Today’s Topics

- Machine Shop Welding Processes for Steel & Aluminum
- Brazing Advantages & Alloys
- Welding & Brazing Examples
Machine Shop Welding Processes

- Stick
- MIG/Flux Core
- Oxyacetylene
- TIG
Stick Welding

- Electrode Lead
- AC or DC
- Constant Current Power Supply
- Work Lead
- Welding Electrode
- Work
- Ground Clamp

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Stick – General

- Limited heat control: ON/OFF
- \( \approx 1/8" \) steel
- Medium skill & practice required
- Excellent for plate, angle iron, shapes
- Very good penetration
- $400–600 for basic equipment
- Really for heavier work pieces of uniform thickness

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Stick Premium Rods – When Nothing Else Works

- Repair or “Premium” rods available for unknown, hard-to-wet metals & cast iron
- No AWS Classification
- $50/lb, often 10lb minimum
- Available from: Castolin Eutectic, Stoody/Thermadyne, Haynes International/Hastelloy

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Stick Welding Aluminum

- Aluminum welding rods are available
- Thickness $\approx \frac{1}{8}$" steel
- Great for field repairs of pipe & tanks
- Excellent in wind
- Requires considerable practice
- Serious flux problem
Stick Aluminum Flux Problems

- Flux very aggressive & nearly impossible to remove, burns through paint
- Maximum 1" weld bead before flux melts off
- ≈ 1/8" Al thickness
- Great for field repairs of pipe & tanks
- Excellent in wind
- Requires considerable practice
- Not for precise work
Stick Aluminum Welding Rods

Bottom Line:
- Limited shop applications
- Hard to use
- Better alternatives

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# Stick Welding Process Capabilities Summary

<table>
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<tr>
<th>Process</th>
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<tbody>
<tr>
<td>Stick &gt;1/8&quot;</td>
<td>★★★★</td>
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Wire Feed Welding

MIG/FCAW has "ON/OFF" problem of stick welding, so limited control

Easy to learn

$600–800 for basic small machines

Fast metal deposition

Good penetration on steel

For larger scale work pieces
Wire Feed Welding

- Work
- Shielding Gas Supply
- Shielding Gas Regulator
- Shielding Cylinder
- Gas Flowmeter
- Electrode Spool
- Drive Motor
- Cable Assembly Termination
- Motor Driven Pinch Rollers
- Cable Assembly
- Work Lead
- Welding Gun
- Gun Switch
- Direct Current Constant Voltage Power Source
- Voltage Control
- Wire Feed Speed
- Switch Circuit for Electrode Feed Motor and Arc
- Shielding Gas to Electrically Controlled Valve
- Shielding Gas Supply
- Welding Power to Work
- Input Power

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Entry Level Miller
140 A Wire Feeder

Electrode Wire on Feed Spool

Feed Roller Mechanism (See Blow-up Below)

Without Nozzle for Fluxcore

Nozzle for GMAW

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Wire Feed Welding Aluminum

- MIG (GMAW) welds Aluminum, uses argon cover gas
- No self-shielded process like FCAW
- Excellent for plate, tanks, heavy sections
- Easily & often automated
- See aluminum tanker trucks on the road with beautiful long weld beads

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Wire Feed Welding
Aluminum Problems

- Aluminum removes heat rapidly
- Minimum 180 A power supply
- 140 A welders that run on 20 A/110 Volts won’t work properly
Aluminum Wire Feed Welding Wire Problems

- Aluminum wire is soft, “birdnests” & cannot be pushed through cable
- Requires spool gun or push-pull gun
- Guns $500–1500
- Waste of time without these guns
- Inexpensive guns are rarely work well
Wire Feed Welding
Aluminum – Spool Gun

Electrode Wire Spool
Gas Diffuser
DC Drive Motor Housing
Power Wires
Shielding Gas Hose
Wire Feed Welding
Aluminum Push-Pull Gun
Wire Feed Welding
Aluminum – Preheating

- Every 100°F = 10 A welding Current
- Preheat to 350–400°F in oven or on hot plate
- Decreases HAZ width as work gets up to temp faster
Wire Feed Welding
Aluminum – Bad Practice
Department

- Preheating work with oxyacetylene torch & sooting for temperature indication
- Idea is carbon sublimes at preheat temperature
- Adds carbon to weld, never good
- Risks liquation & heat treat modification
- Solution: Go to HF and buy laser temp probe for $50, or send job to pro!
# Wire Feed Welding Process Capabilities

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Oxyacetylene Welding in the Machine Shop

- Integral Check Valve
- Integral Flashback Arrestor Element
- Victor Model 100 FC
- Replaceable Tips
- Plastic Dust Caps
- Classic Aircrafter Bantam Model 44
- A-Size to B-Size Hose Adapter
- Smith or HF Miniature
- Replaceable Tip
Oxyacetylene Welding in the Machine Shop

- Welds have very good appearance
- Excellent for steel
- Small torches, small wire for small work
- Requires 100+ hours to gain puddle control
- Excellent for tubing race car & airframes

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Oxyacetylene Welding Aluminum

