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Welding Technology

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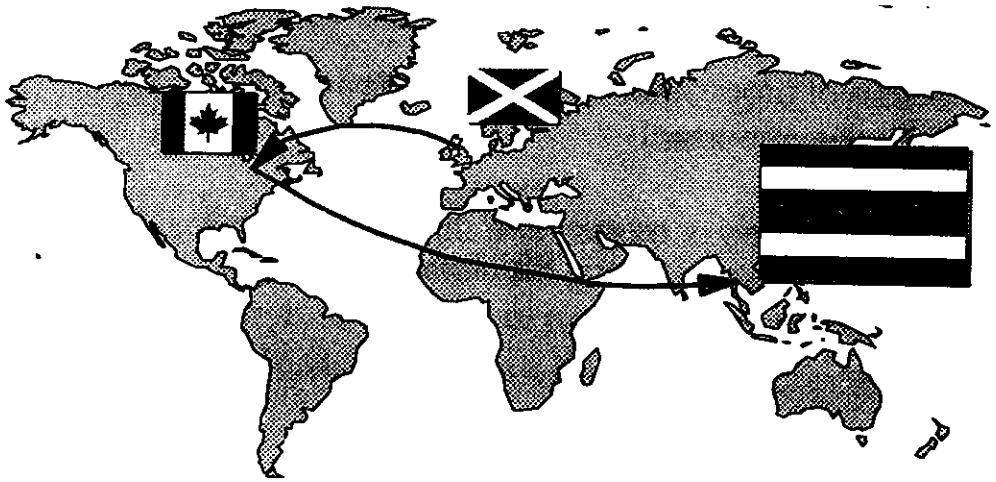
Subject Matter

Holding the world together...



Welding - A Joining Process

- Welding is:
  - a collection of processes for joining materials
  - economically important
  - versatile
    - ✓ ...joins hundreds of metals and alloys, e.g. steels, aluminium, nickel, copper, titanium, zirconium
    - ✓ ...in thickness from .01 mm to 600 mm and more

Welding Applications

- Many items could not exist in their present form without the strong, reliable joints that welding provides
- Nuclear power plants, chemical process plants, oil & gas equipment, ships, bridges, automobiles, fridges and tin cans

Competing Joining Processes

- Welding — pressure vessels, ships
- Brazing — gas turbine vanes
- Soldering — electronic component assembly
- Bolting — structural steel, machine parts
- Riveting — truck bodies, aircraft skins
- Adhesives — aircraft
- Integral construction
  - casting, forging, powder metallurgy, machining

Course focus

- The course will focus mainly on electric fusion welding processes and their applications in engineering construction

Course Topics

- Welding Processes
- Welding Metallurgy
- Weld Quality
- Weldment Design

WA - defect

WD -

Learning Objectives

- To become familiar with welding processes and equipment used in engineering construction.
- To gain insights into the welding metallurgy of structural steels and the resulting weld properties.
- To understand weld quality control methods and their application.
- To acquire some problem-solving skills in designing and specifying welded structures.

Teaching Format

- 1 to 1-1/2 hour presentation by lecturer
  - Students ask questions to confirm or clarify points and respond to questions posed by lecturer.
- Tutorial
  - Class discussion of tutorial questions and topics of interest
- Self Study
  - Students study reference material.

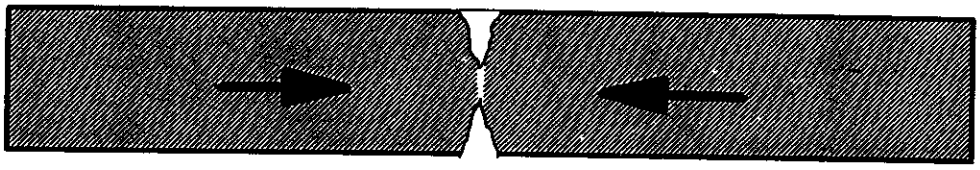
Welding Processes Introduction

What is a Weld?

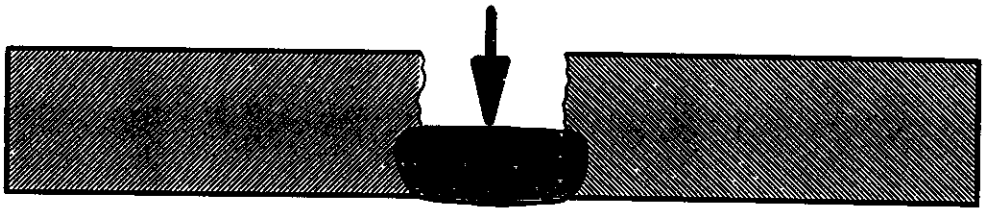
"A weld is a localized coalescence of metals brought about by the application of heat, with or without fusion, the addition of filler metal or the application of pressure"

American Welding Society

Basic Welding Techniques



Solid Phase Joining



Joining by Molten Metal Bridging

Requirements for a Welding Process

- Energy source
- Means for removal and exclusion of contaminants
- Control of weld metallurgy

History of Welding Processes

- Pre-industrial
  - prior to 19th century
- Invention
  - late 19th century
- Acceptance & development
  - mid 20th century to present

Pre-Industrial Joining Methods

- Soldering and brazing
  - Early civilizations joined metals for weapons, tools and jewellery
- Forge welding
  - During the Iron Age it was discovered that pieces of iron could be joined by heating and hammering
- Riveting and bolting

Early Developments

- Forge welding is unsuitable for joining large plates and shapes
- Fusion welding
  - Promised to solve the problem of joining large metal pieces
- "Fusion" = melting
  - Fusion welding requires a sufficiently intense heat source to be passed along the joint to melt the edges

Invention of Fusion Welding

- Electric arc
  - Experiments showed that electric arcs could melt metals
  - In 1885, Bernados was awarded the first patent on electric fusion welding
- Flames
  - The French chemist LeChatelier realized that oxygen-acetylene flames were also capable of melting metal
- Resistance Welding
  - Joule discovered that electrical resistance heating could be used to join metals

· a w - current

Acceptance & Development

- Welding used for production of military and civilian items in the western world during the 1940s
- New welding processes and techniques were subsequently developed
- Continued improvements in quality, performance, and cost

Welding Process Classification

Heat Source	Shielding Method					
	Vacuum	Inert Gas	Gas	Flux	No shielding	Mechanical exclusion
No heat	Cold pressure					
Mechanical	Explosive				Explosive	Friction, ultrasonic
Chemical		Plasma	Atomic hydrogen	Gas	Forge	Thermit
Electric resistance					HF induction, Flash butt	Spot, seam, butt welding
Electric arc		GTAW, GMAW, PAW	CO2 GMAW	SMAW, SAW, ESW, FCAW	Capacitor discharge	
Radiant Energy	Laser, Electron Beam	Laser	Laser	Laser	Laser	

Source: PT Houldcroft Welding *Process Technology*,, Cambridge University Press