Welding:

Took over from riveted construction because:

- Welding aids prefabrication techniques
- Easier to obtain watertightness
- Joints produced more quickly
- Less skilled labour required
- Reduced steel weight – hence increased deadweight
- Less maintenance (slack rivets)
- Smoother hull = reduced fuel costs
Fusion Welding:

Intense heat source which melts edges of material to be joined as it is traversed along the joint.
For example: gas welding, arc welding & resistance welding.

Gas Welding:

Fuel gases mixed with oxygen, e.g. acetylene ~ 3000 degC.
Change ratio of oxygen to acetylene and vary efficiency of flame.
Oxidising: Oxygen>Acetylene
Weld materials with high conductivity e.g. copper
Neutral: Oxygen=Acetylene
Weld steel
Carburizing: Oxygen<Acetylene
Carbon into molten steel causes problems
Gas Welding:

Temperature is low & hence method is comparatively slow.
Suitable for thin steel plate up to 7 mm welded at 3 to 4 metres per hour.
In shipbuilding used for ventilation & air con. trunking, cable trays etc.

Electric Arc Welding:

Wire or electrode connected to a source of electrical supply with a return lead to the plates to be welded.
By removing electrode a short distance from the plate, electric current jumps gap & high temperature electrical arc is created.
Electric Arc Welding:

Electric Arc Welding – Slag Shielded Processes:

Originally bare wire was used. However this resulted in unsatisfactory welds.
By dipping wire in lime a more stable arc was achieved.
Developments resulted in many forms of slag coatings being used: mineral silicates, oxides, fluorides, carbonates and powdered metal alloys plus a liquid binder.
Electric Arc Welding – Automatic Welding with Coated Wires or Cored Wires:

‘Fusarc’ machines traverse plate at set speed & flux covered wire is fed continuously to maintain correct arc length and deposition of weld metal.

Cored wires used since allow higher welding currents with high deposition rates and improved quality.

Electric Arc Welding – Submerged Arc Welding:

Arc is maintained within a blanket a granulated flux.

A consumable filler wire is used & arc maintained between this wire and plate.

Granulated flux breaks down & provides some gases & highly protective thermally insulating molten container for the arc.

Common method in shipyards for downhand welding.
Electric Arc Welding – Gas Shielded Processes:

Bare wire with gas shielding developed in 1960s – adopted for lighter steel structures and aluminium alloys.
Principally automatic or semi-automatic.
- Tungsten Inert Gas (TIG)
- Metal Inert Gas (MIG)

Gas Shielded Processes - TIG:

Arc drawn between watercooled non-consumable tungsten electrode & the plate.
Inert gas (usually Argon) shield protects weld metal from atmosphere & filler metal added as required.
Arc ignited by high frequency discharge across gap.
Used on plate < 6mm & in particular aluminium.
Gas Shielded Processes - MIG:

An extension of TIG whereby the electrode becomes a consumable metal wire.

May be fully automatic or semi-automatic using handgun.

Extensively used for welding aluminium structures.

CO\textsubscript{2} used as shielding gas in steel.

Other Processes – Electro-Slag Welding & Electro-Gas Welding:

Electro-Slag welding used for automatic vertical welding of thicker steel plate, down to approx 13mm.

Electro-Gas welding uses electro-slag technique with gas shielding. Commonly used for shipbuilding purposes in thickness range 13mm to 50mm.

Particularly vertical butts of side shell.
Other Processes – Friction Stir Welding:

Solid state process using a non-consumable rotating tool to soften material.
Used for aluminium alloys. (Tool not yet developed for steel).

Cutting Processes – Gas:

Small area of steel plate heated to a given temperature & confined stream of oxygen blown in area.
Molten oxide & metal removed by kinetic energy of oxygen stream.
Usually acetylene used with oxygen as preheat gas.
Cutting Processes

Gas:

Cutting Processes – Plasma Arc:

Plasma is a mass of ionized gas which conducts electricity.

Constricted arc with very high temperature. Melts plate locally.

Can cut between 0.6 to 150mm.

May cut steel or aluminium alloys.

Water tables used to reduce distortion & absorb dust reduce noise & ultraviolet radiation.
Cutting Processes
Plasma Arc:

Welding Practice:

Butt weld is strongest joint for tensile load on 2 plates.
Tack welds used to hold plates & sections in place prior to full welding.
Fillet welds may be either continuous or intermittent depending on intended structural effectiveness.
Welding Practice:

Welding Sequence:

During welding heat is applied to plate – metal will expand & contract on cooling.

Distortion may occur or if high restraint provided residual stresses, which should be avoided.

