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Economical production of TWP®-plate-sections

überreicht von der

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und der

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Meyer Werft restructured their construction procedure completely and started to produce plate-panels by using newly developed laser-welding lines as well as tailor-welded-plates.*

Economical production of TWP®-plate-sections

German shipyard Jos. L. Meyer GmbH, Papenburg, and their project partners Schuler Held Lasertechnik GmbH & CO. KG and Graebener Maschinentechnik GmbH & CO. KG revolutionised shipbuilding within recent years (see HANSA 9/2002, S. 82) by installing Laser-welding (LASER = Light Amplification by Stimulated Emission of Radiation) systems which are really based to light-beams. The core components of this new prefabrication of the shipyard are laser systems produced by Schuler Held Lasertechnik and plate milling systems by Graebener Maschinentechnik.

Main plate-panel-line at Meyer's new technology hall: Laser 1 on blue portal right; Laser 2 on blue portal behind yellow girder-portal Photo: Schuler Held

With the help of a laser hybrid process, these systems automatically weld together the panels and walls, first vertically and then horizontally. The major advantages are:

1. The process is fully automated despite the different configurations of the panels.
2. The size of the system and the quality of the welds permit prefabrication of sections as large as 20 x 20 m without ever having to turn the panel.

In shipbuilding, such component size, welding precision, and the level of automation amount to a revolution – especially for processes that typically have been done manually before.

Welding Process

Just as in the automobile industry, shipbuilders also try to reduce material consumption and weight in order to keep operating costs as low as possible. In shipbuilding they also make use of the technique known as »Tailor Welded Plates« (TWP®) that is, joining panels made of plates of varying thickness as required by the specifications of the ship's hull. Panel dimensions, in this case, can reach 20 x 20 metres.

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Meyer Werft uses a laser-hybrid process (see HANSA 6/2002, S. 66) that the company itself perfected. With the aid of MIG welding, filler metal and the seam edge are fusion-welded while the focused spot of the laser (following directly behind) ensures fusion into the root of the seam by means of deep penetration welding effect. In this way the laser produces a weld that is as good as a conventional root penetration seam even though it is processing from just one side and with a very low angle of beam spread. The weld edge preparation is the key factor to success.

Instead of using plasma cut edge, Meyer is using a milled edge. The advantages on Laser Hybrid Welding are:

- The panels no longer have to be turned for a root penetration weld, a process, which becomes more and more difficult as the prefabricated blocks and panels get bigger.
- Welding rates are much higher than pure MIG welding – but also higher than pure laser welding.
- Because of the deep penetration, the side angle can be reduced to 6°, which helps to make dramatic reductions in the quantity of extra wire needed, compared with conventional welding processes.
- Reducing the side angle also reduces the milling volume when preparing the weld.
- Reducing the area affected by heat also reduces the energy input applied per unit length, resulting in tangible reductions in panel distortion. This ensures that the welding process can be automated. Moreover, costly and time-intensive reworking is reduced and the assembly of the blocks in the dock simplified.
- By using a MIG welding source to apply energy in areas near the surface, the laser is made available solely for deep penetration welding, i.e. for the process urgently dependent on the laser's qualities. Energy costs are almost halved, compared with pure laser welding.

Laser 2 on blue portal in main plate-panel-line Photo: Schuler Held

Plate edge preparation by means of milling

Milling technology, in contrast to grinding or even plasma respectively flame cutting, becomes more and more accepted in the field of plate edge preparation. The main advantages are:

- High milling speed of up to 8 m/min can be reached.
- Due to the parallel processing of plates the very small gap widths can be achieved, and afterwards most modern welding technologies such as laser-

TPW® – Registered by GRAEBENER

View into milling-drain of milling-portal; right and left hydraulic plate clamping devices; laser-hybrid welding head in background
Photo: Schuler Held

or laser-hybrid-welding can be applied.

- The creation of various seam types (I,Y,V,U, etc.) can be achieved without problems.
- No heat is transmitted into the component during the milling process. Due to this fact there are no tensions inside the component.
- After the milling process the components show a clean and metallic surface.
- The edge preparation by means of milling can also be applied for thicker plates.
- In contrast to the traditional processes chips produced during the milling process can be recycled without any problem.
- Milling is a non-polluting process. There is no toxic gas or hazardous dust. Ventilation units as used for the traditional processes are not necessary.

Plate preparation by milling meets the requirements which are related directly to the laser-hybrid-welding such as high precision and reproducible plate edge preparation according to the given edge type as well as a processing almost free of burst.

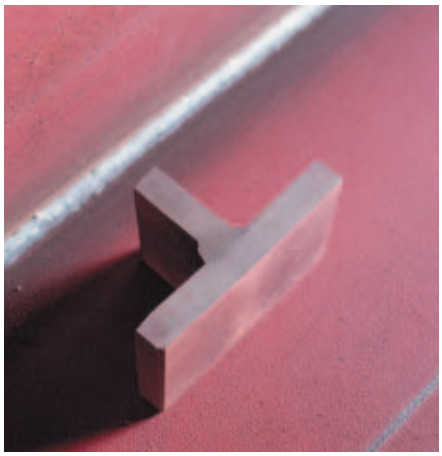
Milling also meets the requirements which are related to the TWP® process. Here, different dimensions of the individual plates as well as individual variation and combination possibilities, when joining the plates to a panel or plate field, have to be considered. Especially when joining plates of different thickness corresponding transitions between the individual plates have to be provided.

