Research projects in laser cutting of mild steel with oxygen

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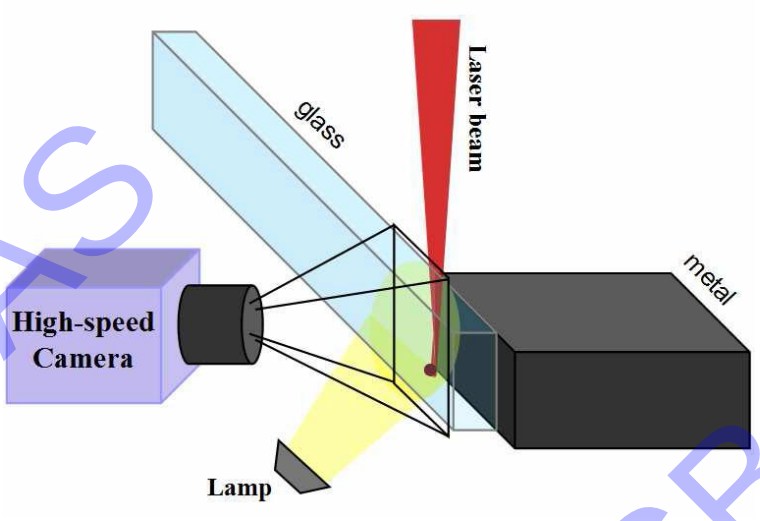
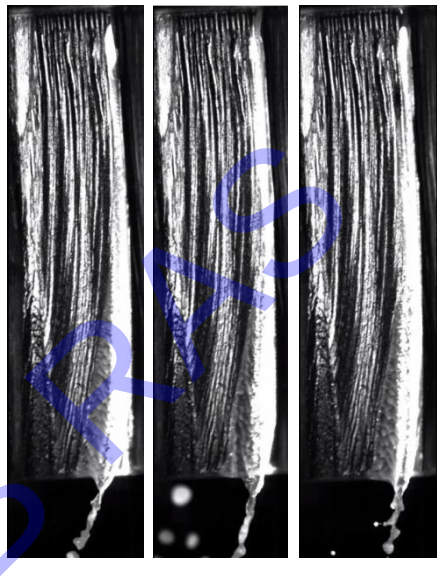
High speed visualization of laser cutting process (in progress)

Laser cutting process of mild and stainless steel with CO2 and Fiber lasers is studied experimentally with modified trim cut technique. The unique experimental setup allows to obtained surface of the cut similar to real cutting process. High speed recordings with the frame rates up to 10 000 f/s are done. 4mm and 12mm thick mild and 6 mm stainless plates steel are cut with 2 KW fiber laser, and up to 20 mm mild up to 6 mm stainless steel plates are cut with CO_2 laser. The cutting speeds and other parameters are typical for the real technological process.



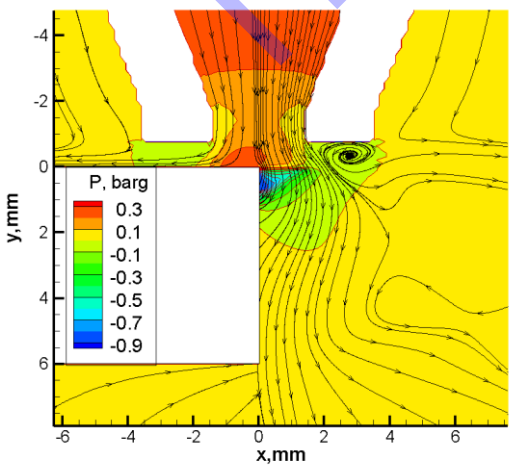
Scheme of the experimental setup



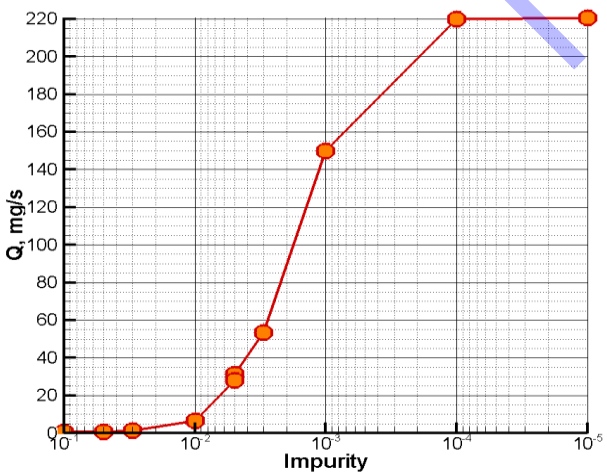
Cutting of 20 mm mild steel, CO2 laser 4kW, 0.7m/min, oxygen pressure 0.6 bar

Calculation of reaction rate (in progress)

The interaction of the oxygen jet with the cutting front, which is responsible for the high sensitivity to oxygen purity and for the unobvious effect of gas pressure on the cutting process, is studied. The rate of oxygen mass transfer from the jet core to the cutting front, which determines the combustion intensity, is obtained by the numerical solution of gas-dynamics and diffusion equations.



