ATHANASSIOS KALIUDIS

Build it with Light - Laser in Architecture

Modern architects love steel and freedom. Laser technology allows metal fabricators to offer them both.

What on earth would Jean Prouvé say, architect and designer, who was also a skilled blacksmith, ran his own metalworking company in the mid1920s, where he developed economical methods of designing and constructing facades, window and door frames, roof elements and similar components. Up until his death in 1984, he poured his creative energy into efforts to blend industrial manufacturing technology with architecture–and he ultimately succeeded in turning the concept of industrial architecture on its head. While other industrial architects were busy setting the stage for industrial production with their factories and workshops, he focused primarily on what industrial manufacturing methods could offer architecture. But let's return for a moment to that steel truss.

If Prouvé were to take a tour of the TRUMPF Smart Factory that opened in Chicago in 2017, his heart would probably skip a beat. The 45 x 55-meter cantilevered roof in this fully connected factory is supported by eleven steel trusses welded from individual pieces of steel. All the pieces were cut using the factory's own machines. As a result, visitors – and not just imaginary ones like Prouvé – can appreciate this roof as a great example of what the smart factory's machines can do and experience first-hand just how much laser machines can offer the world of architecture. So what might Prouvé have asked fellow architect Frank Barkow from the architects' firm Barkow Leibinger, which designed the TRUMPF Smart Factory? His first question would probably have been how the building could possibly have had a budget high enough to include such extraordinary structures. He would have been amazed to discover that it wasn't nearly as high as he might have expected–all because TRUMPF laser machines were on hand to cut and weld the steel trusses and make the whole roof construction financially viable.

TRUMPF Smart Factory in Chicago, USA. (Source: TRUMPF)

The roof of the production facility at the TRUMPF Smart Factory in Chicago is supported by eleven steel trusses, each made up of many

individual pieces welded together. (Source: TRUMPF)</p>

More freedom for less money thanks to laser technology

More and more architects are realizing that they can put their ideas into practice without breaking the budget by making use of laser technology. Property developers have fewer worries about exceeding the agreed costs, and passersby get to enjoy ever more aesthetic buildings. The current trend in architecture is to give the same weighting to form as to function, especially in airports, shopping centers and hotel lobbies. Specifically, that means that support structures should not only hold everything up but also look as attractive as possible. In architectural circles, the buzzword is architecturally exposed structural steel (AESS). As the name suggests, this involves making the steel structure of a building visible. In the past, it was relatively unimportant whether the weld seams on steel components looked good or not–but not anymore.

» Today's architects have completely new expectations with regard to steel sections and profiles

Michael Stumm, vice president of Swiss steel profile manufacturer Montanstahl SA

"What lies behind AESS is a reclassification of highquality steel products," says Michael Stumm, vice president of Swiss steel profile manufacturer Montanstahl SA. "Today's architects have completely new expectations with regard to steel sections and profiles." The corners play an important role in this context. Architects are increasingly clamoring for a specific type of steel profile known as a sharp corner profile (SCP). That's because a sharp corner– in other words, a small radius–does not jar the eye when the viewer turns their gaze on the support structures of a facade or roof. "Architects have always been keen on sharp corners," says Stumm, "but previously they were only possible with aluminum and thin-walled steel profiles, both of which are too weak to bear any heavy weight."

With lasers to coveted sharp edges

So how does Montanstahl create these sought-after sharp corners on large steel profiles? Take sharp-edged rectangular hollow sections (see box on page 19), for example, which are a popular choice of support structure for facades. These are conventionally produced by bending a flat bar of sheet metal into a four-sided shape and welding it on one side. The disadvantage of bending lies in the outer radii, which are subject to the traditional rule of thumb of two times the material thickness. So a piece of steel that is 20 millimeters thick yields an outer radius of 40 millimeters, creating more of an egg shape than a rectangular hollow section. An alternative is to take four flat bars of metal and weld them on all sides. That offers the added benefit of being able to use different material thicknesses that are precisely tailored to the structural requirements, which saves on steel. But there's a catch: this fourmetal-bar method is extremely expensive and time-consuming. Unless, of course, you take a tip from Montanstahl to achieve fast, deep and highly durable laser weld seams. Laser welding makes sharp-edged rectangular hollow sections so economical that they finally become a feasible option for an increasing number of construction projects.