Furthermore, the reductions of the manufacturing and cycle times as well as an economic manufacturing process are requirements, which have to be met by the process applied for the plate preparation. Edge milling is used above all because of the high precision edge preparation and the high advance speeds, which can be achieved. Correspondingly designed cutters are used for the edge preparation.

For the milling process the plates are hydraulically clamped onto the support tables over the total milling length. By means of this, a possible waviness of the plates can be compensated. Furthermore, the tension has a positive effect on the milling result and the life of the cutting tools. High precision guiding systems of the plate edge milling machines as well as the possibility to simultaneously process the plate edges to be joined ensure the compliance with the small form and gap tolerance for the laser-hybrid-welding. The arrangement of the milling tips in the cutter guarantees a processing almost free of burst.

In order to reduce the production times and the adherence to small tolerances, the plates in the same clamping are milled at first and than joined until to the necessary gap distance are reached. Last, they are welded by means of the laser-hybrid-process. For this purpose, the machine bed of the plate edge-milling machine can be moved back and forth and the welding equipment is integrated into the plate edge-milling machine.

The requirement of a TWP® process is to provide the possibility to join different individual plates in various variations and



Full penetration in stiffener weld seam

Butt and fillet joint

Laser-hybrid-welding head with MIG torch cleaning station
Photos: Schuler Held

combinations by welding. The machine concept of the plate edge milling machines allows a segmental adjustment of the plate supporting tables in height. Therefore the plates can be clamped by means of individual hydraulic clamping elements. The production sequence is as follows: First individual plates are joined to a plate strip at the cross edges, then the plate strips are welded to panels respectively plate fields.

Equipment

At the heart of the system are welding machines from Schuler Held Lasertechnik, two butt-joint welding machines for the production of panels in connection with two plate milling systems from Graebener Maschinentechnik. The first butt-joint welder joins individual plates to stripes, which will be welded to panels in the second butt joint welder. Here for the first time anywhere butt-welded seams are applied continuously over a length of 20 m. Indeed, the machines used for this purpose are the most ambitious systems that Schuler Held Lasertechnik and Graebener Maschinentechnik have ever built.

The Graebener Maschinentechnik milling system, with integrated clamping device, does the edge preparation of the weld seam. While the plates are clamped the welding is performed directly after milling operation is done. The welding process itself uses an RF-excited $C0_2$-laser with a peak output of 12 kW and a MIG welding current source of 450 A.

A major influence on the quality of the weld is how accurately the distance between the laser focus and the MIG current head can be maintained relative to the weld seam root and how well the parameters of the laser and the MIG processes are coordinated. These welding parameters are es-

tablished in a comprehensive series of tests and stored in the machine's control system in the form of a technology database.

The butt joint welder uses a light section sensor to trace the weld line. This sensor registers any horizontal weld deviation or tramping. The axes of the MIG and laser head are subsequently adjusted, in accordance with the sensor signal. Depending on the size of the deviation, the technology parameter records are modified to comply with the programmed functions of this deviation. Overall a central monitoring station on which all status information for the individual machines can be displayed performs control and monitoring of the manufacturing line.

Summary

By means of combining plate edge preparation by milling and laser welding, shipbuilding can achieve an unprecedented manufacturing accuracy and at the same time save costs. In order to give a first hint about the investment and the cost situation the following example can be consulted:

- **TWP® line consisting of:** 3 laser sources with 12 kW each, 3 laser machines (2 butt joint welders; one 4 m wide and one 20 m wide as well as one fillet joint welder 20 m), two plate edge milling machines, plate handling and plasma cutting system for a total price of approx. 11,300,000 €.
- **Conventional line consisting of:** Submerged arc welding units (2, one large and one small), fillet joint welding unit, plate handling und plasma cutting unit for a total price of approx. 9,200,000 €[1].

Graebener plate milling machine

Milling head

If the steel works per ship are calculated with 350 kh and if the hourly rate is 65 €/h the result would be costs of 22,750,000 €. This calculation is based on an estimated inaccuracy outlay of 20 %, i.e. that this would be costs of the amount of 4,550,000 €. When using a TWP® line 50 % of this costs could be saved, here 2,275,000 €.

In this case the TWP® line in contrast to the conventional line has paid out after one ship (9,200,000 € + 2,275,000 € = 11,475,000 € > 11,300,000 €). Expenses for the air ventilation, cleaning of the work surroundings, etc. which occur due to the application of grinding, flame cutting, submerged arc welding, etc. have not been taken into account yet.

Additional advantages are better and safer working conditions for the staff since many tasks can be avoided due to the fact that only few adjustment works are necessary. These are additional reasons for the application of a TWP® line.

Just as it happened some years ago in the automotive industry, this technology of tailor welded plates will make its way to the manufacturers. By means of this technology, ships can be especially designed for their respective application and therefore result in a cost reduction for the shipbuilder as well as for the ship operating company. ❑

1) This line must be calculated twice in order to achieve the same output as a TWP® line.

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