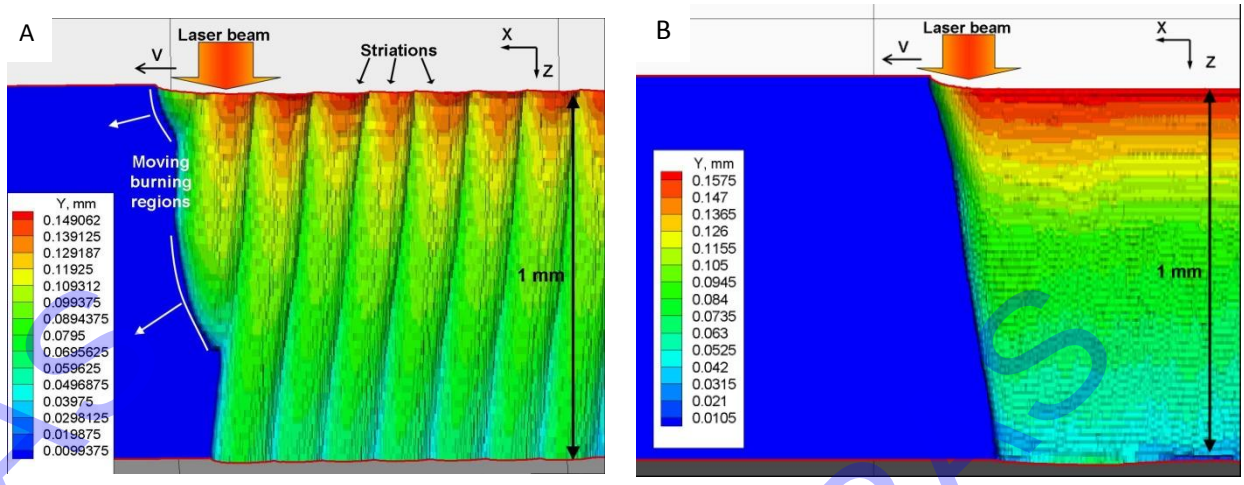
Pressure field and streamlines of oxygen flow inside cut kerf in the case of oxygen purity 99.99%.



Reaction rate on the cut front versus the initial content of the inert impurity in the oxygen jet

Simulation of striation formation due combustion cycles (finished)

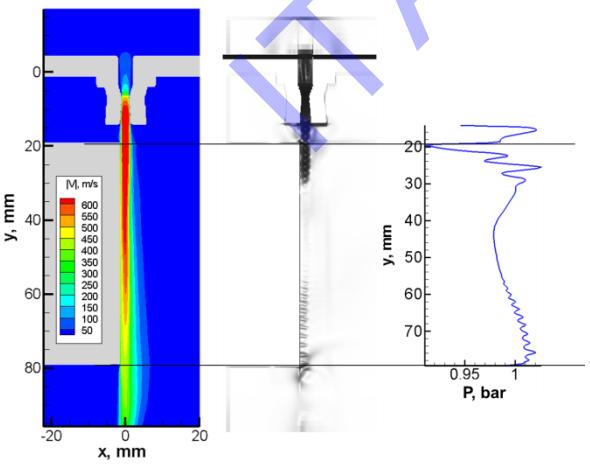
Striation formation in laser cutting of mild steel with oxygen is studied numerically. It is shown that striation formation takes place due to cycles of non-sustained combustion. A periodically repeated ignition, combustion and extinction cycles are connected only with temperature oscillations of the cutting front. If linear speed of combustion wave propagation is higher than cutting speed the striations of combustion type are formed, over wise the striation free cut is formed. The effect of threshold cutting speed is obtained.



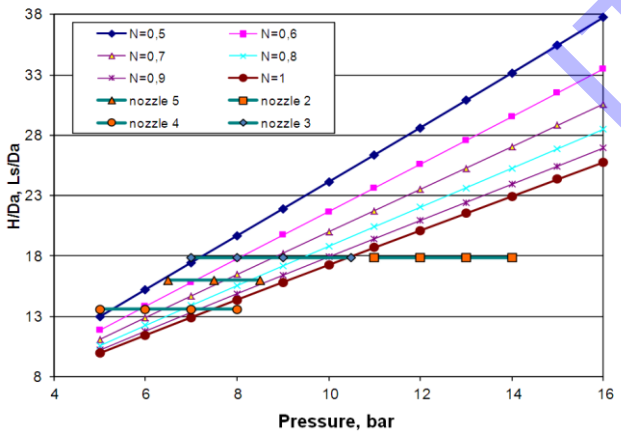
Cut surface profile. Cutting speed: A- 20 mm/s; B- 40 mm/s

Parameterization of hybrid laser-assisted oxygen cutting of thick steel plates (finished)

Specific features of hybrid laser-assisted oxygen cutting of mild steel sheets are studied theoretically and experimentally. The shape and geometrical size of a supersonic confuser-diffuser nozzle are demonstrated to play an important role in the formation of oxygen cutting jet. The numerical solution of three-dimensional Navier–Stokes equations reveals a pseudoshock phenomenon in the gas flow in a narrow channel, which is the reason for elevated roughness in the lower part of the cut under certain conditions. A method of the analytical calculation of effective cutting parameters, which depend on the material thickness, nozzle geometry, and range of oxygen pressure, is proposed. Engineering recommendations are formulated, and proved with full-scale cutting experiments of steel sheets up to 30–50 mm thick.



Supersonic jet flow of oxygen in the plane of symmetry of the channel geometrically similar to the cut obtained by laser-assisted oxygen cutting: gas velocity; gas density gradient; pressure on the leading edge.



Calculated and experimental values of the dimensionless sheet thickness, and length of the supersonic part of the oxygen jet normalized to the nozzle critical diameter versus the pressure for different jet pressure ratios and nozzle geometries