TRUTEC Building in Seoul, Korea. (Quelle: TRUMPF)

Result better, production faster and cheaper

Another interesting example is sharp-edged T sections. The most that conventional methods could manage was to create sharp corners on short and thin-walled T sections. But the thicker the metal, the harder it got. What's more, the cut has to be clean and consistent along the entire length in order to create a gap-free join where the edges meet. The laser makes it easy to achieve that at Montanstahl. Things get trickier with welding, however, because conventional methods such as MIG and MAG leave protruding weld seams in their wake that subsequently have to be ground down to make them more aesthetically pleasing. Even more challenging in the case of thicker materials is heat input, which can warp long steel sections into oversized corkscrews. To tackle this problem, Montanstahl uses laser welding, which relies on high penetration depths combined with low heat input to create a clean weld seam. A T section machined with a laser doesn't just look better –it is also quicker and cheaper to produce.

One striking example of why laser welding's high penetration depth makes sense is when a hurricane hits a building before it has been completed. That's what happened to the Novartis Headquarters in New Jersey, for which Montanstahl was fabricating the facade pro - files. "For the ten millimeter thick metal, they had told us it would be enough to weld between one and four millimeters on each side. But with laser technology it made no difference to us, so we welded the full ten millimeters," says Stumm. The hurricane didn't bend a sin - gle profile –a great example of how to get additional peace of mind with no extra effort.

More freedom with free-form profiles

Anyone who can look into the eye of the storm without flinching is likely to be open to embracing new forms. Many modern building designs can only be realized using free-form profiles. But in the past, these kinds of unconventional shapes could only be created using soft and relatively unstable alu - minum sections. But what happens when the wind gets hold of alu - minum sections that protrude 15 meters into the sky at the top of a skyscraper? Can they withstand the force of the wind? That's some - thing building designers no longer have to worry about. By building complex geometries out of steel sections, they can make even their most labyrinthine facade fantasies come true!

Europe's highest building was processed with a TRUMPF Laser

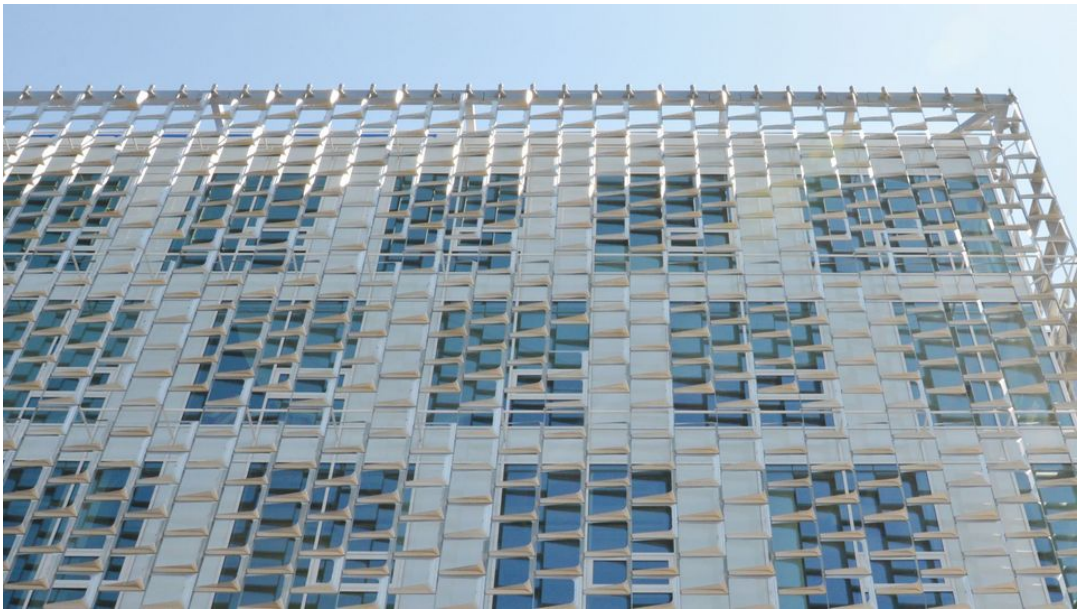
Standing 462 meters tall and completed in 2018, the Lakhta Center in Saint Petersburg (see stage image), which is the headquarters of gas giant Gazprom, is the tallest building in Europe. The design of the top 22 meters would have been impossible without a laser. It was fabricated by the company Edelstahl-Mechanik GmbH, which is based in Göppingen, Germany. "It was crazy," says managing director Josef Eisele, referring to the tight deadline of just four months from order placement to delivery. With the tower spiraling its way into the sky like a drill bit, every sheet of the outer cladding is different. The tapered and twisted stainless steel parts, up to 60 millimeters thick, were all 3D laser cut using TRUMPF lasers. And that wasn't the only time the laser was put to use for the Lakhta Center skyscraper: to prevent icicles from turn - ing into potentially deadly projectiles, the tower's metal panels are heated from the inside. Edelstahl-Mechanik's employees also used

