

Sensor Torch Based Adaptive Intelligent Control for Circumferential Welding of Pipes

An ONR SBIR Phase I Project

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Objectives

- **Manual welding of pipes with guaranteed full penetration by welders with minimal skills;**
- **Orbital welding of pipes with guaranteed full penetration for (roughly prepared) square butt joints of up to 3/8 in. thick wall.**

Method: Adaptive Sensing and Control

- **Sense the weld penetration;**
- **Switch the current to the base level after the full penetration is confirmed.**

- **Full penetration: guaranteed;**
- **Burn-through: WILL NOT OCCUR before the current is switched to the base level after the full penetration is achieved.**

- **Why Adaptive and Can Be Used for Manual Operation ?**

KEY: Sensor

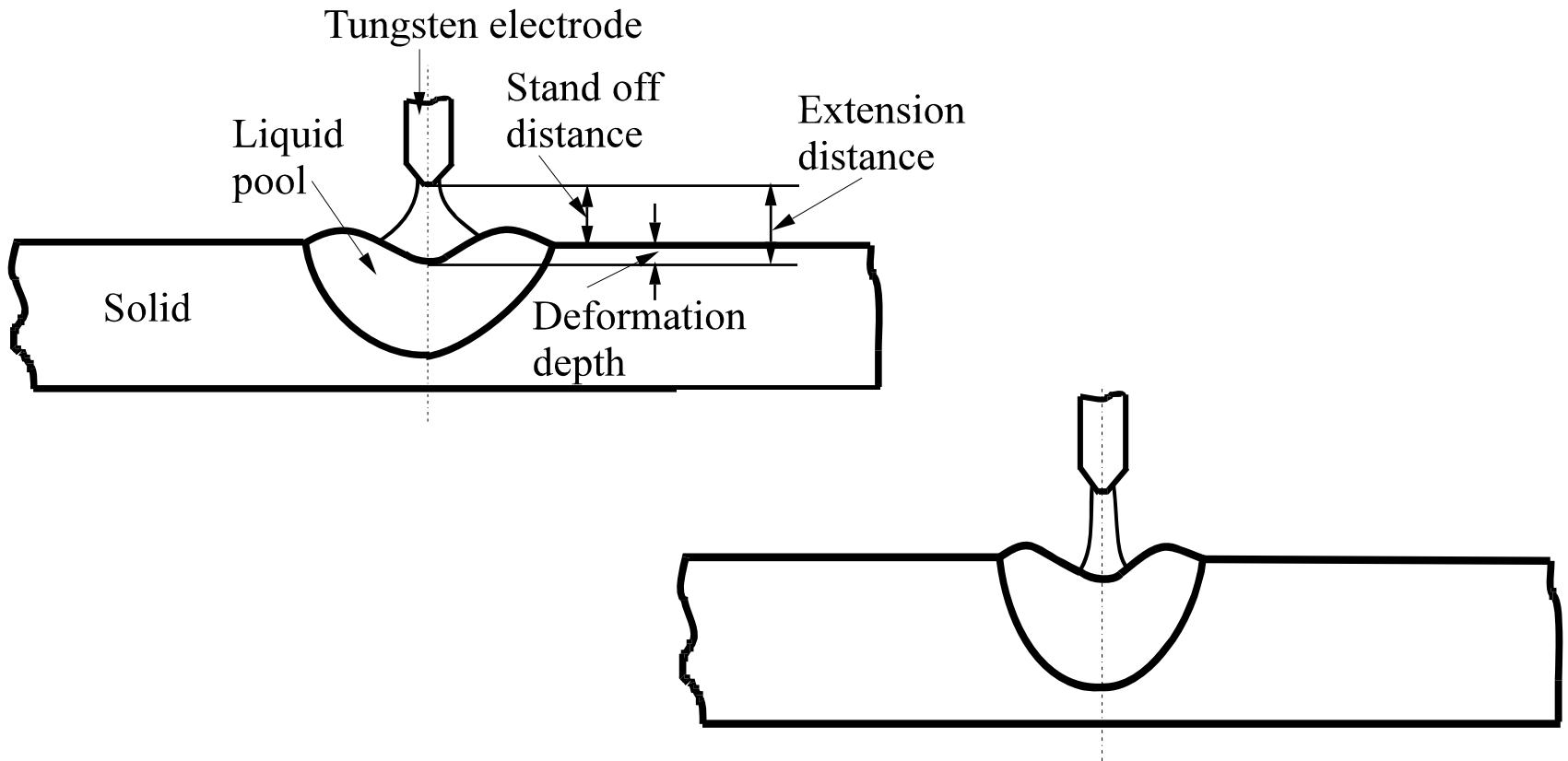
A durable sensor which is reliable and can be carried by welders

