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Department of Mechanical Engineering
RV College of Engineering®, Bengaluru – 560059

ELEMENTS OF MECHANICAL ENGINEERING

UNIT- II

VISION SYSTEM IN MANUFACTURING

&

JOINING PROCESSES

Unit- V (8 hours)

Vision system in Manufacturing: Introduction, Role of human vision in computer interaction, importance, types of computer vision in manufacturing, Architecture of a Vision System, Artificial Intelligent v/s Computer vision, applications of Computer vision in various industries, **A case study:** Computer inspection of Two-stage Soldering Defect in PCB board

Joining Process: Classification of Welding process, working of Arc Welding and Gas Welding Process.

Soldering, types of Solders and fluxes.

Introduction

vision systems are a set of integrated components that are designed to use information extracted from digital images to automatically guide manufacturing and production operations such as go/no testing and quality control processes.

These systems can also play a role in automated assembly verification and inspection operations through their ability to guide material handling equipment to position products or materials as needed in a given process. They have wide applications across different industries and can be used to automate any mundane, repetitive tasks that would become tiring to a human inspector or operator.

The use of machine vision systems allows for 100% inspection of products or parts in a process, resulting in improved yields, reductions in defect rates, increased quality, lower costs, and greater consistency of process results.

Usually, computer vision in manufacturing is used for product and quality inspection, structure surveillance, and tracking for damages or faults. Cameras allow manufacturing plants to inspect their products for tiny defects. They can be much more sensitive than the human eye, and machines' attention is never tired.

Role of human vision in computer interaction in manufacturing:

- Vision-based Human-computer interaction **provide a wider and more expressive range of input capabilities by using computer vision techniques to process data from one or more cameras.**

- Human–computer interaction (HCI) is research in the design and the use of computer technology, which focuses on the interfaces between people (users) and computers. HCI researchers observe the ways humans interact with computers and design technologies that **allow humans to interact with computers in novel ways**.

- Human–machine interaction (HMI) refers to **the communication and interaction between a human and a machine via a user interface**. Nowadays, natural user interfaces such as gestures have gained increasing attention as they allow humans to control machines through natural and intuitive behaviors.

Types of computer vision in manufacturing:

- Image segmentation
- object detection
- edge detection
- pattern detection
- image classification
- feature matching

Image segmentation:

Image segmentation involves **converting an image into a collection of regions of pixels that are represented by a mask or a labelled image**. By dividing an image into segments, you can process only the important segments of the image instead of processing the entire image.

Object detection:

The object detection works by : Gathering and organizing data– The computer interprets either a pixel-based or vector-based image, identifies the important data from the image, and classifies it into distinct objects to be analyzed and retained.

Edge detection:

Edge detection is an image processing technique for finding the boundaries of objects within images. It works by detecting discontinuities in brightness. Edge detection is used for image segmentation and data extraction in areas such as image processing, computer vision, and machine vision.

Pattern detection / Pattern recognition: It is **a data analysis method that uses machine learning algorithms to automatically recognize patterns and regularities in data**. This data can be anything from text and images to sounds or other definable qualities. Pattern recognition systems can recognize familiar patterns quickly and accurately.

Image classification:

