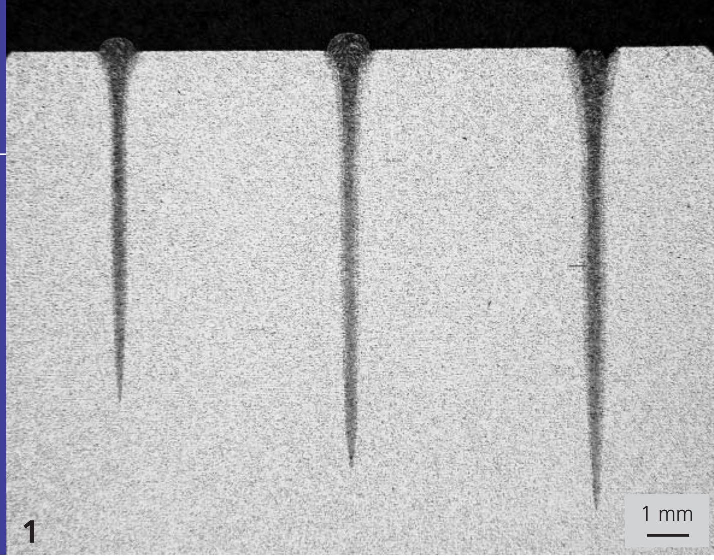


1

LASER BEAM WELDING WITH 5KW SINGLE MODE FIBER LASER

THE TASK

The 5kW single mode fiber lasers represent the latest development level in commercially available highly focusable laser beam sources combining high laser power with extreme beam quality. A beam parameter product of 0.5 mm·mrad and a fiber diameter of 30 µm lead to focusing and intensity conditions, which are comparable to or even exceed those of electron beam welders. The question is how to best utilize these features in laser welding applications.

First preliminary investigations aim at determining the process limits and potential applications.

OUR SOLUTION

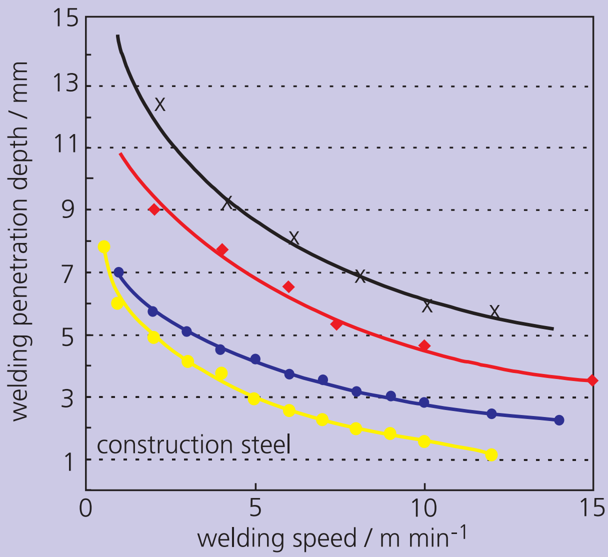
To compare laser systems, we use welding penetration curves. Laser beam penetration depths into a material and weld seam cross sections as a function of path energy and focus location are compared. The process stability is investigated based on flushing the optical path after focusing and analyzing its influence on the welding penetration depth.

The 5 kW single mode fiber laser is equipped with a standard collimator (aperture f_{coll} = 200 mm). The welding penetration depth experiments were performed at apertures of 300 mm and 500 mm. Un-alloyed constructions steels and naturally hard aluminum alloys were used as test materials.