Technical Approach

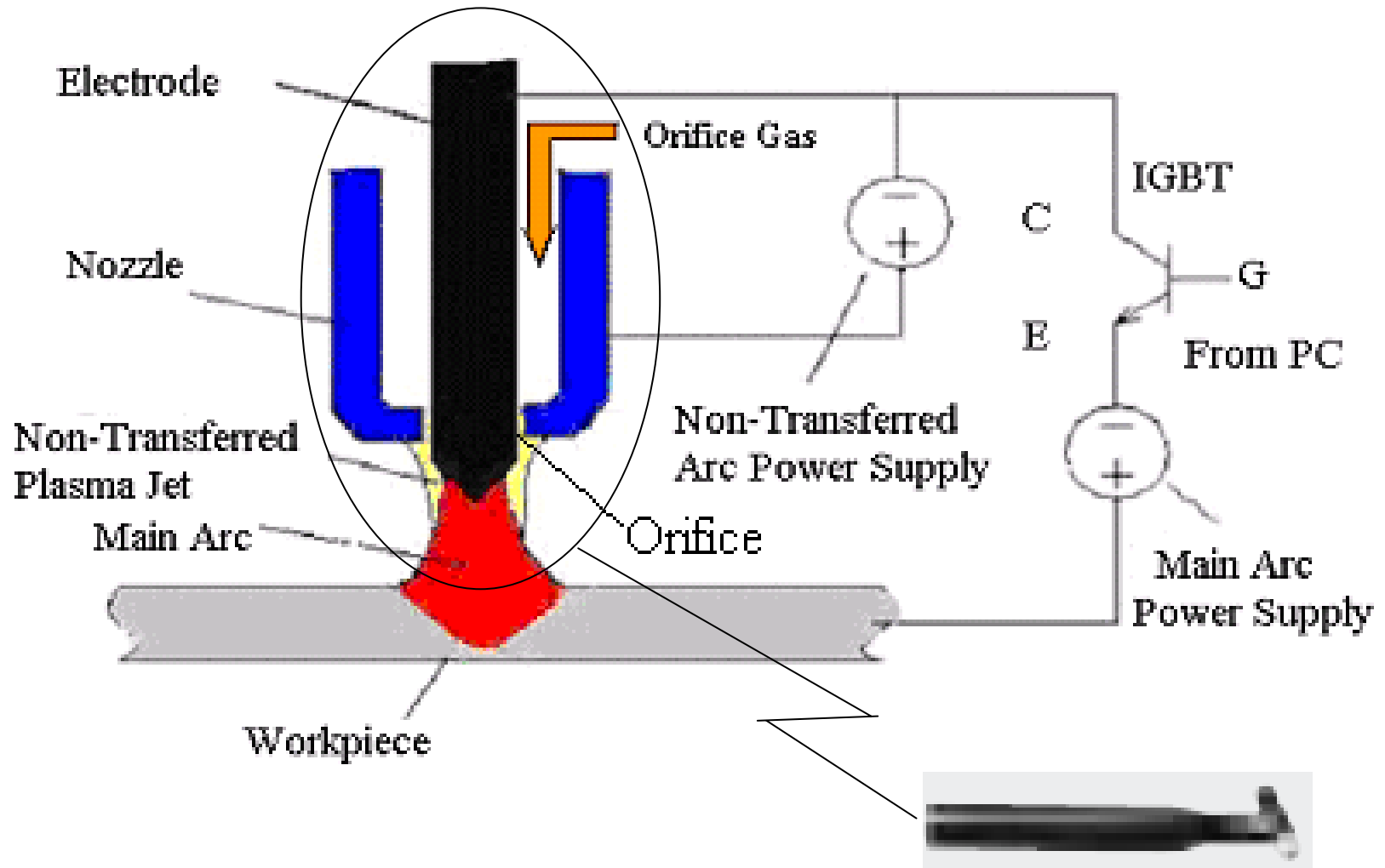
- **Measure the depth of the weld pool surface to determine the degree of the weld penetration;**
- **Why?**
 - (1) Skilled welders can observe the shape of the weld pool surface and use the observed information for penetration control;**
 - (2) Burn-through can only happen when the depth of the weld pool increases to certain level.**