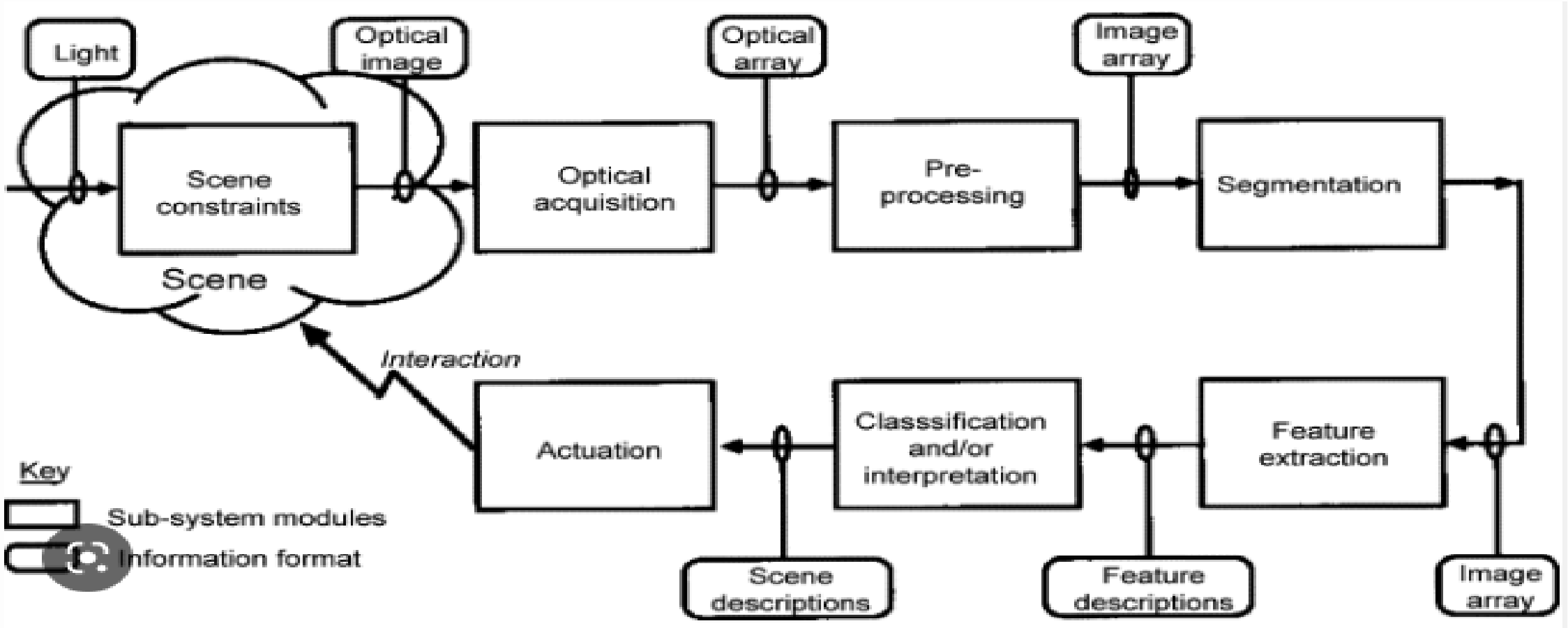
Industrial image processing is generally used in automated inspection systems. Image processing operations are used to improve the image quality, enhance desired features, and so on. Analysis of the enhanced images enables pattern recognition.

There are two types of methods used for image processing namely, analogue and digital image processing. Analogue image processing can be used for the hard copies like printouts and photographs. Image analysts use various fundamentals of interpretation while using these visual techniques.

Feature matching:

A manufacturing feature is commonly defined as a collection of related geometric elements which correspond to a particular manufacturing method or process, or which can be used to reason about the suitable manufacturing methods or processes for creating that geometry.

Architecture of a vision systems:



Differences between computer vision & artificial intelligence

- Computer vision is different from artificial intelligence because computer vision is used to process images with a set of general rules. At the same time, AI is a field where machines can learn to perform complicated tasks for themselves. For example, consider object recognition.
- Computer vision is a branch of AI. It only deals with helping machines discern what's in images or videos. AI also involves algorithms that deal with language, algorithms that predict things, algorithms that understand patterns changing over time, and much more.
- Computer Vision is the ability to recognize and discriminate between things in the same manner that humans do when walking or watching a movie that is at the heart of computer vision. A) conventional programming i.e. hard coding the description of all existent items in this world, which is impractical/impossible; or b) we can teach a computer the capacity to recognize and interact with any object in the universe. AI technologies like deep learning can be used to teach computers instead of handing them a set of instructions

SLAG
- Computer vision is very similar to human vision, only superior. Systems equipped with this type of AI can inspect and analyze thousands of products or processes in a matter of minutes, unlike the human brain.

Industrial Applications of computer vision system:

1. Automated assembly

- Cycle time control
- 3D vision monitoring
- Optimizing Supply Chains
- Digital Lean Manufacturing

2. Quality inspection of the product

3. Safety: Computer vision helps object tracker in a video and detects them in an image, thus allowing businesses to enhance their security significantly.

4. Factory synchronization and dynamic scheduling: Manufacturing systems (e.g., enterprise resource planning and manufacturing execution system) provide dynamic resource allocation and schedule. In addition, those systems accumulate and use visual data for real-time tracking of material and product movement. As a result, agility improves, inventory reduces, and overall equipment effectiveness grows.