- Welding rods may have internal, external, or separately applied flux
- Many rods have shelf life
- Pre-cleaning is critical
- Requires considerable practice for acceptable results

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Oxyacetylene Welding of Aluminum Conclusions

- OK if you are prepared to spend the time developing the torch skills
- Control not as good as TIG
- For medium to large work
- Many rods have shelf life
- Pre-cleaning is critical
- There are better alternatives
Oxyacetylene Welding of Aluminum Conclusions

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TIG in the Machine Shop

Think of TIG torch as an electric flame
Control of heat input & weld puddle are best of all welding processes when used with foot control
Requires practice & good hand/eye/foot coördination
TIG in the Machine Shop

- Direction of Welding
- Gas Nozzle
- Nonconsumable Tungsten Electrode
- Filler Metal
- Arc
- Gas Shield
- Shielding Gas in Solidified Weld Metal
- Current Conductor
What TIG Can Do

- Weld any pure metal with itself
- Weld most alloys except brass
- Apply silicon bronze braze filler metal to steel, stainless steel & cast iron
- Apply Aladdin aluminum rod to aluminum & white metal castings
- Use rods from 1/8" to 0.020"

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TIG Power Supplies

- $200 for basic Harbour Freight for steel, but no foot control
- $2600 for Miller to do steel & aluminum includes foot control
- Many possible electronic features
- The more money, the more features, easier to get good results with less skill
$4000 TIG Power Supply

THERMAL Arc 300GTSW

AMPERAGE / VOLTAGE
METER
A V
PREVIEW (PUSH)

PULSER SLOPER
OFF ON

STICK OUTPUT SELECTOR
H.F. START TIG
AC DC
LIFT START

POWER WARNING

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Welding vs. Brazing & Soldering

- Welding joins via *fusion*
- Brazing & Soldering via *adhesion* or inter-atomic attraction

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Soldering vs. Brazing

- Solders considerably weaker than brazes
- Some brazes approach strength of welds
- Brazing can hide the braze & color-match the workpiece
Soldering vs. Brazing

- Soldering under 840° F
- Brazing over 840° F

- Solders: Pb, Sn, Sb, Cd
- Braze Filler Metals: Ag, Cu, Sn, Cd, Zn, Al, Ni, Si, P

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Silver Solder

- Commonly used in jewelry
- A few percent silver plus lead & other elements
- Much weaker than silver braze
Brazing Advantages over Welding

- Lower temperatures
- Joins dissimilar metals
- Joins most metals, carbides & ceramics
- Parts may be repositioned/salvaged
- Some materials that cannot be welded, can be brazed
- Lower skill, less expensive equipment
- No distortion & precise positioning
Principal Brazing Alloys

- Brass
- Silver with & without cadmium
- Silicon-Bronze
- Sil-Fos
Brass Brazing

- 1650°F or dull red heat
- 60% Copper/40% Zinc
- Borax water-based flux
- 56,000–60,000 psi
- Steel, stainless, cast iron
- Inexpensive & widely available

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Silver Brazing

≈ 1200° F
5–50% Silver, rest copper & zinc
Higher the silver, lower the MP
Many alloys available
40,000–130,00 psi
f(clearance, surface roughness, alloy)
Expensive, $50+/ounce
Capillary attraction in small cracks

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Rôle of Cadmium

- Improves Wetting
- May lower melting point
- Cadmium fumes toxic may cause loss of brain cells
- Cadmium ions toxic in food
Silver Brazing Steel

Cut Line for 1/4" Snap-on Extension

1/2" Brass Base

1/4" Snap-On
Socket Extension

Step to Fit Base

Cut a Registration

Cut Chamfers

Fill Chamfer with Braze Metal Chips

Slip Fit 0.003-0.004" Oversized

Braze

Finished Close
Quarters Socket

Socket Head

Chips

Socket Extension

1/4" Snap-On

Straight Knurls
Silver Braze Strength + Precise Registration

Stainless Steel Nozzle Fitting

Positive Bottom Stop for Tubing Position

0.002--0.004" Oversize Hole Opening for Braze Filler Metal

Stainless Steel Hypodermic Tubing

Slip-fit Section to Align Tubing Axially
Silicon Bronze Filler Metal

- Can be applied by brazing or with TIG torch
- Lower shrinkage vs. weld filler metals
- Steel, stainless steel, cast iron
- Golden sheen
Sil-Fos Ag-P Brazing Alloys

- Special silver braze category
- No need to clean copper tubing
- Alloys with copper
- For critical or high-pressure lines
- Excellent vibration resistance
- Joints cannot be disassembled

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Aladdin 3-in-1 Aluminum Rod

- Aluminum, Zinc, White Metal Repair
- 720° F melting point
- 120° F below brazing temperature
- Weak joints
- Scrub with s/s brush under flame
- No flux
- Solder & solder welds

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Solder Welding
Aluminum Propeller with
Aladdin 3-in-1 Aluminum Rod

Repair Example: Repairing a Propeller
Conclusions

- There are many alternatives for joining metals in the shop.
- Choice depends on availability, metals, skills, cost, strength, appearance.
- TIG is not cheap, but very versatile.