Non-transferred Plasma Charge Sensor

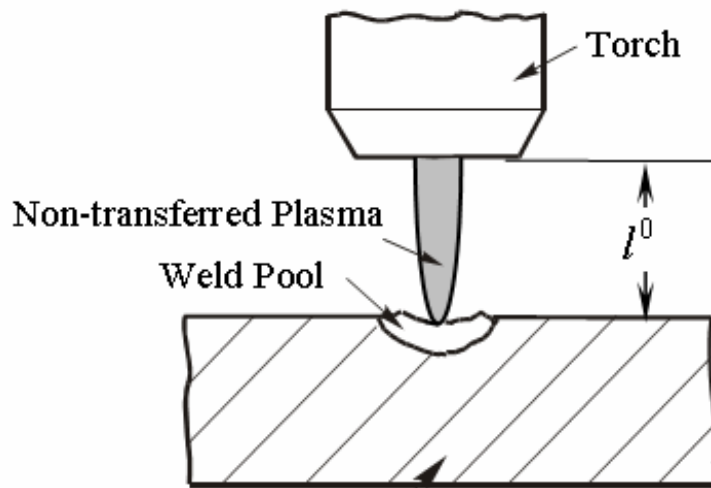
- Arc behavior and weld pool surface



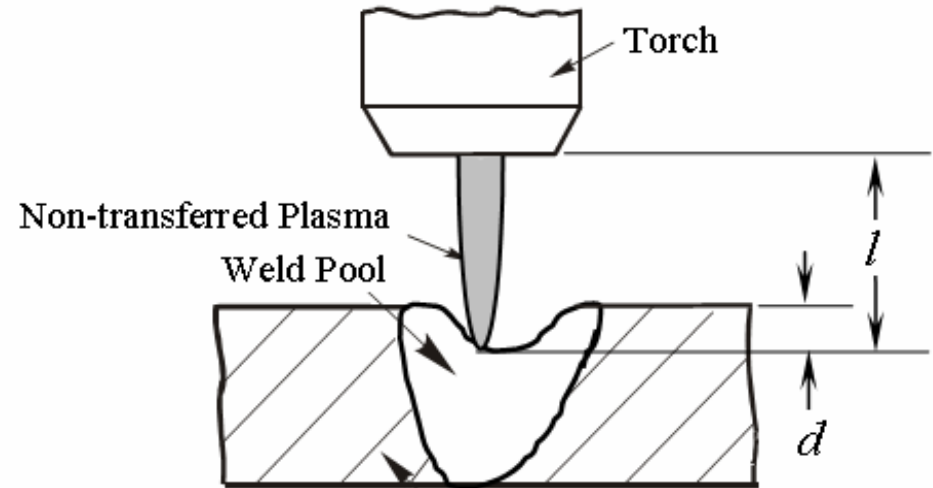
Integrated Sensing/Welding System



Robust/Adaptive Sensing GTAW Application



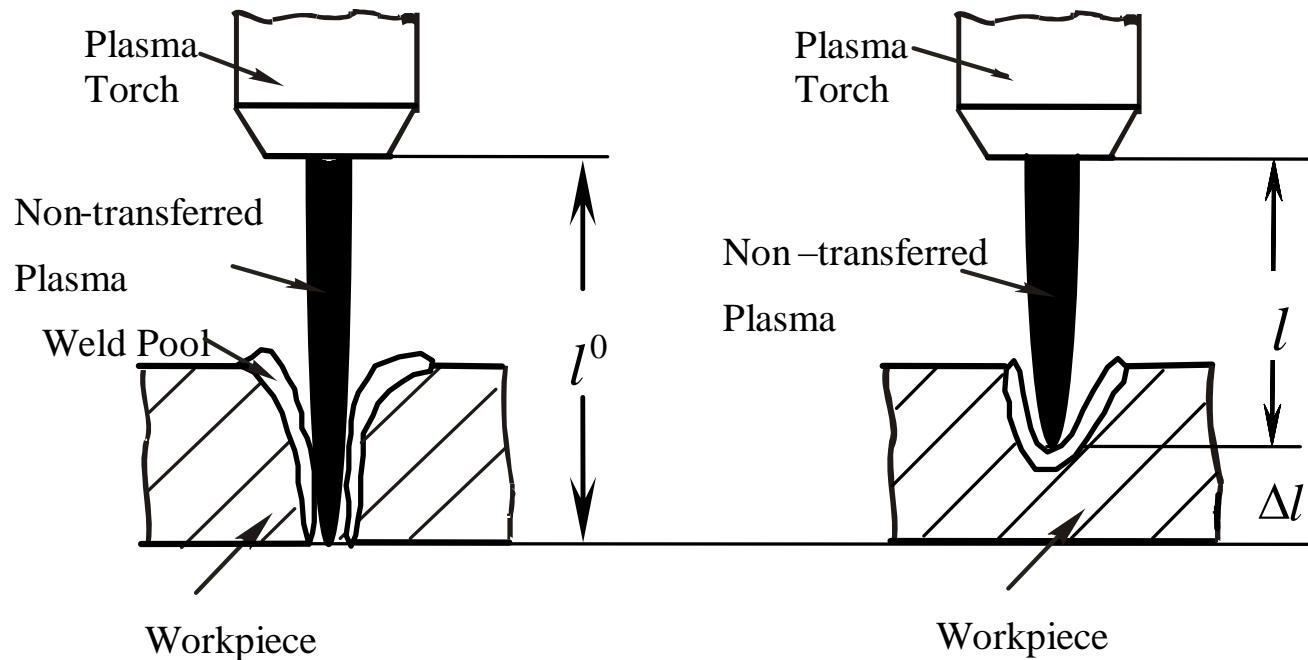
Workpiece
(a) Reference



Workpiece
(b) Distance to the reference

$$\Delta l = l^0 - l = \frac{A}{V_a^0} - \frac{A}{V_a} = A \frac{V_a - V_a^0}{V_a^0 V_a} = A \frac{\Delta V}{V_a^0 V_a}$$

