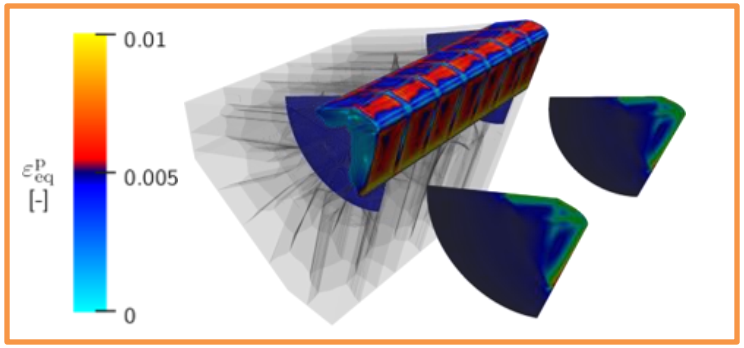
Mathematical and computational methods and techniques applied

- Finite volume method was used to solve a dynamic shockwave propagation followed by a pseudo-static material relaxation, that is, to simulate one laser shock peening shot. Simulation of the whole process, where numerous shots are required, is driven by custom-implemented python module.
- Solved physics: Elasto-plastic shockwave propagation hardening treated material
- Mathematical modeling: Partial Differential Equations solved via Finite Volume Method
- Implementation: pyLSP (own python code), OpenFOAM (open-source C++ library)



Plastic strain and in-material compressive residual stresses after row 1 LSP



Plastic strain and in-material compressive residual stresses after row 1+2 LSP

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Results & Benefits to the company

- Results

.Open-source simulation framework for LSP on industrial parts is available

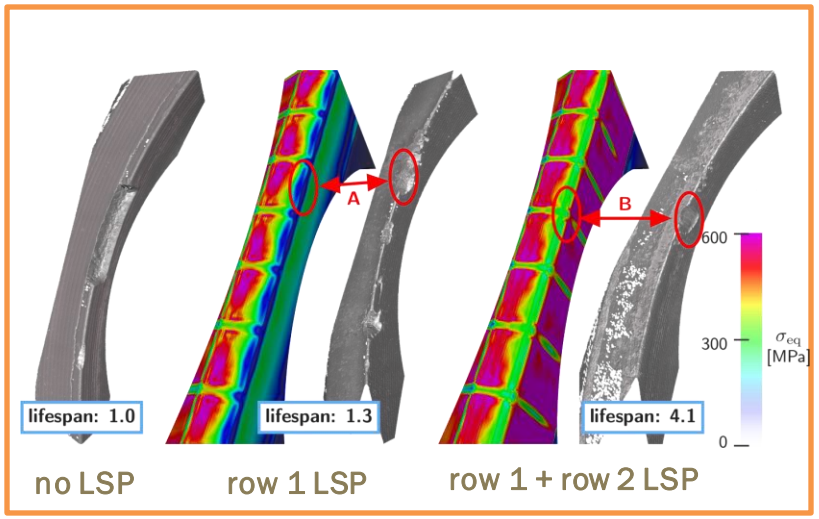
.LSP treatment increasing cutting edge lifespan by 400 % was devised

- Benefits

.Better LSP results explainability was achieved

.LSP optimization for specific part and material is now possible

.Combining numerical simulation and industriall reasearch and development, LSP competitiveness was increased



Comparison of cutting edge fatigue wear with simulated distribution of LSP-induced compressive residual stresses

Numerical **simulation allows for** part- and material-**tailored Laser Shock Peening**, leading to an **increase in** LSP **applicability and competitiveness**.

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