

# Content

- ▶ Monitoring techniques
  - ▶ Arc sensors
  - ▶ Optical sensors
  - ▶ Infrared sensors
  - ▶ Ultrasonic sensors
  - ▶ Digitalised visual testing
  - ▶ Macroscopic weld bead inspection
  - ▶ Others

# Monitoring techniques – Arc sensors

## Principle

- ▶ Control the arc length using an automatic voltage/current control system
- ▶ Measurement of the position of the electrode compared to the workpiece.

## Advantages

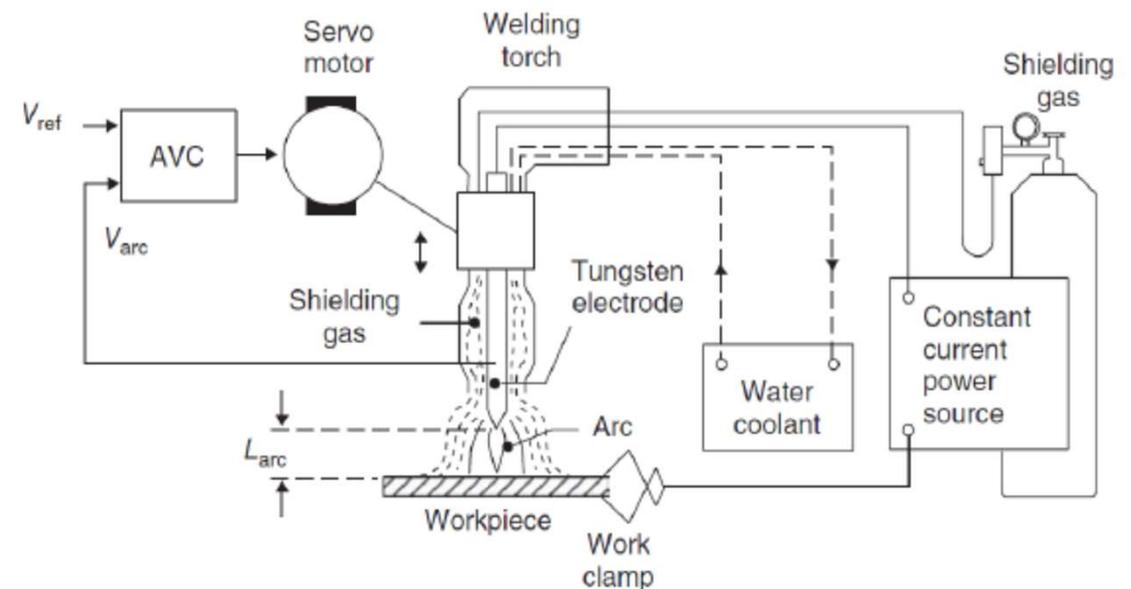
- ▶ No need for additional space
- ▶ Sensing accuracy not affected by wire bending, smoke, welding spatter, and arc heat
- ▶ Relatively low-cost and low maintenance costs

## Limitations

- ▶ reliability depends on the groove geometry, welding position, arc sensor algorithm

## Applications

- ▶ Automatic 3D seam tracking



# Monitoring techniques – Optical sensors

## Principle

- ▶ Photosensors for arc length detection, weld pool oscillation analysis, and weld pool measurement.
- ▶ Light source sensed by the optical sensor can be used to estimate and measure the welding process variables and adjust the welding parameters inline
- ▶ Sensors : electro-optic, CCD, CMOS sensors, high speed camera

## Advantages

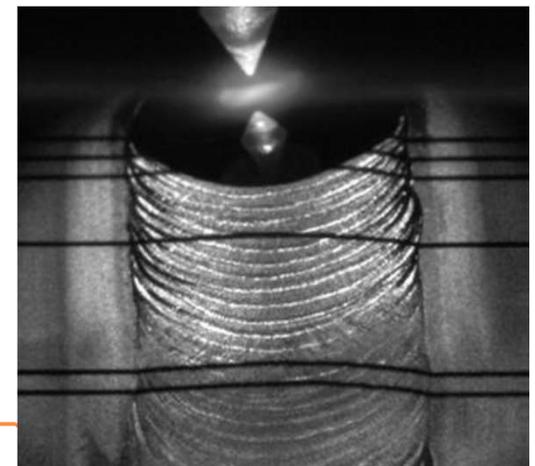
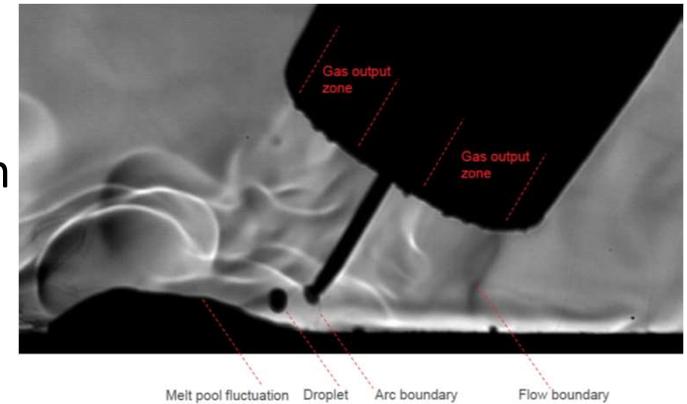
- ▶ Contactless detection
- ▶ Rapid changes are detectable by the high speed camera

