Tool Design for Joining Processes

ITCD – 301-001
Types of joining processes

- Physical
  - Application of heat
  - Application of pressure
  - Both heat and pressure
- Mechanical
  - Does not involve changes in composition
  - Edges remain distinct
Tooling in joining

• Hold the parts in correct relationship
• Assist and control the joining process
• Mechanically or physically
• Alignment of workpieces
• Physical joining requires tooling
• High temperature makes manual positioning impractical
• Tooling for hot processes should withstand heat and accelerate or retard flow of heat
• Hot fixtures should have thermal expansion coefficient so that it remains functional
Welding Fixtures

<table>
<thead>
<tr>
<th>Heat Input</th>
<th>Process</th>
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<tbody>
<tr>
<td>High</td>
<td>Gas tungsten-arc welding</td>
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<td>Shielded metal-arc welding</td>
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<td>Gas metal-arc welding</td>
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<td>Flux-cored arc welding</td>
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<td>Low</td>
<td>Submerged-arc welding</td>
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<td>Laser</td>
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Figure 10-1. Degree of heat input based on process.
Distortion

Figure 10-2. Typical types of distortion occurring during welding.
Distortion based on material type

Distortion Potential by Material Type

- Low-carbon steel
- High-strength steel
- Nickel-based alloys
- Nickel-copper alloys
- Copper alloys
- Stainless steel
- Aluminum

Figure 10-3. Distortion potential based on material type.
Fixture design objectives

• Hold the part in the best position
• Providing proper heat control of the weld zone
• Provide suitable clamping to reduce distortion
• Providing channels and outlets for welding atmosphere
• Providing access for the welding process
• Providing for ease of operation, part loading and unloading
Other factors

- Cost of fixture
- Size of the production run and rates
- Adaptability of available welding equipment
- Complexity of the weld
- Quality required in the weldment
- Welding process to be used
- Conditions of welding
- Dimensional tolerances
- Materials to be welded
- Part-surface finish requirements
- Coefficient of thermal expansion and thermal conductivity of workpiece and tool
Gravity type fixture gas welding fixture

Figure 10-4. Simple welding fixture using gravity to help locate parts.
Gas welding fixture

Figure 10-5. Workpieces with simple fixturing for gas-welding operations.
Factors for gas welding fixtures

• Part print tolerances
• Material heat resistance
• Heat-transfer qualities
• Fixture rigidity required to ensure workpiece alignment accuracy
• Prevent rapid heat dissipation from the weld area
• Cast Iron, carbon steel and stainless steel
Arc welding fixtures

Figure 10-7. Workpiece with simple fixturing for arc-welding operations. (Courtesy Alloy Rods Division, Chemetron Corp.)
Arc welding fixtures

Figure 10-6. Typical backing bars. (Courtesy Alloy Rods Division, Chemetron Corp.)

Figure 10-8. Backing bars with provisions for (a) directed gas flow, (b) diffused gas flow, and (c) pressurized gas.
Design considerations in arc welding

• Exert enough force to prevent or minimize part misalignment
• Too much restraint leads to weld cracking due to residual stresses
• Promote heat dissipation from the weld line
• Support the molten weld, govern the weld contour
• Protect the root of the weld from the atmosphere
Resistance Welding

Figure 10-10. Resistance-welding methods.
Spot welding

Figure 10-11. Typical spot-welded joints.

Figure 10-12. Assembly showing series-welded joint.
Figure 10-13. Spot-welded assembly showing a typical joint design for an indirect weld.
Flash butt welding

Figure 10-14. Flash-butt welding.
Typical standard electrodes
Design considerations

Figure 10-17. Locating lands.

Figure 10-18. Set-block locators.

Figure 10-19. Dowel-pin locators.
Clamp installation

Figure 10-20. Typical clamp installation with the fixture supporting the workpiece directly beneath the clamps.

Figure 10-21. Air-actuated clamping methods.
Laser welding

Figure 10-22. Laser welding.
Nesting fixture

Figure 10-23. Simple nesting fixture with work in place.
Soldering machine with nesting fixture

Figure 10-24. Soldering machine using simple nesting fixture.
Nesting for brazing

Figure 10-25. Nesting fixture for brazing with an external inductor.

Figure 10-26. Nesting fixture for brazing with an internal inductor.
Bolts and studs

Figure 10-33. Typical assemblies using threaded fasteners: (a) bolt and nut; (b) cap screw; (c) stud.
Single-thread nut

Figure 10-34. Single-thread nut.
Figure 10-35. *Stamped nut applied and tightened after full nut is in place.*
Riveting

Figure 10-38. Workpiece simply supported for riveting.
References

- Fundamentals of tool design, fifth edition, Society of Manufacturing Engineers
Questions?