Vision system in Manufacturing

5. Predictive maintenance: Equipment downtimes can be expensive, thus leading to substantial losses. Computer vision technology can consistently and accurately monitor production machinery for the early signs of degradation. Reinforced with IoT and deep learning, these computer vision systems can be highly accurate and consistent. As a result, they can alarm engineers for maintenance before it is too late and the issue occurs.

6. Reading barcodes and QR codes: It is a popular computer vision use case in the manufacturing industry. Recognizing and reading barcodes and text is not an easy task to do every day. Smart factories use modernized artificial intelligence as well as computer vision-powered systems and applications to solve this problem and flag off green signals for industrial automation.

7. Training: Computer vision could be used as a part of a machine learning system to create a virtual environment for training and skill development.

8. Track-and-trace: Some manufacturers must track and trace their products from the production line to the client. It is especially crucial for fresh food and medicine.

JOINING PROCESSES

WELDING

- Welding is a process of joining two pieces of metal by the application of heat with or without the application of pressure and filler material.
- Welding produces a permanent joint.
- Welding is used in joining pressure vessels, tanks, bridges, railways, machine frames & brackets, building the body of automobiles, aircrafts & ships etc.

Welding process may be broadly classified as;

1. Plastic welding or Pressure welding

2. Fusion welding or Non Pressure welding

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In this type of welding, the metal pieces to be joined are heated to a plastic state and then joined together by the application of pressure without the addition of filler material.

Ex: Forge welding, Resistance welding.

2. Fusion welding or Non Pressure welding

In this type of welding, the metal pieces to be joined are heated to molten state and allowed to solidify without the application of pressure. A filler material is used during the welding process.

Ex: Arc welding, Gas welding.

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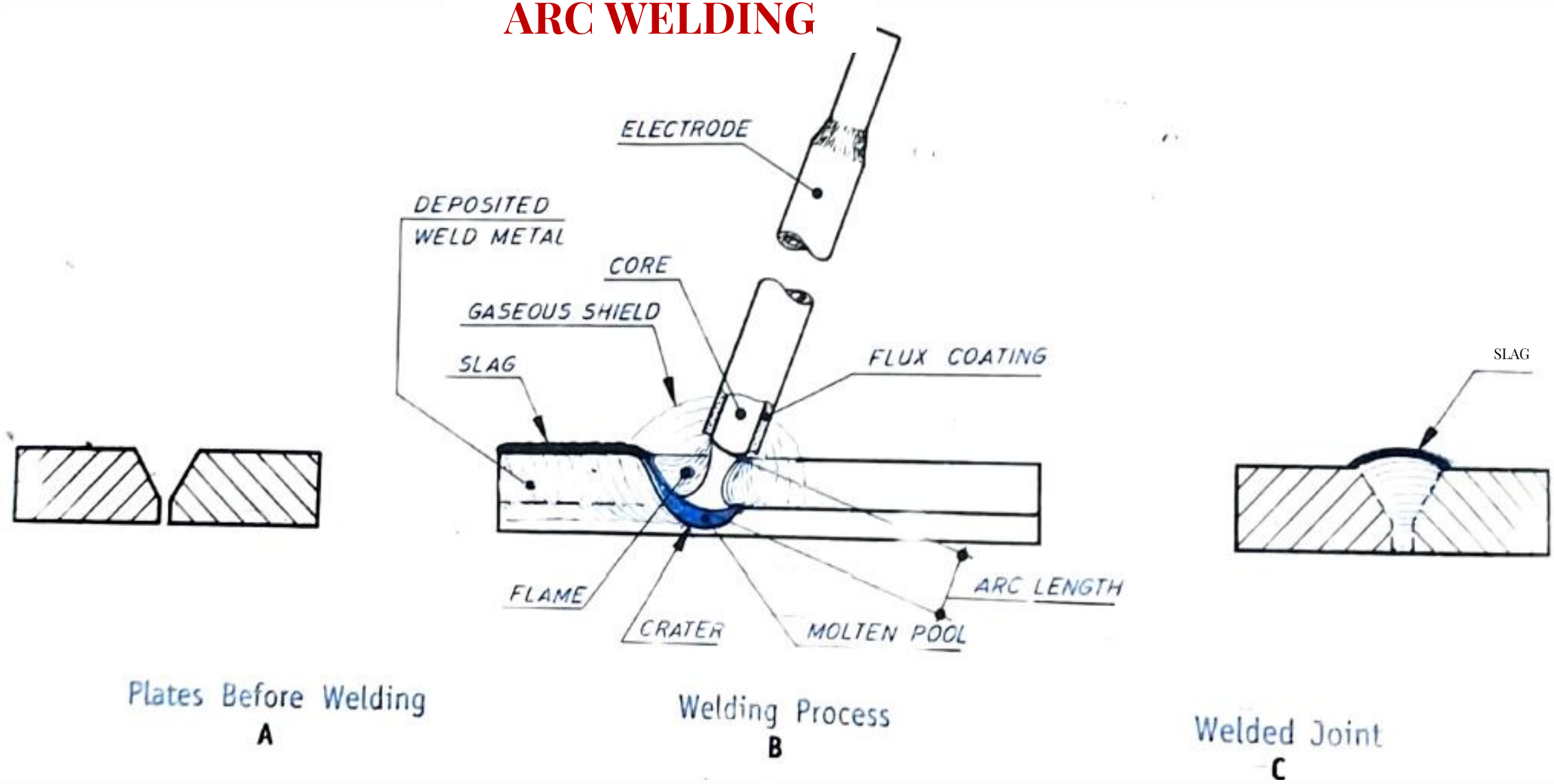
ARC WELDING