RESULTS

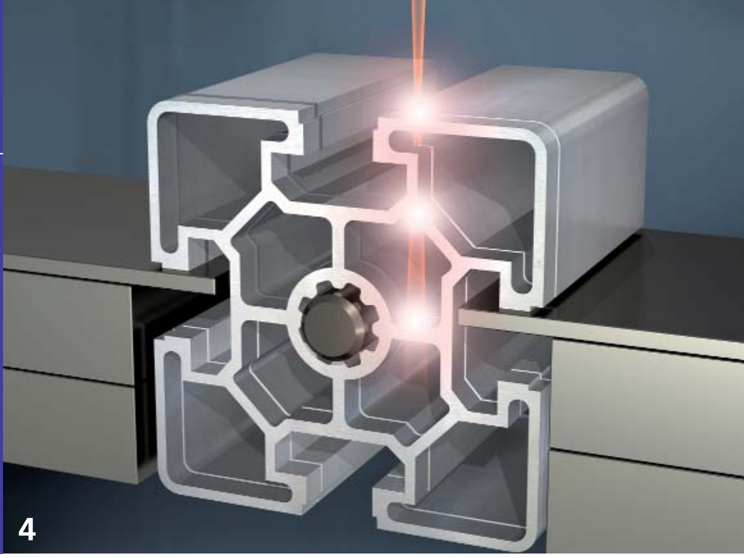
The new laser increases the welding penetration depth by more than 30 % (Fig. 2) compared to a 4 kW multi mode fibers laser (fiber diameter 50 µm, beam parameter product 2 mm·mrad).

Welding penetration depth for various laser types with different beam qualities (f - aperture, d_f - focus diameter)



X fiber laser, 4,0 kW, f = 300 mm, d_f = 30 µm, BPP: 0,5 mm·mrad
◆ fiber laser, 4,0 kW, f = 300 mm, d_f = 125 µm, Bpp: 2,0 mm·mrad
● disk laser, 4,0 kW, f = 200 mm, d_f = 200 µm, BPP: 8,0 mm·mrad
● fiber laser, 4,0 kW f = 200 mm, d_f = 510 µm, BPP: 18,5 mm·mrad

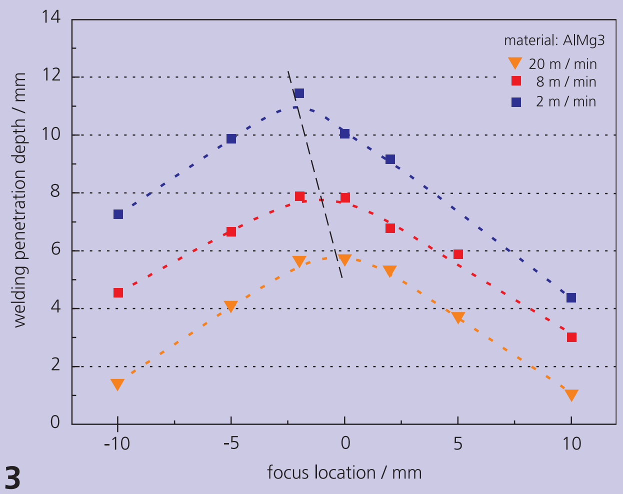
2



4

The weld seams are characterized by an extremely high aspect ratio and the seam flanks are very parallel. Strong welding penetration depths fluctuations were observed for low welding speeds ("spiking"). At such a high beam quality the intensity on the part surface has a strong influence on the welding penetration depth. Through experiments with a varying focus location and at a measured Rayleigh length of about 1.4 mm (at f = 300 mm) this becomes obvious. The highest welding penetration depths in aluminum were achieved with a focus location within the part (Fig. 3).

Welding penetration depth as a function of focus location for aluminum AlMg3 (5 kW laser power)



3

Highly focusable laser beam sources such as the 5 kW single mode fiber laser investigated here are an excellent choice for the welding at hidden welding positions. In a first test we welded in a single pass simultaneously two lapping joints with focus locations 40 mm apart. The total sheet stack thickness was 8 mm with individual sheets being 2 mm thick. This implies substantial technological advantages for clamping, handing and process time.

1 *Welding penetrations in unalloyed steel at 5 kW with focus positioning at the surface, from left to right: 8 m / min, 6 m / min, 4 m / min*

4 *Possibility of welding at hidden weld positions with lasers of highest beam quality*

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