## Limitations

- ▶ Sensitive in a harsh environment (smoke, spatter)

## Applications

- ▶ Monitoring of weld pool behaviour
- ▶ Measurement of plasma temperature
- ▶ Defect detection



# Monitoring techniques – Infrared sensors

## Principle

- ▶ Measure the emission radiation from the surface of the weld
- ▶ Provide information about the temperature profile, cooling rate, seam tracking, bead width, and penetration depth

## Advantages

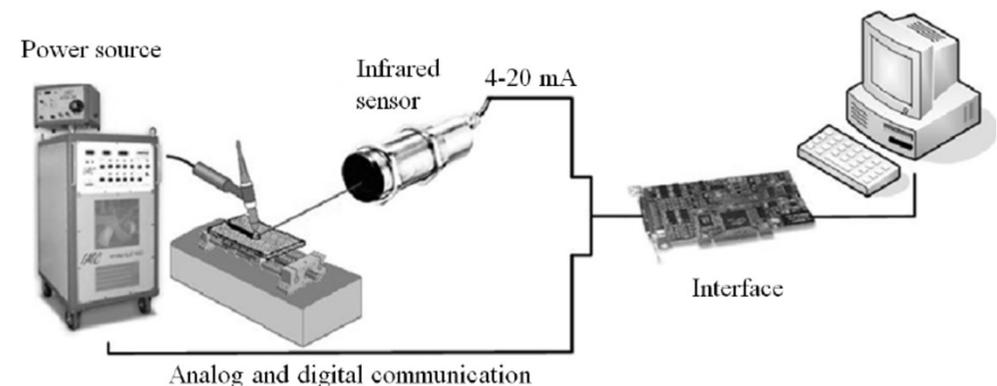
- ▶ Small size and low cost
- ▶ Placed near the welding area

## Limitations

- ▶ Interference with the arc radiation and emissions

## Applications

- ▶ TIG welding
- ▶ Monitoring of weld process parameters, such as the weld penetration depth, seam tracking, cooling rate measurements, weld bead monitoring



# Monitoring techniques – Ultrasonic sensors

## Principle

- ▶ Measurement of acoustic waves of high frequency
- ▶ Piezo-electric transducer to convert ultrasonic vibrations into electric signals

## Advantages

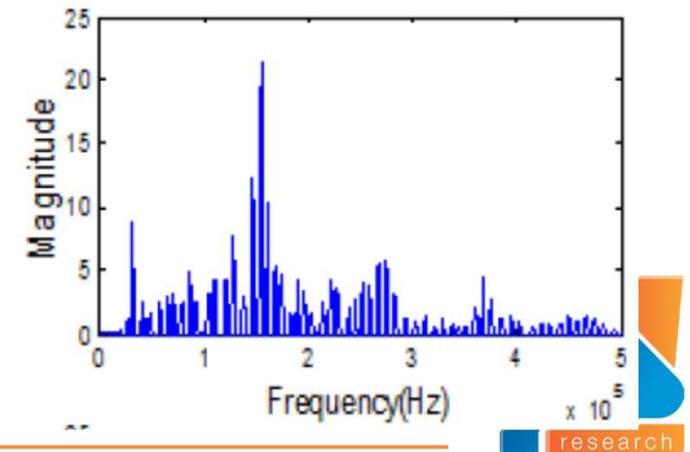
- ▶ Can be non-contact
- ▶ High resolution
- ▶ Access in tight spaces

## Limitations

- ▶ Complexity

## Applications

- ▶ Inline detection of weld defects



# Monitoring techniques – Digitalised visual testing

## Principle

- ▶ Measurement of the weld geometry

- ▶ Laser scanner

## Advantages

- ▶ non-contact
- ▶ High resolution

## Applications

- ▶ MIG/MAG welding

