Fundamentals of Design for Welding

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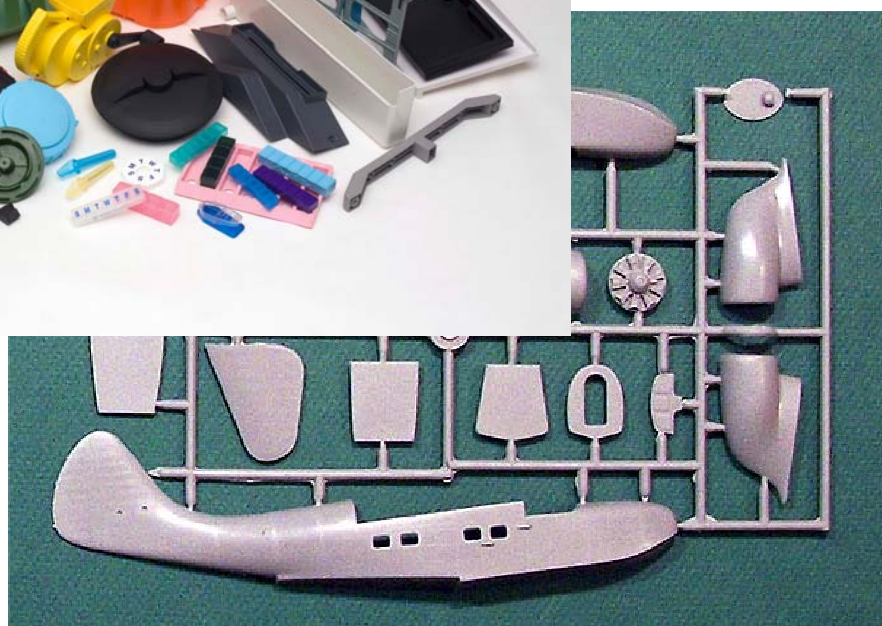

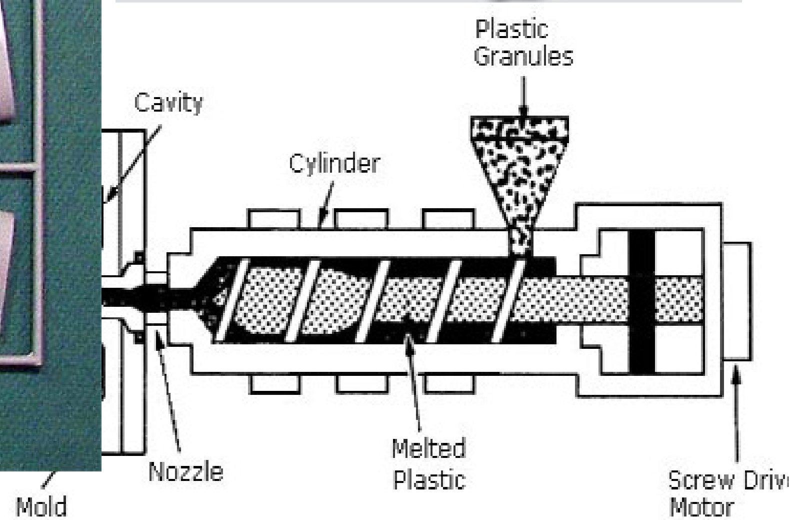

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Revision A

Design for Welding

Welding is the process where material is fused together by the application of heat energy which in turn liquefies and mixes the adjoining materials. On cooling the material fused or welded together. Welding sometimes includes the application of a filler material is the weld location.

A weldment is an assembly of component parts joined by welding. It may be a bridge, a building frame, an automobile, a truck body, a trailer hitch, a piece of machinery, or an offshore oil drilling structure. In the field of weldment design, the primary objectives are to produce an assembly that performs its intended functions, has the required reliability and safety, and can be fabricated, inspected, transported, and placed in service at a minimum total cost. The total cost includes the cost of design, materials, fabrication, erection, inspection, operation, repair, and product maintenance.

The designers of weldments must have an understanding of basic design principles and concepts. They must have some knowledge of and experience in cutting and shaping metals; assembling components; preparing and fabricating welded joints; evaluating welds in compliance with established acceptance criteria; and performing nondestructive examination and mechanical testing. Designers routinely apply knowledge of the following areas when evaluating the effects these may have on the design of weldments.

- Mechanical and physical properties of metals and weldments.
- Weldability of metals.
- Welding processes, costs, and variations in welding procedures.
- Filler metals and properties of weld metals.
- Thermal effects of welding
- Effects of restraint and stress concentrations
- Control of distortion
- Efficient use of steel, aluminum, and other metals in weldments
- Design for appropriate stiffness or flexibility in welded beams and other structural members
- Design for torsional resistance

Design for Welding

- Effects of thermal strains induced by welding in the presence of restraints
- Effects of stress induced by welding in combination with design stresses
- Practical considerations of welding and the selection of proper joint designs for the application.
- Communication of weldment design to the shop, including the use of welding symbols

As several of these topics involve highly specialized areas of science and technology, designers should refrain from relying entirely upon their own knowledge and experience, which may be generalized. They are encouraged to consult with welding experts whenever appropriate.

Analysis of Existing Designs for Manufacturability:

When an entirely new machine or structure is to be designed, information should be obtained about similar products, including those marketed by other manufacturers or builders. If a new design is to replace an existing design, the strengths and weaknesses of the existing design should be determined. The following factors should be considered in identifying the strengths and weaknesses of existing designs:

- Performance history of the existing products
- Features that should be retained, discarded, or added
- Any suggestions for improvements that have been made
- Opinions of customers and the sales force about the existing products.
- Effective costing of manufacturing and materials

Typical Welding Challenges and Defects:

Due to the melting and solidification cycle and the resultant microstructure changes, one must carefully monitor all welding process parameters, including shielding gases, fluxes, welding current and voltage, welding speed and orientation, and preheating and cooling rates. In terms of different materials: carbon and low-carbon alloy steels are weldable with no significant difficulties Thicknesses of up to 15mm are more easily weldable than thicker work pieces that require preheating (to slow down the cooling rate); aluminum and copper alloys are difficult to weld because of their high thermal conductivity and high thermal expansion; titanium and tantalum alloys are weldable with careful shielding of the weld region.

Thermoplastics (such as polyvinychloride, polyethylene, and polypropylene) are weldable at low temperatures (300 to 400ºC), though glass-reinforced plastics are not generally weldable; ceramics (SiO2-AlO2) have also been welded in the past using CO2 and Nd:YAG lasers with some preheating. Welding defects can be classified as external (visible) and internal defects, some of these are listed and illustrated below:

- Misalignment: It is an external defect caused by poor preparation. Distortion: It is an external defect caused by residual stresses due to unsuitable process parameters.
- Incomplete penetration: It is an internal defect caused by excessive weld-speed, low weld current, too small of a gap, or poor preparation. Undercut: It is an internal defect—a groove that appears at the edge of the joint, caused by high current or voltage, irregular wire speed, or too high welding speed.
- Porosity: It is an internal defect—in the form of isolated or grouped bubbles, caused by an insufficient flow of gas, moist or rusty base metals, or entrapment of gases.
- Cracking: It is an internal defect—localized fine breaks that may occur while the joint is hot or cold, caused by hydrogen embrittlement, internal stress, lack of penetration, excessive sulphur and phosphorus content in base metal, or rapid cooling.

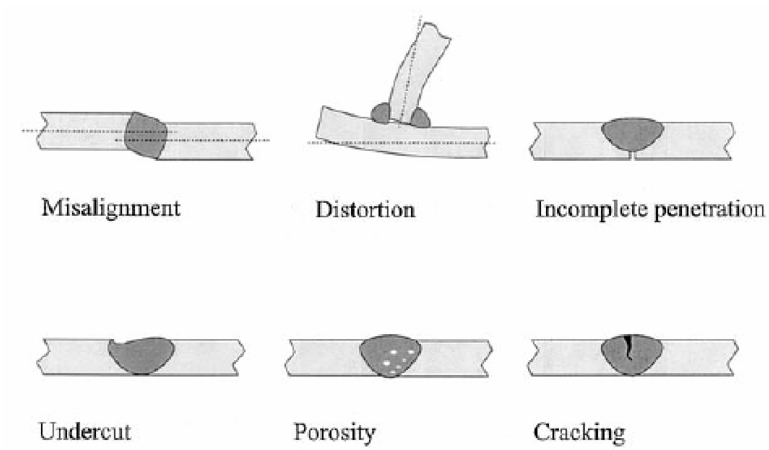

Figure 32

Cracking: It is an internal defect where localized fine breaks may occur while the joint is hot or cold. Cracking is caused by hydrogen embrittlement, internal stress, lack of penetration, excessive Sulfur and Phosphorus content in base metal, or rapid cooling.

In addition to the process parameters that must be controlled to avoid welding defects, a designer may consider the following additional guidelines: weld locations should be chosen to maximize strength and avoid stress concentrations, though some awareness of intended use and appearance is important; careful edge preparation must be employed if unavoidable; and welding should be minimized owing to potential dimensional distortions.

Welding Cost Considerati

As an industrial process, tl ... Many different variables
affect the total cost, includi ... nding on the process,
equipment cost can vary, fr ... xyfuel welding, to much more
expensive methods like las ... cost, they are only used in
high production operations ... s, they are only implemented
when high production is ne ... ing), the hourly wage, and
the total operation time, inc ... aterials includes the cost of
the base and filler material, ... time and welding power
demand.

For manual welding metho ... As a result, many cost-
saving measures are focuse ... h high deposition rates can
be selected, and weld parar ... and automation are often
implemented to reduce labo ... ates additional setup time.
Material costs tend to incre ... ly do not amount to more
than several percent of the

In recent years, in order to ... welding has become
increasingly more automat ... obots in resistance spot
welding (especially in the a ... nized devices both hold the
material and perform the w ... robotic arc welding increases
in popularity as technology ... welding of dissimilar
materials (such as steel and ... on stir, magnetic pulse,
conductive heat seam, and ... ore specialized methods like
laser beam welding practic ... dustries. Researchers also
hope to better understand tl ... , residual stresses, and a
weld's tendency to crack or