An Approach to Best Welding Practice : Part – II

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"AN APPROACH TO BEST WELDING PRACTICE: Part – II" is the Second Detail Part of the **"AN APPROACH TO BEST WELDING PRACTICE"** which was written as a General and Overall approach to the subject matter. This Part – II is particularly focused to the Operational Aspects relating to the Set-up of Jigs, Fixtures, Rotators, Manipulators and Equipment for Productivity.

Set-up of Jigs, Fixtures, Rotators, Manipulators and Equipment for Productivity

Each and every Mass Production enterprise utilizing Welding as the Major Manufacturing Process uses a number of Jigs, Fixtures, Rotators, Manipulators depending up on :

1. Volume of production per unit time period.
2. Size and weight of the finished product.
3. Number and break up of component assemblies, sub-assemblies for the finished Assembly.
4. Accuracy and tolerance limits of the component assemblies, sub-assemblies for the final Assembled Product.
5. Weld Sequence in Product Design and WPS.
6. Type and Degree of Automation in use.

The above mentioned guiding factors need an analytical approach to decide up on :

1. Break up of Assembly, Sub-assemblies, Component assemblies
2. Use of Jigs/Fixtures for each of the above or not.
3. If so, whether to use Jigs or Fixtures or Manipulators or Rotators or Positioners.
4. Number of Jigs/ Fixtures/ Manipulators/ Rotators/ Positioners for each to balance production flow.
5. Arranging Lay out of the Jigs/ Fixtures/ Manipulators/ Rotators/ Positioners according to the Production Flow and Line Balancing.

Most of the Jigs and Fixtures in use are Designed and Fabricated in the manufacturing unit itself by the Production and Maintenance Engineers with so called "Experienced Staff" instead of "Qualified and Experienced" Production Engineers and Welding Engineers. As a result, critical situations in production activities may often arise. The best approach to avoid such situations and create a productive environment will be to follow a set of standard guidelines as under.

A. Use Jigs & Fixtures for Small Component assemblies avoiding dimensional mismatch, assembly problems and unbalanced Assembly Line.

B. Use adequate number of Jigs and Fixtures for sub-assemblies for balanced and uninterrupted Production Flow rate and final output.

C. Make Jigs and Fixtures "Fool Proof", avoiding occasional fitment of wrong component/right component in wrong orientation, causing scrap/wastage/delay.

D. Make Locating Pads of hardened steel minimizing wear and tear due to prolonged use resulting defective product.

E. Avoid projected and protruding Locating Pads causing fitment delays and lost time.

F. Avoid manual, conventional and time consuming Clamping. Use standard hydraulic and pneumatic semiautomatic and automatic Clamping. Regular maintenance of Clamping arrangement is necessary to remove causes of malfunctioning of arrangement and disruption in production .

G. Use proper materials to construct Jigs/Fixtures. Avoid fabrication out of scrap, rejected components roughly gas cut and welded to form an unbalanced flimsy structure often producing distorted sub-assemblies.

H. Procure and place Positioners in the production only after evaluating the effectiveness and productivity.

The Best approach to Welding concerning the use and utilization of the Jigs/ Fixtures/ Manipulators/ Rotators/ Positioners as regards designing, fabricating, installing, maintaining stems from an analytical and continuous improvement effort. Following basic design parameters and the functional requirement may serve as the guideline and checklist.

Design Parameters and Functional Requirements

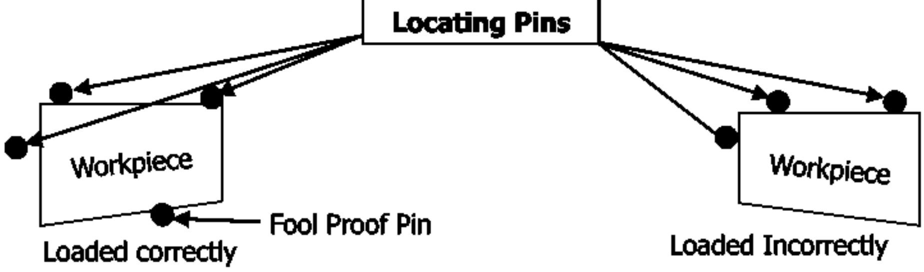
1. Cost benefit analysis must be carried out before considering the use of Jigs/Fixtures. The primary consideration is whether the welded product is only one in quantity or in large number of repeating nature. If the production requirement is large, whether only one or more in number is required has to be calculated. Again, whether to use separate fitting and welding fixtures or an integral fixture covering both the operations has to be studied from the point of view of industrial engineering and costing.
2. Material Selection is Critical. Fixture material must be chosen properly. One of the first steps in designing a welding fixture is to choose the fixture base-metal. Factors include initial cost, long-term maintenance costs, and special characteristics particularly suited to the welding application, such as the critical aspect of maintaining accuracy and part repeatability in an environment exposed to elevated heat and weld spatter.

   Common material options include mild steel, high-carbon tool steel, aluminum, stainless steel, and copper. Various alloys of the common base materials are available with improved work hardening, and wear resistance properties. Each material has different characteristics that can impact productivity and quality.

   Initial cost considerations promote the use of square/ rectangular structural steel tubing for a majority of the framework of the fixture. From a wear resistance standpoint, fixture hard stops and locating points are often made of alloyed high-carbon tool steel in an effort to resist deformation. Another commonly sourced wear resistant alloy, aluminum-bronze, work hardens and is not as prone to residual magnetism when compared to tool steel.
3. A major cost element apart from the material is degree of mechanization including clamping arrangement and automation in operation. There are many clamping / locating options to choose from at the design stage of a fixture. The least complex involves simple manual clamping such as swing, push, or plunger clamps applied to a fixed or stationary table and are typically applied for short-run or prototype parts. In an R&D or short-run setting, these are very simple, low-cost methods to locate a part. The cost of labour intensive nature of manual clamping is compensated by flexibility and versatility in these settings. Design will be compact and easily assembled and provide for strong and mechanized clamping system preferably of hydraulic/pneumatic systems.

	Mild Steel	Tool Steel	Stainless steel	Aluminum
Material Cost	Low	Medium	High	Medium
Wear Resistance	Medium	High	Medium	Low
Electrical Conductivity	Low	Low	Low	Medium
Thermal Conductivity	Low	Low	Low	High
Thermal Expansion	Low	Low	Medium	High

4. Fixture must be "Fool Proof". Fixture must not allow the un-welded part to change its orientation in relation to the welder during the welding operations.



Clamping Devices to be used effectively

5. Design must not require welder / fitter / operator to lift more than a 50 lb. or 22.6 kg load. Design must facilitate a fixture to accommodate a work piece up to two ton. Design must minimize the force needed to move the work table. Design must be ergonomically suitable to operators.

6. Complex applications might involve semi-automatic or automatic clamping through pneumatic or hydraulic systems and automatic setting of parts against locations, in fact a dedicated fixture. Fixture is to be synchronised to welding program. Fixture must not interfere with the welding process. Design will have enough degrees of freedom to complete all weld operations. These fixture

- **For large 3D Frame assemblies**
- **Operated Electrically or Hydraulically.**
- **Ergonomic Working Height**

installations are more complicated with higher initial costs, and frequently involve the installation and routing of wiring, and pneumatic or hydraulic line, motorized rotational movements, synchronizes positioning with welding duration. Advantages of automatic clamping include the reduction or elimination of labour involvement for actuation, part proximity sensing, and sequenced clamping.

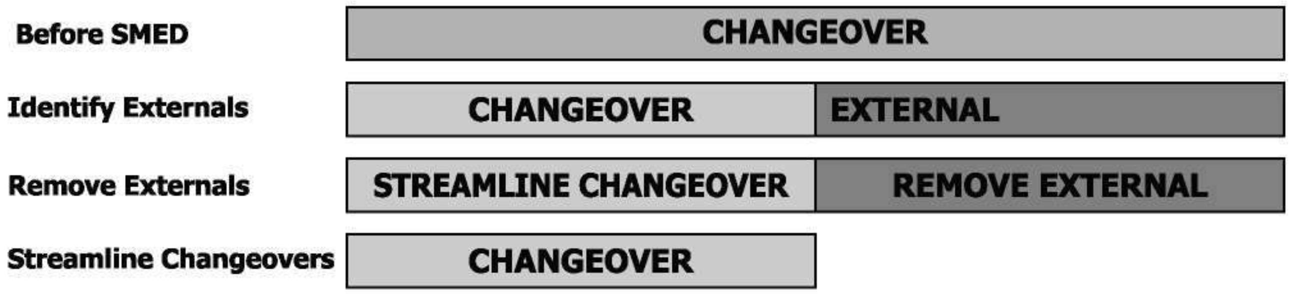
7. Orientation of the Fixture to Maximize Deposition Rate - Fixtures should position the work relative to a vertical orientation to take advantage of the force of gravity. When welding a part in the flat position, gravity helps. The finished welds are flat, uniform, and more easily made with higher deposition rates, that directly increase travel speeds and productivity.