the cutting laser to mark the positions of the bolts that hold these vital heaters in place, saving themselves the subsequent effort of mark - ing them out with a stencil. "Without laser technology, it would have been impossible to get all that done in such a short time with just 100 people on the job," says Eisele.

Laser convinces when it comes to simply making things look beautiful

Ironically, it's the superb seam quality of laser welding that sows doubt in the minds of some structural engineers: can something that is hardly visible really be tough enough to do the job? That's a question Eisele has heard many times. Recently, Edelstahl Mechanik GmbH supplied sections for a new building at Harvard University and was faced with the same doubts: "The U.S. structural engineers were skeptical, but they had no choice but to wait and see how it all turned. After all, the required penetration depth for the largest sections would have been impossible without the laser," says Eisele. The Harvard project also shows Eisele's outstanding capabilities when it comes to simply making things look beautiful: each individual piece of the facade features decorative holes cut by a laser.

Eisele began taking on architectural jobs around 20 years ago when a production manager he knew asked him to use a laser to cut mirror-finish sheets for a decorative facade, because mechanical processing methods spoiled the shiny surfaces. The fact that people are now focusing more on "designer buildings where aesthetics play a major role," as Eisele puts it, suits him well. This increases the pressure on structural engineers and architects to get acquainted with laser technology, which is still new to many of them.



Harvard John A. Paulson School of Engineering and Applied Sciences in Boston, USA. (Quelle: TRUMPF)
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Advantages of metal jewelry facades often unknown to architects

Binder Parametric Metal GmbH has also experienced the challenge of gaining acceptance in the market, as sales director Christian Geiger explains: "Talking to architects, we've noticed that many of them still haven't fully taken on board the benefits of making a decorative facade out of metal: it's easy to assemble, completely recyclable, very robust, economical and can be adapted to whatever shape is required." The company, which is headquartered in the Bavarian town of Karlskron, has carved itself a niche in 3D metal facades –and the laser is the per - fect tool for cladding buildings in new forms. Precision is the key when it comes to free-form surfaces, whether they are fabricated for the facades of parking garages or for decorating the inte - rior of all sorts of other buildings in a truly unique way. "For a good facade, you need the edge to be perfectly precise all the way around, even when it passes through three-dimensional forms," says Geiger. A laser has no trouble achieving this kind of precision whatever the shape, and it is equally serene in the face of small batch sizes and time pressure –two challenges that facade builders often have to deal with.

Multistory parking garage in Bietigheim-Bissingen (Source: TRUMPF)

“Lasers are fast and flexible. We can use our systems for so many different things because they are so quick to reprogram,” says Geiger. TRUMPF demonstrates how these systems work together at its Smart Factory in Chicago. But what would Jean Prouvé have to say about laser machines as he gazed down on Industry 4.0 from the skywalk? Perhaps that he had always known the machine industry was capa - ble of inspiring architecture? Maybe he would even see the TRUMPF Smart Factory as the successful realization of a fusion between indus - trial architecture and architecture from industry? Or perhaps he would simply be too flabbergasted to speak!

ATHANASSIOS KALIUDIS
通快激光技术事业部新闻发□□

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