“Backstep’ & ‘Wandering’ methods used to minimise distortion.
Testing of Welds:

- Visual examination – surface defects spotted through routine inspections by experienced inspector or surveyor.
- Radiographic – X-ray or gamma ray devices, shielding required.
- Ultrasonic – pulses of ultrasonic energy, no health issues.

Weld Faults:
Case Study – Incat, Tasmania:

001 Derwent Explorer (Jeremiah Ryan)
LOA = 18.2 m
Built 1977
Material: Steel
Designer: Phil Hercus
Builder: Robert Clifford
Case Study – Incat, Tasmania:

- 004 Freedom Flyer (Fitzroy)
- LOA = 20 m
- Maximum speed = 28 knots
- Built 1981
- Material: Aluminium
- Designer: Phil Hercus
- Builder: Robert Clifford

Case Study – Incat, Tasmania:

- High-speed catamarans
- Evolution in size from 18m up to 112m presently under construction.
- Lightweight structures, full aluminium construction.
- Minimise lightship weight to maximise deadweight and speed.
- Resiliently mounted superstructure to aid passenger comfort by isolating from noise & vibration.
- Constant emphasis on weight reduction.
- Commercial & military operations.
- Production techniques developed to reduce build time and maximise profits.
Case Study – Incat, Tasmania:
Cutting:

Plasma Arc cutter - CNC

Open air bed

Plate sizes up to 12m x 2.5m

Thickness from 3mm to 40mm

(Thinnest plate used in vessels ~ 2.5mm extrusion)
Incat Tasmania - Plate Shop: Plasma Cutter

Incat Tasmania – Assembly Shed:
Incat Tasmania

Frame Bending Machine:

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Incat Tasmania – Rolling Machine:
Incat Tasmania – Bending Press:

Incat Tasmania - Guillotine:
**Welding:**

MIG fully manual system
Argon gas

Also MIG automated system on clamping rig with stainless steel backing plate.

Building the ships is still essentially a manual process.

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**Incat Tasmania – Unit Assembly:**

- Frames
- Rolled Shell Plate
- Extruded T-bar
- Extruded Vehicle Deck
Extrusions:

Reduction in production time and costs focussed on extrusion technology.
**Extrusions:**

Original ratio 80% plate - 20% extrusions.

Extrusions were the main decks, flooring, T-bar stiffeners & architectural components.

Now ratio 55% plate - 45% extrusions.

Extrusions also used in wetdeck undersurface, all vehicle decking, crossbracing, joiners, curved fairing surfaces on shell plate above waterline, void bulkheads, some interior walls & some exterior walls above waterline.

Incat Tasmania – Unit Assembly:

- Frames
- Sea Chest
Incat Tasmania – Unit Assembly:

Frames

Incat Tasmania – Unit and Module Assembly:

112m Catamaran Engine Rooms
Case Study - Incat, Tasmania:

112m Catamaran Engine Rooms

Incat Tasmania – Module Assembly:

Jig - Waterjet Assembly
Incat Tasmania – Module Assembly:

Jig – Wave Piercer Assembly

Incat Tasmania – Building Sheds:
Incat Tasmania – Building Sheds:

Incat Tasmania – Keel Blocks:
Incat Tasmania – Keel Blocks:

Incat Tasmania – Keel Blocks:
Incat Tasmania – Keel Blocks:

Incat Tasmania – Waterjets Ducts:
Incat Tasmania – Wet Deck:

Incat Tasmania

Wet Deck:
Incat Tasmania

Centrebow:

Incat Tasmania – Centrebow:
Incat Tasmania

Wave Piercer Bow:

Incat Tasmania – Automatic Welding:
Incat Tasmania – Automatic Welding:

Incat Tasmania
Hull Construction Crane:
Incat Tasmania – Hull Construction:

Incat Tasmania – Hull Construction:
Incat Tasmania – Hull Construction:
Incat Tasmania - Refit Work:

HSV-X1
U.S. ARMY

Incat Tasmania
Launching:
Incat Tasmania – Launching:
Incat Tasmania – Launching:

Incat Tasmania – The Brain’s Trust:
Incat Tasmania – Ride Control T-Foil:

Incat Tasmania – Finished Product:

Vessel Name: Milenium Dos
Hull Number: 058
Date Completed: 2nd May, 2003
Vessel Type: 98 metre Evolution 10B Wave Piercing Catamaran
Operator: Compania Trasmediterranea S.A.
Route Location: Valencia to Ibiza and Palma de Mallorca
Example of Welding:

Video on how to arc weld....

Further reading:
