Material *News*

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FORCE TECHNOLOGY

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Editorial

Dear Reader

Welcome to the latest edition of Material News.

It is frustrating to invest a lot of money in, for instance, a new railing in hot-dip galvanised steel in your block and discover that the paint flakes off shortly afterwards. Learn how you can avoid it by using the correct preparation and paint system.

Read also two exciting articles about welding processes. We describe tendencies within welding technology in Denmark, and what we believe that the use of highly productive welding processes in Danish industries will mean to productivity and quality.

We were present at the Herning hi[11] fair where our rotating wind turbine tower was a great success and drew a lot of visitors.

Enjoy your reading.

Ernst C. Kristensen
Vice President

Hot dip galvanised steel and paint – flaking or success

Paint flakes off hot dip galvanised steel. Why? Do the job correctly and get a nice result.

Paint on hot dip galvanised steel

Painting hot dip galvanised steel is quite a good idea. You combine zinc's excellent rust preventive properties and provide the steel with a nice coloured finish. The combination of a zinc layer and paint will give the best of both products and ensure a long remaining service life. This combination is often denominated: Duplex systems.

But sometimes something goes terribly wrong! After 6-12 months under outdoor weather conditions the paint starts to flake off in large pieces. And if you use a scraper or a knife, you may peel off the whole layer of paint all the way to the zinc layer. A success has become a financial and esthetical nightmare.

What happens and how do you avoid it?

To clarify the phenomenon you will have to look at the actual zinc layer. Subsequently, the pre-treatment of the zinc layer prior to painting and the subsequent painting treatment must be assessed.

Hot dip galvanising

During the hot dip galvanising process, steel is immerged in huge tubs with melted zinc (at approximately 450 °C). Depending on the process and the chemical composition of the steel, including its silicon content, the steel is given a zinc layer of 50 – 300 µm at immersion. Hot dip galvanised steel, which is to be painted later, is given a zinc coating of 60 – 100 µm, depending on the steel's silicon content. Higher layer thickness does not provide better protection against corrosion if the steel is subsequently painted on the contrary very thick zinc layers are much more ductile and may cause problems with coating flaking at sand sweeping.

Flaking

Roughly, you may divide the causes for the paint flaking into three:

- Insufficient or incorrect pre-treatment of the hot dip galvanised surface prior to painting
- Incorrect paint
- Incorrect painting specification for the actual task

Pre-treatment

Firstly remove remains of grease, oil, corrosion products and salts by washing or emulsion cleaning. Then remove remains of zinc ash, runners and other impurities by grinding with sandpaper or nylon sponges. If the construction is to be installed in corrosive surroundings (C4 or C5) the whole surface must be ground and not only surfaces with sediments. The zinc layer may also be sand swept, slightly depending on the paint specification on surface roughness.

The same procedure must be used on hot dip galvanised items that have been kept under outdoor conditions and in humid surroundings, to remove loose layers of

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e.g. zinc carbonate.

Remove the dust after grinding and sand sweeping, and paint immediately to prevent creating new zinc salts.

Paint
Most paints adhere satisfactorily on pretreated hot dip galvanisation with only one, however significant, exception: Alkyd paints cannot be used on zinc. However, alkyd paints are among the most selling paints due to their generally good properties and prices, and one might be tempted to use them on zinc surfaces, but this is not recommendable as they saponify and are decomposed by zinc salts.

Paint specification
It is tempting to believe that now when you have a solid layer of zinc at the bottom you may reduce the film layer thickness on the subsequent layers of paint. This assumption is incorrect.

The paint cover must protect the zinc surface against corrosion attack in the exact same way as the coating protects the steel surface without zinc, and if the surface is not protected moist and oxygen may penetrate the thin film. Thus, as mentioned before, zinc salts will form and since such salts hold poor mechanical strength the paint will lose its adhesiveness on the surface and flake off.

Paint specification for hot dip galvanised steel
The specification for Duplex systems depend on the environment in which the hot galvanised and painted is to be applied. In less aggressive environments (C1, C2 and C3) two or three layer acrylic systems may be used. In more aggressive environments, such as C4 and C5, epoxy-polyurethane systems are recommended.

The first layer of paint applied to the zinc could be slightly diluted to great advantage. Thus the paint will become more fluid and easier at filling all micro cracks and uneven parts of the zinc layer and thereby good adhesion is achieved. For the same reason, we advise against applying solvent free primers on zinc. They are often viscous and thixothrope and will have a tendency to form on the surface without penetrating sufficiently.

Experience with Duplex systems
The paramount advantage when painting hot dip galvanised steel is the long-term protection against corrosion. The coating will not need repair for many years to come – 20 years- and literature states longer periods. Expensive repair treatments may be avoided and thus the Duplex system becomes financially advantageous, when you distribute the investment for the system over the many maintenance-free years.

Many owners and contractors are aware of this and Duplex systems are seen more often in buildings and enterprises.

If you ensure good pre-treatment of the hot dip galvanised surface before painting and apply the correct paints for the purpose, you will obtain long durability of steel structures with Duplex systems.

One year old Duplex system painted with alkyd-paint has been destroyed. Cost for repair, more than DKK 50,000.