   When sheet metal applications are designed with lap or 'T' joints, simple positioning of the part to allow a 15-degree downhill torch motion can result in travel speed increases of 10 - 25 percent, by using gravity as an ally.

   In overhead welding, deposition rates are lower and it is more difficult to maintain proper weld contours. Welding overhead also requires overcoming the force of gravity and preferably avoided in orientation of the fixture.

8. Fixture must operate on "SMED" principle. Loading components and parts and their fitment for welding, and unloading the welded assembly from the fixture must be quick.

   In SMED, the changeover process is broken into a sequenced list of steps called elements. The essence of SMED is to convert as many elements as possible to "external" (performed while the equipment is running), and to remove or streamline the remaining elements.



9. Friction between moving parts must be minimized. All rotating and moving parts should have proper bearings and slides with regular oiling, greasing and maintenance.

10. The objective of the integration of the fixture and clamping / locating device is to insure that the weld joint location repeats, in a 3-dimensional space relative to the system, within +/- half the diameter of the applied welding wire. For example, using 1.2 mm diameter wire allows a tolerance of +/- 0.6 mm.

11. Obtaining good fit-up is critical to controlling costs. In order to obtain a good fit-up consistently, emphasis must also be placed on preconditioning operations such as cutting / shearing, machining, heat treating, and bending / forming processes.

12. Gap location and width must be consistent from part to part, with the same tolerances as the weld joint location. Beyond plus or minus half the diameter of the wire thickness, the weld size may be required to be increased to offset the smaller weld throat that results. A larger weld may require 125 - 200% more weld metal than required if proper fit-up is maintained.

13. Optimizing the Welding Circuit - For the best utilization of input power an optimized welding circuit to maintain short arc lengths while reducing spatter, stubbing, arc-flare, and arc outages, all in an effort to maximize travel speeds is required.

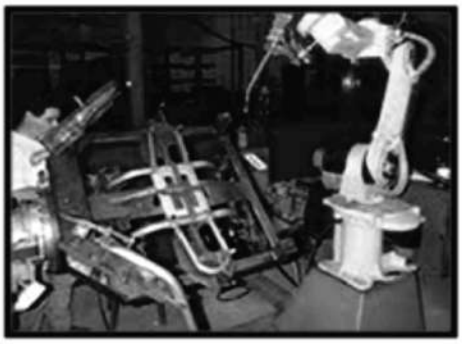
    Special care must be taken to identify the optimum location of the work lead on the robotic welding fixture. As a general rule, it is desirable to locate the work cable and sense lead (if applicable), as close to the welding arc as possible, connection directly to the work piece is preferred At this point, the anticipated welding travel directions also to be considered with the preference to move in the direction away from the work lead and connecting all the work sense leads from each power source to the work piece at the opposite end.

In following up of above detailed discussions it is imperative to have a look at some standard manipulators and some very effective and productive Welding Fixtures in use.

Positioner

Under-frame Fixture

Structural Welding Fixtures



Robotic Welding Fixture

SUMMARY

Jigs, Fixtures, Positioners, Manipulators are essential equipment in effective and efficient production system especially where welding is the major manufacturing process. In order to obtain the best productive result the approach to design, manufacture and use of the same must be critically examined and methodically executed.

Productivity is achieved through Robust Design, Automatic Clamping, Ergonomic Operation, Fool Proofing,, SMED Operating Principle, Positioning for Maximum Deposition Rate of weld metal, Regular Maintenance and of course Continuous Improvement in all the critical areas.