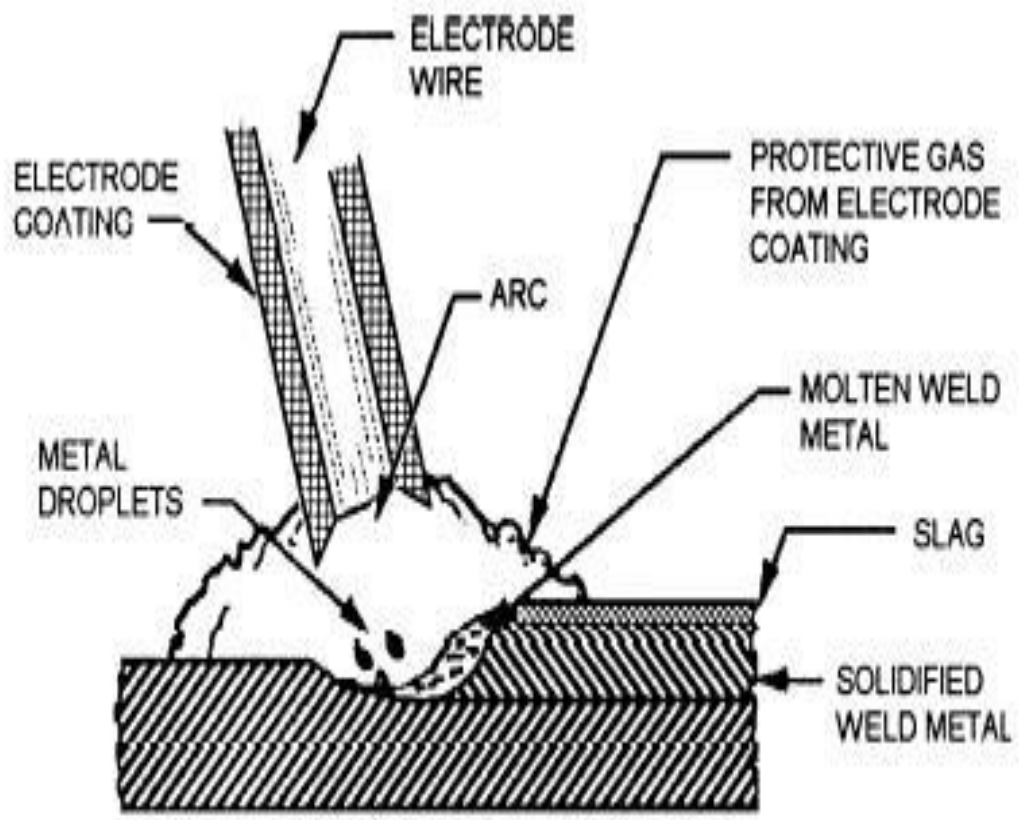
- The principle of arc welding is that, when two conductors of an electric circuit are touched together momentarily and then instantaneously separated slightly, an electric arc is formed.
- A high heat density is produced throughout the length of the arc at a temperature of 5000 to 6000 Centigrade.
- In arc welding, usually the parts to be welded are wired as one pole of the circuit, and the electrode held by the operator forms the other pole.
- When the arc is produced , the intense heat quickly melts the workpiece metal which is directly under the arc, forming a small molten metal pool.

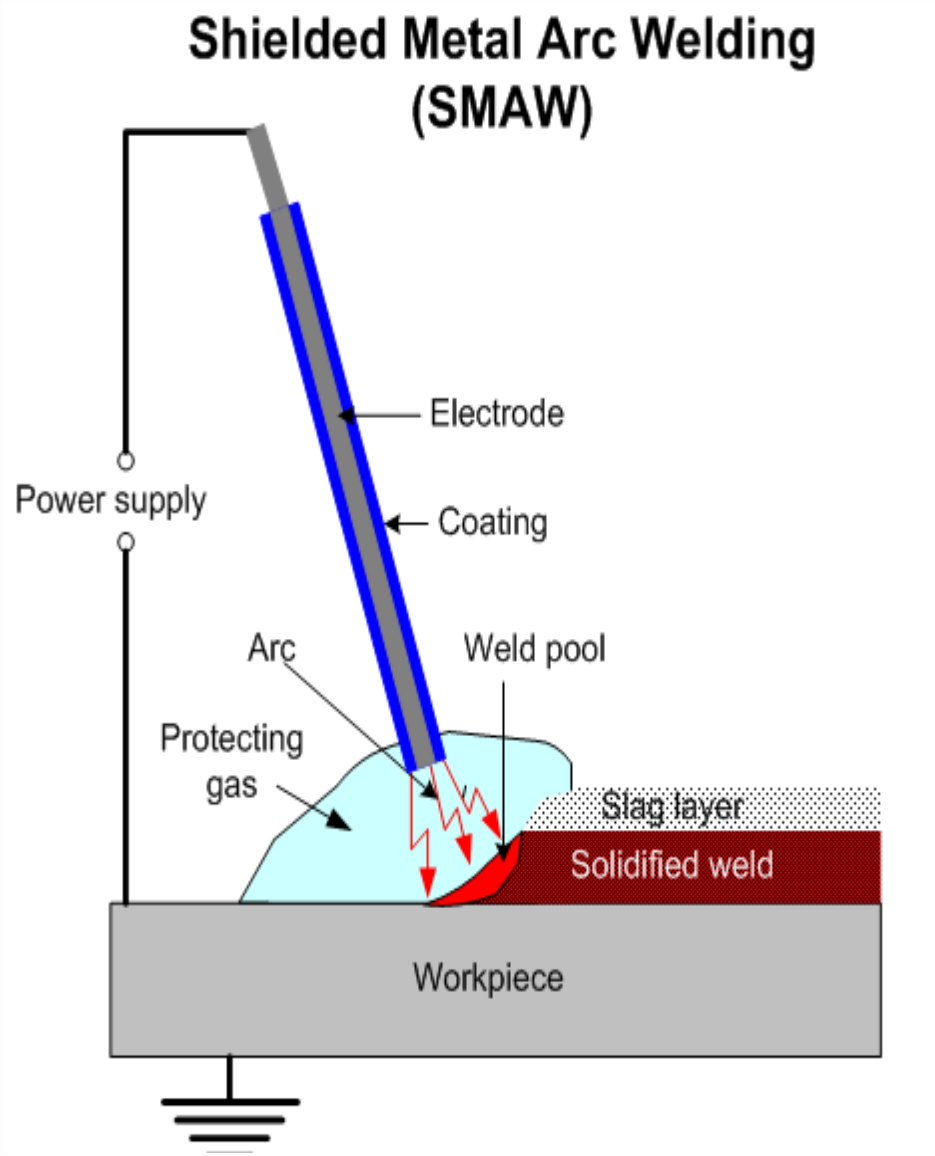
- At the same time the tip of the electrode at the arc also melts, and this molten metal of the electrode is carried over by the arc to the molten metal pool of the workpiece.
- The molten metal in the pool is agitated by the action of the arc, thoroughly mixing the base and the filler metal. A solid joint will be formed when the molten metal cools and solidifies.
- The flux coating over the electrode produces an inert gaseous shield surrounding the arc and protects the molten metal from oxidizing by coming in contact with the atmosphere.