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Tendencies within welding technology

The quantum leaps within welding technology have been few for the last decades. And when the opportunity of radical progress finally presents itself, there is often a long period of inertia before the welding sector embraces the possibilities.

Laser welding facilitates a quantum leap in welding productivity and is now everyday life at car factories and a number of shipyards. At car factories, lasers are primarily used in connection with laser-MIG hybrid welding of overlap joints and fillet welds with welding speeds of up to 9 metres per minute. At shipyards, laser-MIG-hybrid is used for e.g. building of cruise liners, in order to achieve high productivity and minimise welding deformations. These years, serious work is made to introduce laser welding in connection with the erection of pipelines, which entails a great potential for the speed by which is it possible to advance across the landscape.

The development of more compact and less heavy laser-MIG hybrid welding heads means that – instead of large handling robots - more common 6 axis welding robots can be used.

From being large, expensive and vulnerable devices, lasers have steadily become less expensive, and by the emergence of powerful fibre lasers, it is now possible to buy robust, compact devices without moving parts delivering almost any high power according to the customer's wishes. If you wish for a 50 or 100 kW laser, you just have to order it, though it seems doubtful at present whether power outputs exceeding about 30 kW will be of much use in terms of added welding penetration and speed.

Investigating use of fibre lasers
Among others, Vestas, LORC, Bladt Industries and FORCE Technology participate in a recently initiated project supported by The Danish National Advanced Technology Foundation (ATF) that will elucidate the possibility of using a powerful fibre laser for joining of large material thicknesses found in for instance offshore wind turbine foundations and wind turbine towers. The potential seems to be promising, but there will be prerequisites as to groove preparation and fit-up tolerances, similar to the ones implemented for e.g., pipeline welding.

This ATF-project will also deal with the possibility of automating submerged arc welding of large round items such as foundations and towers to a degree that one person can operate several work stations. Partly to improve the productivity, partly to ensure a uniform, satisfactory quality and minimise weld repair rates.

Even though a lot of welding production
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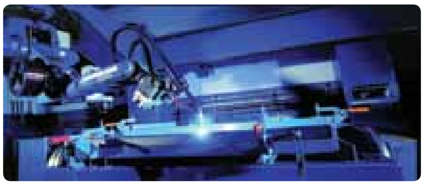
is outsourced, it may, paradoxically, often be difficult to hire qualified welders and operators in both Denmark and a number of other countries. This is possibly due to welding production's poor image and appeal to young people. The lack of qualified labour is a further impetus to automate so that the welding depends less on the operator's qualifications and experience.

Highly productive prosesses in pipeline

Within MIG/MAG welding, the development within electronics and faster processors has resulted in far better control and manipulation of drop transfer in the electric arc. This is used in short-arc welding of thin materials, where a minimum heat input is desirable, or in welding of root passes in heavier material thickness; preferably in the vertical down weld direction. The latter would be far too risky as to welding defects with traditional MIG/MAG power sources.

Other highly productive processes are in the pipeline, but have not really moved on from the laboratory stage yet. One example is plasma welding with great penetration. Plasma-MIG hybrid welding is a competitive process to laser MIG, and is less demanding as to fit-up tolerances and capital cost. However this process also involves disadvantages such as a comparatively high risk of solidification cracks in connection with high welding speeds. Thus at present, it seems that the faster laser-MIG hybrid process is the most successful alternative.

It is now up to the welding sector to seize the opportunity to improve both productivity and quality by using modern power sources, increased automation and/or new, highly productive welding processes as laser and laser-hybrid welding.



FORCE Technology is involved in an ATF project which is studying the possibilities of using powerful fibre lasers for joining heavier material thicknesses such as in offshore wind turbine foundations and wind turbine towers.

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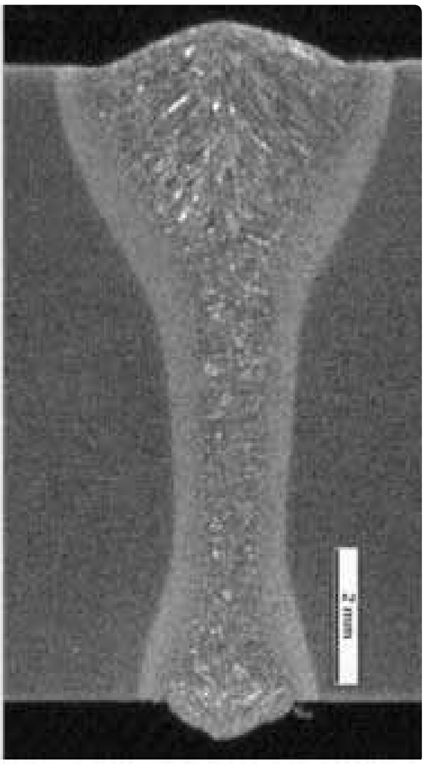
High energy welding

The concept of high energy welding is not unambiguous but brings associations to several very different processes such as e.g. submerged arc, plasma and beam welding.

High energy or high intensity?

The high level of energy is a common characteristic for these processes and each of their respective applications are typically associated with high production rates. But with that most of the similarities end since there is a huge difference in the energy applied to the welded items in these processes. Submerged arc welding is capable of melting down large amounts of material and involves high heat inputs in the range of several KJ/mm, whereas laser welding on a similar material thickness may be performed with a little more than one tenth of the heat input. The primary difference lies in the laser supplying its energy concentrated in a very small area, in which the intensity will become sufficiently high to form a keyhole. In practice, this means that high intensity welds may be performed faster and with much less subsequent deformation, than welds performed with traditional high energy processes.

Modern high energy processes are not only ideal for welding in large material thicknesses, but also for objects where the dimensional tolerances after welding are critical. In many components where deep penetration is obtained post weld treatment may be necessary. Furthermore, the obvious automation advantages of beam welding generally lead to quality improvements of the welded components.



Highly intense welding with fibre-laser/hybrid (Source: FIBLAS-project, EU)

State-of-the-art high energy welding

Highly intense welding methods are no new phenomena. Electron beam welding has been known since the late 1950's and laser welding since the 1980's but the processes are by many regarded as exotic, extensive and not least expensive. A reputation the processes have earned so far, for their almost hysterical requirements to material tolerances, surface cleanliness, investments and special training. However, lately the foundation on which such prejudices are built has begun to crumble as new laser types with unprecedented intensity levels are showing up on the market at lower prices, with markedly lower energy consumption and significantly higher lenience to object tolerances. New laser types even show penetration depths which until recently have only been obtainable in high-vacuum electron beam welding, but without the need for complicated/elaborate vacuum chambers.

On-site laser welding: Let the mountain come to Mohammad

Previously it was only possible to harvest the gains of highly intense welding methods in especially designed welding work shops where the extensive and sensitive set-ups of electron beam welders, vacuum chambers or traditional welds have been set up. It was necessary to bring the items to the workshop. But with modern multi-kW fibre lasers, the machines have become so sturdy and transportable, that

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on-site welding is now a reality. This way, welding on very large components/structures may be performed at the assembly site, in dock or where the need might arise. The laser, including cooling components etc. is transported in a smaller container, which again is connected to a standard 2x CEE 63 A power supply with cooling water, if necessary. Via a 50 m long fibre the laser light is led to the component, which is to be welded.

Large, heavy components no longer need to be taken to the welding workshop the workshop may be brought to the component.

On-site laser welding is not only a theoretical possibility it has become applied in connection with welding in ship building and pipelines. (Source: FIBLAS, EU-financed research project).

Transportable fibre-laser for on-site welding dimensions: 4.6x2.0x2.15m (LxBxH). Photo: GSI SLV.

Welding with gap – No longer a problem

Often occurring welding tasks require that welding may be performed despite the presence of a certain gap between the components. Until recently, this has been a real problem for highly intense beam –based welding processes, since their immediate advantage: The very concentrated application of their energy meant that the energy which is focused on one tiny little spot, was able to pass between the two items without applying its energy into them, and thus no welding could be performed. In practice, for electron beam welding processes this meant that gaps could not be tolerated at all, whereas for laser welding until recently it has meant that gaps (larger) than a few tenths of millimetres have been destructive to the process.

With the combination of modern fibre laser technology and traditional arc welding in a hybrid process, where lasers and arc are united in the same molten pool, the gap tolerances are extended by a half to a full millimetre. The laser creates a keyhole and provides good penetration while the MAG process ensures binding over the gap, if any, and provides simultaneous fill-up. Furthermore, the hybrid process increases the processing velocity and consequently decreases the heat input and minimises deformation.

Laser/hybrid processes are already applied in several European shipyards where the process has proven its worth in connection with gap tolerant welding of large panel components where heat induced deformations are no longer a problem.

Perspectives for Danish Industry

With ever decreasing demands for welding in the Danish heavy industry, one might think that these highly intense welding processes will remain an undergraduate curiosity for a few people only, but reality has proven otherwise already: Fibre-lasers are already in use in Danish companies, who produce small and extremely precise components for the foodstuff or medico industries, where the requirements to surfaces after welding are exceptionally high, and where there is an immediate benefit from the low heat input of the fibre laser, its high processing speed and extremely uniformly high quality.

Components in exotic alloys which previously had to be milled from one piece and components in thin materials from foils at a few millimetres material thickness are obvious candidates for welding with modern highly intense processes.

When adding the processing advantages with the fact that modern fibre and disc lasers have clearly taken the lead as regards to energy efficiency, there is even a green hanger upon which to pin the last arguments when you consider an investment calculation.

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Exhibited at the hi[11] fair

Our exhibition at hi[11] was a great success.

This year, we exhibited at the Herning fair hi[11] where we presented a part of a wind turbine tower.
We had installed automated equipment for welding (OPAU, optimal automation) and for NDT examinations (FUWI, fast ultrasonic welding inspection). The rotating wind turbine tower attracted many visitors, and they were very interested in studying how it works. The panel of judges at hi[11] awarded our OPAU system three out of three possible stars as a Danish innovation.

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The wind turbine tower was a great success at hi[11].

Material *News* is a newsletter on corrosion, metallurgy and welding and is published twice a year.
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