Robust/Adaptive Keyhole Sensor for Thick Plate: Plasma Application

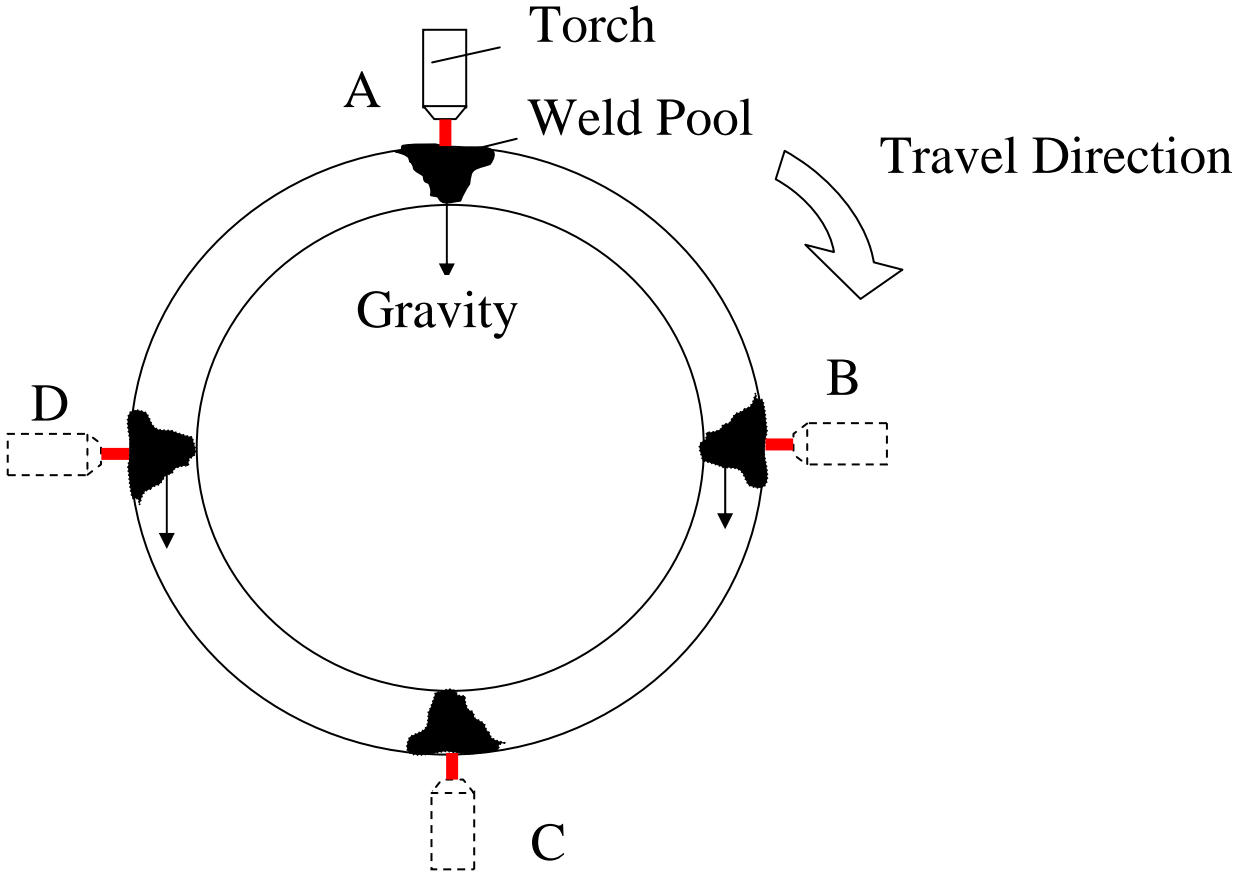


(a) Reference

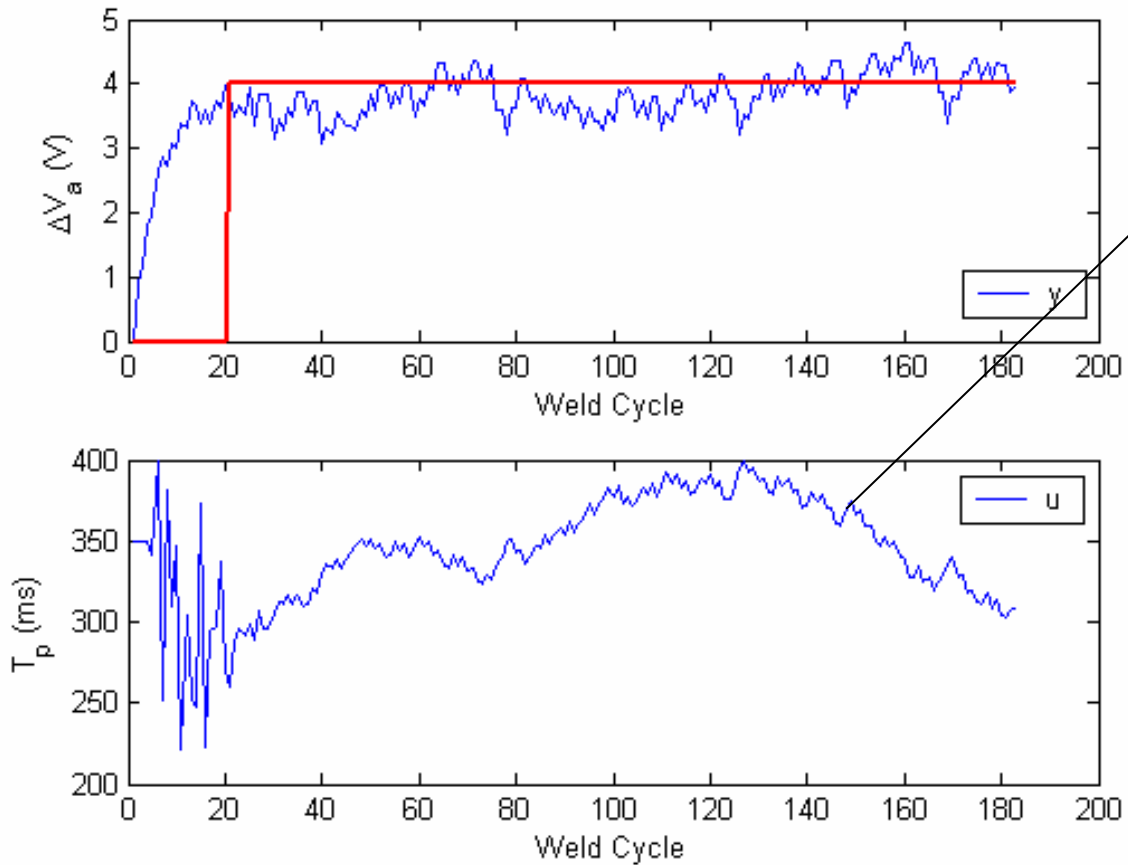
(b) Distance to the reference

$$\Delta l = l^0 - l = \frac{A}{V_a^0} - \frac{A}{V_a} = A \frac{V_a - V_a^0}{V_a^0 V_a} = A \frac{\Delta V_a}{V_a^0 V_a}$$

Laboratory Demonstration Circumferential Pipe Welding



Controlled Pipe Welding half circumference



Welding Parameters are automatically changed.

Controlled Pipe Welding



SBIR Project

- **Phase I: Demonstrate the feasibility for manual operation for 1/8" wall thickness and 3/16" wall thickness using a manual torch;**
- **Phase II:**
 - (1) Develop the control system which works for manual and automated operations;**
 - (2) Demonstrate at shipyards.**
- **Partners: Bath Iron, Ingalls (manual operation)
Newport News (automated operation)
Magnatech (integrates the control system in their pipe welding systems, commercialization, marketing)**