ARC WELDING


ELECTRODE
DEPOSITED WELD METAL
CORE
GASEOUS SHIELD
SLAG
FLUX COATING
FLAME
CRATER
MOLTEN POOL
ARC LENGTH
SLAG
Plates Before Welding
A
Welding Process
B
Welded Joint
C

ARC Welding


ELECTRODE WIRE
ELECTRODE COATING
PROTECTIVE GAS FROM ELECTRODE COATING
ARC
MOLTEN WELD METAL
METAL DROPLETS
SLAG
SOLIDIFIED WELD METAL


Shielded Metal Arc Welding (SMAW)
Power supply
Electrode
Coating
Arc
Weld pool
Protecting gas
Slag layer
Solidified weld
Workpiece

Arc Welding Machine

- The function of a welding machine is to generate a low voltage (10 to 50 V) and high current. (50 A to 300 A).
- The current may be alternating current or direct current & the polarity of the electrode may be positive or negative, depending on the type of electrode and the metals to be welded.
- In A.C arc welding, a ***step down transformer is used to step down the voltage from 220/440 V to 80 to 100 V & a current of 100 to 400 A.***
- In D.C welding, the ***workpiece is connected to the +ve pole of a D.C generator and the electrode to –ve pole.***

- It is called ***'straight polarity' and is used when high heat is required.***
- When less heat is required, the polarity is reversed. Because of the option of reversing the polarity, D.C welding may be used to weld many metals which require more heat to melt.
- In A.C welding, the polarity changes in every cycle.
- Also the current & the voltage acquire a value of zero twice in every cycle, and hence higher voltage is required to maintain the arc.

ARC WELDING ELECTRODES

Welding Machine

Arc welding Electrodes

- The electrode used in arc welding is of consumable type & it is coated with flux.
- The flux coating is usually made of *chalk (lime), Ferro manganese, cellulose, Starch, Kaolin (China clay), iron powder, etc.*
- The flux forms a slag after welding which can be removed by chipping hammer & a wire brush.
- The purpose of coating the electrodes are;

(i) Protection of molten metal from oxidation

(ii) To prevent rapid cooling of molten metal

(iii) To establish & maintain the arc.

(iv) (iv) Addition of alloying elements.

PURPOSE OF EACH INGREDIENT OF FLUX COATING

- ***China clay, mica*** etc. produce a slag which because of its light weight forms a layer on the molten metal and protects the same from atmospheric contamination.
- Ingredients, like ***cellulose, wood, starch,*** calcium carbonate etc., form a protective gas shield around the electrode end, arc and weld pool.
- Deoxidizing elements like ***Ferro manganese*** refine the molten metal.
- Alloying elements like ***Ferro alloys of manganese, molybdenum*** etc. may be added to impart suitable properties and strength to the weld metal.
- ***Iron powder*** in the coating improves arc behaviour, bead appearance; helps increase metal deposition rate and arc travel speed.

SAFETY DEVICES USED IN ARC WELDING

- The welding shield protects the eyes from infra-red & ultra -violet radiations.
- Gloves are used to protect the hands from spark & to insulate from electric shocks
- Chipping hammer & wire brush to clear the slag.
- Apron to protect the clothing from sparks & spatter
- Earthing clamp will avoid the risk of electric shock.

GAS WELDING

Gas welding is a fusion method of welding in which a strong gas flame is used to raise the temperature of the workpiece to melt them. As in arc welding, a filler material is used to fill the joint.

The gas combinations that can be used for heating are;

