It has long been considered that the most productive and cost effective welding position within the shipbuilding industry is the flat position (PA). To satisfy this, great emphasis is put in at the design stage to maximize the use of this position. However, even when adopting this philosophy, welding has to be carried out in a variety of other positions. Many shipyards have found major benefits when welding a specific section of the ship hull in the overhead position (PE).

Carbon steel to carbon steel link-ups

Large block sections of the ship are welded together in the block build strategy, fig 1. On each section there are a large number of webs, girders and longitudinal connections to be made, in addition to the main hull connection. The bottom shell of the hull has traditionally been welded from the inside using a single V preparation, 60° inclusive angle 6mm gap feather edge with flat ceramic tiles on the outside to produce a single sided weld. This weld requires no back gouging treatment, and for a time was considered to be the most effective way if completing the connection. However, there were disadvantages such as:

- Welder access,
- Obstructions from webs, girders, etc, and
- Potentially higher defect levels on multi pass runs passing through access gaps.

The alternative was to weld the connection from the outside, where a free run with minimum restrictions was available. This required reversing the preparation discussed earlier and welding the bottom shell of the ship in the overhead position. To achieve this the following was carried out:

- Joint rooted from the inside against a round ceramic tile, fig 2.
- Welding carried out from the outside using a Kat Oscillator and flux cored welding wire in the overhead (PE) position, figs 3&4.

As the joint moves from the bottom shell it undergoes the transition from the overhead (PE) to the vertical (PG) position. The continuity of the weld is achieved using a flexible track. The weld is then continued up the side of the ship in the vertical position to the main deck, fig 5 (on back page).

When the technique was evaluated against the previous practice, the planned manhours allocated to welding were decreased by 72%. In addition, the visual quality of the weld on both root and cap was of a very high standard.

**Fig 1. Large section of a ship being joined with Kat Oscillation.**

**Fig 2. Joint rooted from the inside against a round ceramic tile.**

**Fig 3. Welding carried out from the outside using a Kat Oscillator and flux cored welding wire in the overhead (PE) position.**
Also radiography results are consistently better than the previous practice. These benefits could not have been achieved without the following key elements:
◊ A reliable oscillation system, and
◊ a high integrity flux cored wire.

To date the Kat Oscillating System has been found to be extremely reliable in the variety of positions and environments within the shipyard. Two flux cored wires are being used, both are of Japanese origin, one is copper coated seamless wire and the other is a more traditional seamed wire. Both wires are E71T-1 type and can be used in all welding positions.

This practice has developed from extensive experience gained elsewhere in the shipyard on carbon and stainless steel.

Stainless steel to stainless steel corrugated bulkheads
To date, four chemical carriers have been built. The cargo tanks are constructed from 316LN stainless steel, and are made up from a series of corrugated bulkheads. The weld profile has to be as smooth as possible to remove potential sites for cargo retention. The oscillator welding process was put into operation, and resulted in extremely high quality welds with minimum surface discontinuities, fig 6. As the joint to be welded was fully tracked, welds were produced without any intermediate stop/starts which further reduced the potential for discontinuities, fig 7. As in the case of mild steel, the stainless steel FCAW wire was of Japanese origin.

The amount of potential back gouging was reduced by welding against a ceramic backing tile. On plate thickness of approximately 34mm, a 2/3 to 1/3 preparation was used with a round ceramic tile placed in the groove. It was found that a larger gap was required for stainless steel than for carbon steel, due to contraction effects. A gap of 8mm was used with the root run being applied with the oscillator. When the round tile was removed a good concave profile was obtained, which only required wire brushing prior to second side welding.

General
The use of the Kat Oscillator within shipbuilding has been increased significantly, and at present, procedures are available for almost all general welding positions. This includes the horizontal position (PC), which in the past has been particularly problematic, especially when rooting onto a ceramic backing tile. A further area being considered is the use of the Oscillator track to double up as an aid to radiography inspection. The X-ray head could be mounted onto the carriage and moved into position for shooting as required.

Summary
The work carried out to date with the oscillator has shown:
◊ Significant improvements in productivity when used in conjunction with a compatible FCAW consumable.
◊ Significant reduction in back gouging can be achieved when welding against ceramic tiles.
◊ Transitional areas from the overhead to the vertical positions can be welded using flexible track
◊ High integrity stainless steel weld caps can be produced.
◊ The track could be used as an aid to NDT, by carrying an X-ray head.

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