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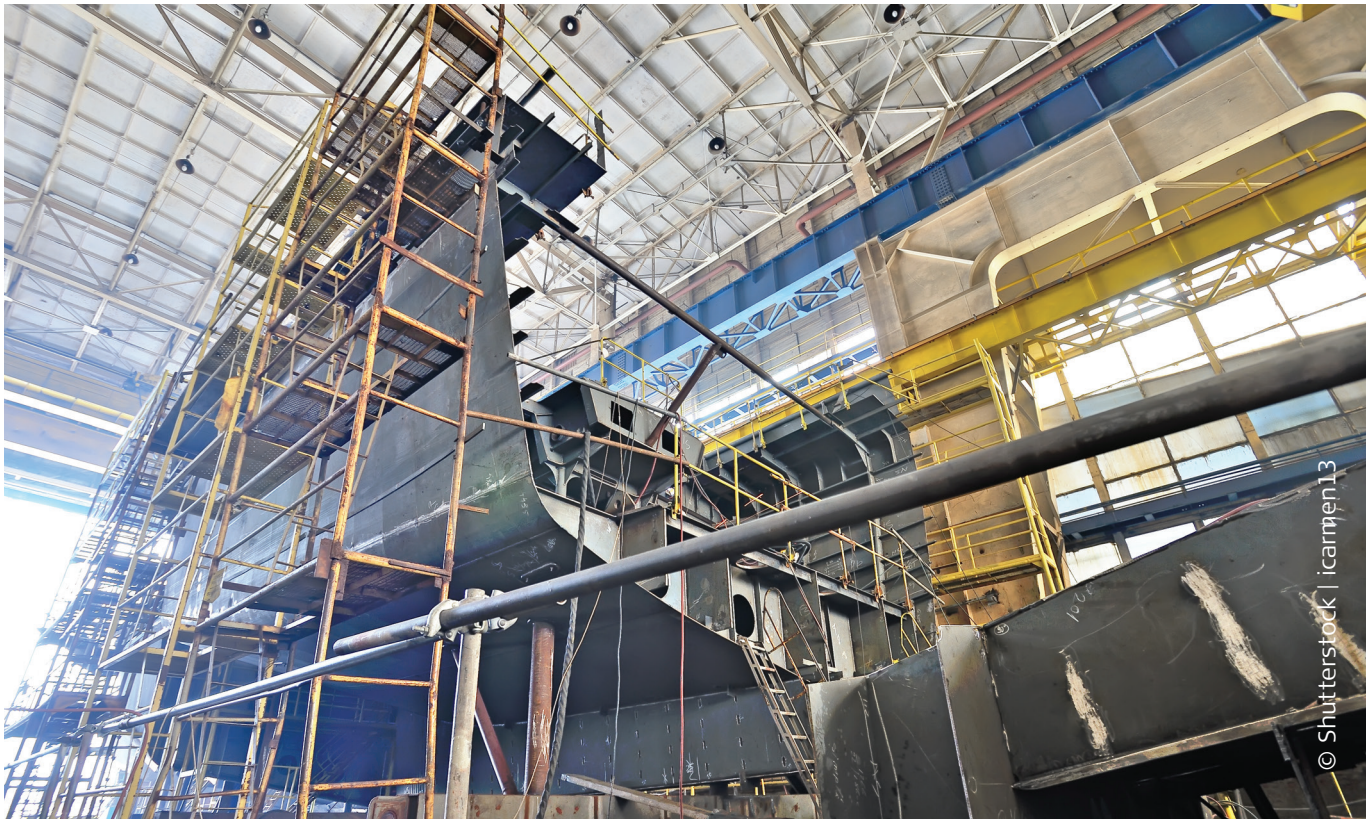
SOS SHIPBUILDING ON SCANS

Imagine putting together a jigsaw puzzle of more than 30 million pieces. The instructions say to group these pieces into about 80 individual blocks, which will weigh up to 800 tonnes. Those blocks must be precisely placed together, offering passengers a safe and pleasant journey aboard a tremendous cruise liner.

Once planned, you have less than one year to construct, all the while meeting budget constraints and exceeding customer expectations in quality.

Welcome to the world of cruise ship building.



At MEYER WERFT, we face these challenges on a daily basis. Building ships since 1795 in Papenburg, Germany, our company has seen the evolution of watercraft transportation from wooden ships to our latest release in April 2015 of the Royal Caribbean Anthem of the Seas. Measuring 350 metres long and 168,666 tonnes, the latest in our long line of luxury cruise ships is making waves in the industry for its sleek design.

NO ROOM FOR ERRORS

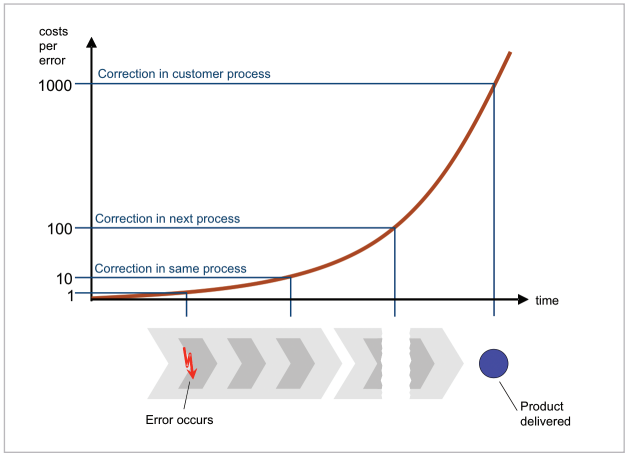
'First time right' is the target for all employees at the shipyard MEYER WERFT in Germany. Minor mistakes in one discipline can have a great effect on staff and material expenses and can even delay the entire building process resulting in additional costs. In particular, the short building period in the dock hall with its 500-meters-long dry dock highlights the daily challenges. By using its full capacity and building two vessels a year at intervals of six months, work processes serve two various types of ships in different stages. While the hull of one ship is completed with the final steel blocks, construction works in the engine room of the subsequent underwater part are already ongoing. Sophisticated quality and advanced planning procedures in design and production ensure that errors rarely occur and are detected promptly.