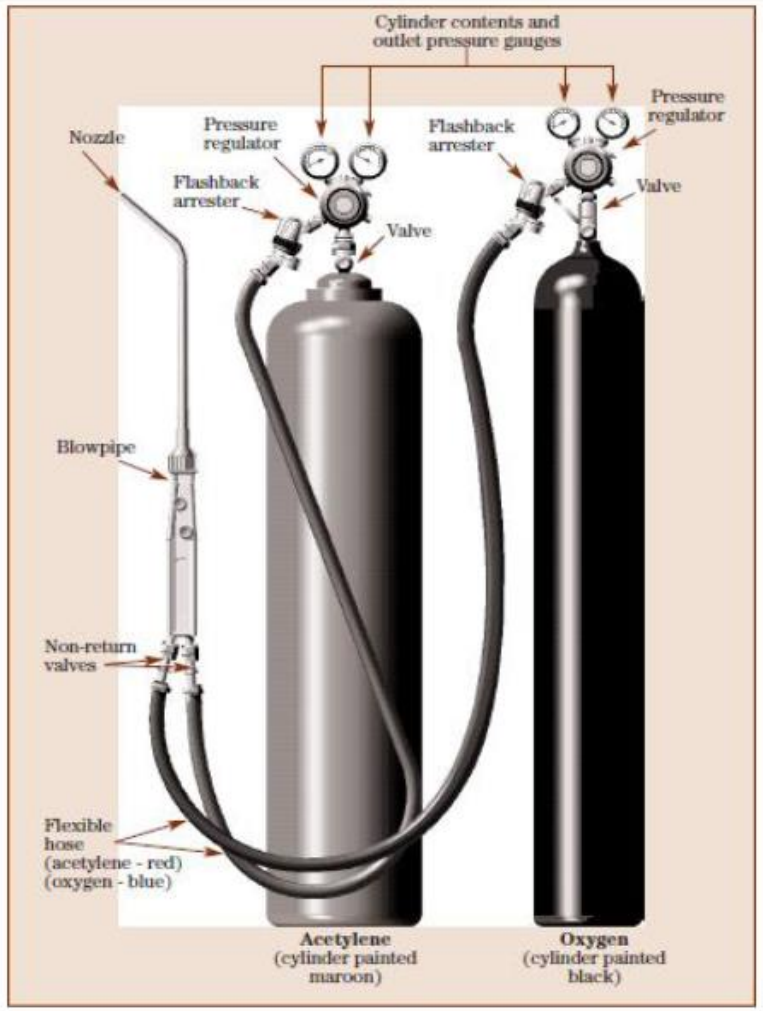
1. Oxygen & Acetylene

2. Oxygen & Hydrogen

OXY-ACETYLENE WELDING

- When right proportions of oxygen and acetylene are mixed in the welding torch and when ignited, the flame produced at the nozzle tip is called as the *Oxy-Acetylene Flame*. This flame when used in welding becomes Oxy-acetylene Welding.
- The temperature attained by the Oxy-acetylene flame is around 3200 Centigrade and therefore has the ability to melt all commercial metals. Thus, there is a complete bonding of the joining metals that can be achieved during welding

JOINING PROCESSES

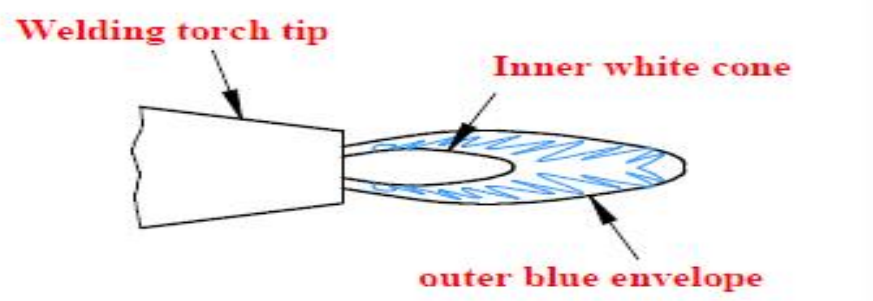


- The oxy-acetylene gas equipment consists of two large steel cylinders; one containing oxygen at high pressure and the other dissolved acetylene also at high pressure.
- It also consists of rubber tubes, pressure regulators, & blow torch.
- The oxygen and acetylene are supplied to the blow torch separately where both of them get mixed together and come out through the nozzle of the blow torch.

TYPES OF OXY-ACETYLENE FLAMES

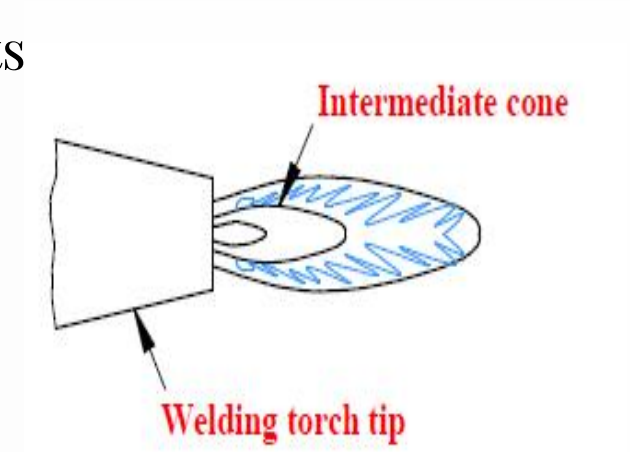
Neutral flame

- A Neutral flame is obtained by supplying equal volumes of oxygen & acetylene. (Oxygen: Acetylene = 1: 1)
- A neutral flame consists of an inner small whitish cone surrounded by a sharply defined blue flame.
- Most of the oxy-acetylene welding is done with the neutral flame.