The roots for such a complex and diversified process lie in a risk-based approach by which the single vessel parts and work sequences are analysed and assessed for potential errors. Actions coming from those studies, though, do not only focus on the so-called 5Rs (right piece, right time, right place, right quantity and right quality). The right information is a key factor in modern and expeditious shipbuilding. Structuring drawing details and the chapters of numerous standard documents in a way that subject areas only receive the exclusive content they need reduces the hazard of missing the forest for the trees.

Information customised for the craftspeople distributes technical details as well as best practice procedures and the knowledge of how to avoid costly defects. With regard to location-independent process steps inside the huge vessel, news about every single improvement on error reduction by using new tools, sequences and available real-time data are inevitable for efficiency.

The second pillar in effective quality management is tests and inspections in short cycles. Quality assurance is supposed to be set up at certain stages where the risk of an error is high. A fast detection avoids having to dismantle, fix and restore completed hotel areas and mechanical spaces of a cruise ship. More than 60,000 single checks within the production process, plus additional checks in the commissioning and delivery phase, ensure problems in late stages will be eliminated.

These tests are carried out by dedicated and qualified staff coming from the disciplines of steel



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construction, welding, material testing, pipe systems, plant engineering, commissioning, interior furnishing and, in particular, dimensional control. The need for short-cycled quality assurance by well-trained inspectors is especially depicted in the above exponential cost graph. As construction cost incurs multiples of 10 or even more during each subsequent step of the process, mistakes not caught by early detection can result in millions of over-budget costs and jeopardise production schedules.

To sum up results at dedicated process steps, quality gates are installed to review test progress and test results. Due to the fact that the owner operating the ship later on and the classification society take part in some of the inspections, the follow-up of remarks and customer satisfaction contribute to a successful ship project completion.

The Quality Management Department comprises the system approach as well as the Measurement Group, which conducts geometric surveys and positioning. Our group is made up of nine different types of engineers, five technicians, six trainees and student apprentices. We conduct all measurement works throughout the entire construction process. Alignment of the plasma torch cutting machines is just one of the first tasks, and absolute accuracy is a must when laying keels and fabricating the blocks. On top of this comes a host of other special jobs, such as determining the overall length of a ship and assisting in research projects. With more and more parts of a ship being prefabricated and attached in blocks, we need to be able to trust our measurements without doubt. Whether you're measuring a complex sun shade composed of multiple concave shapes or a 260-metre-long waterslide with curves and loops, precise connection of the parts is critical.

If we fail to identify potential mistakes or to provide the correct measurements, the entire ship could be scrapped. It is no wonder, then, why we take our responsibilities so seriously.

VERSATILE TOOLBOX

To ensure we do not miss any critical details that could contribute to significant additional costs, we rely on a diverse set of measurement instruments. In particular, 3D laser scanning plays a significant role in helping us ensure construction quality on an efficient cruise ship factory line. Our pool of instruments, consisting of laser scanners, total stations, photogrammetric systems and cameras, are used every day under harsh conditions in both indoor and outdoor environments.

Since 2009, we have added Leica Geosystems laser scanners to our hardware equipment for documentation needs, depending on their high accuracy, speed and rugged design. Along with Leica TruView panoramic scan visualisation software, we've been able to overcome daily challenges with positioning and monitoring of special components and provide exact as-built verifications of complex constructions. Providing approximately 8,000 panoramic photos a year of critical ship elements to our internal clients, we can clearly show surface analysis, geometric controls and fit checks in our efforts to detect deviations at the occurrence

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stage before prefabrication installations. We've also met more advanced standardisation requirements with 3D laser scanning, such as structure analysis, reverse engineering and volume determinations throughout the ship building process. In addition to geometric surveying for construction monitoring, the data provides documentation for warranty needs.

Recently, by automating our 3D laser scanning, we have been able to even improve both our efficiency and our quality of measurements with around-the-clock capturing and monitoring of sections as they come together. Using multiple scans simultaneously day and night, we are gathering scan points to register, cut and fit into CAD models. With automated scan data analysis of the sections, every building part is inspected and our key performance indicators are strictly reviewed. We have realised significant cost and time savings since automating our process and our quality has improved even further.

ADVANCING 3D LASER SCANNING

With our latest purchase of the newest, ultra-high speed 3D laser scanner, the Leica ScanStation P40, we wanted to explore how this technology has advanced and if it could bring yet higher quality to our production. Under real-world conditions, we directly compared it side-by-side to our current HDS7000 scanner by scanning steel beams in the prefabrication stages.

To ensure a direct comparison between the scanners, the settings were equaled with a scan density of 6.3 millimeters point spacing at 10 metres distance from the scanner and set for 3.5 minute scans. We scanned and analysed the edge of the deck plating.

A main weakness in laser scanning in general is the noise at edges, known as mixed pixels. Mixed pixel noise was considerably lowered with the ScanStation P40 over the HDS7000.

There was also a better representation in geometry and contrast of the deckbeam, webplate beam and the deployed High Definition Survey targets with the new ScanStation P40.

At MEYER WERFT, where measurement quality and efficiency are critically important for cruise ship building, 3D laser scanning has proven to be increasingly beneficial in our daily activities. Our test results on the ScanStation P40 point to an even better future for this technology.

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