CARBURIZING FLAME

- A Carburizing flame or reducing flame is obtained by supplying excess acetylene. (Oxygen : Acetylene = 0.95 :1)
- It has three cones; an inner white cone, surrounded by an intermediate whitish cone & a bluish envelope flame.
- Carburizing flame is used for welding alloy steels, cast iron & aluminium to protect from oxidizable elements



OXIDIZING FLAME:

- The Oxidizing flame is obtained when there is excess oxygen having gas ratio as high as 1.5. (Oxygen: Acetylene = 1.5 : 1)
- In appearance, it resembles a neutral flame except that the inner white cone is somewhat shorter.
- It is used for welding nickel and many non ferrous materials.
- This is used for oxy-acetylene cutting and is not suitable for welding, since the weld metal will be oxidized

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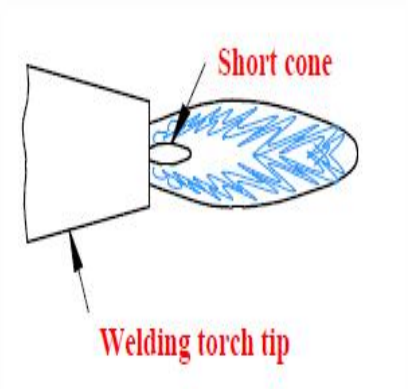

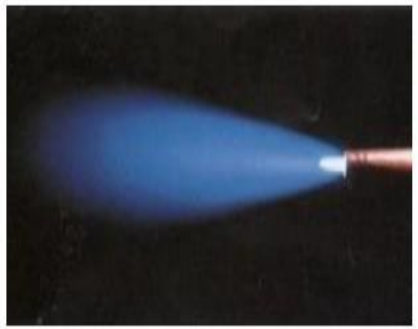

Defects in welding Common weld defects include:

Lack of fusion: It results from too little heat input and too rapid traverse of the welding torch (gas or electric)

Porosity: This occurs when gases are trapped in the solidifying weld metal.

Inclusions: These can occur when the slag covering a weld is not totally removed before another weld run.

Cracking: This can occur due to thermal shrinkage.

Undercut: This is due to excess melting of the parent metal which reduces the strength of the joint.

SOLDERING

- **Soldering is a process in which two or more metal items are joined together by melting and flowing a filler metal (solder) into the joint.**
- The filler metal will have a lower melting point than the workpiece ***(between 1500C-3500C).***
- Soldering differs from welding in that ***soldering does not involve melting the work pieces.***
- An alloy of lead & tin called '**soft solder**' is used for sheet metal work, plumbing work & electrical junctions. The melting temperature of the soft solder will be between 150 to 350 C.
- To clean the surfaces to be joined & to prevent oxidation, Zinc chloride is used as a flux.
- A soldering iron is used to apply heat produced from an electrical source.
- An alloy of Copper, Tin and Silver known as **Hard solder** is used for stronger joints. The soldering temperatures of hard solders ranges from 600 to 900 C

Method of Soldering

- **Cleaning of Joining surfaces:** The joining surfaces are cleaned mechanically to make them free from dust, oil, scales etc and ensure that the molten filler wets the surfaces.
- **Application of flux:** The joining surfaces are coated with a flux, usually rosin or borax. This cleans the surfaces chemically and helps the solder in making a bond.
- **Tinning of the surfaces to be soldered:** Before carrying out the soldering operation, the soldering iron must be “tinned”. This is to remove a thin that forms on the copper bit.

Method of Soldering

- **Heating:** The soldering iron is then heated and the flowing molten filler metal fills the joint interface. Allow the soldered area to cool and then solidify thus making the joint.
- **Final clean Up :** After completing the soldering, and the joints are formed, clean it with steel wool or solvent to remove left –over flux. After this clean the soldering iron using a damp sponge.

Soldering Iron

Soldering Flux

Soldering wire

SOLDERING INSTRUMENTS