Joining

This chapter presents the fundamental approaches used in manufacturing namely casting, forming, welding and machining. Further, common methods of developing joint and selection of suitable methods have been described. Applications, advantages and limitations of welding as a fabrication technique have also been covered.

Keywords: Manufacturing process, selection of joint, welding vs. manufacturing processes, selection of welding process, advantages, application and limitation of welding processes

1.1 Introduction

The manufacturing technology primarily involves sizing, shaping and imparting desired combination of the properties to the material so that the component or engineering system being produced to perform indented function for design life. A wide range of manufacturing processes have been developed in order to produce the engineering components ranging from simple to complex geometries using materials of different physical, chemical, mechanical and dimensional properties. There are four chief manufacturing processes i.e. casting, forming, machining and welding. Selection of suitable manufacturing process for a produce/component is dictated by complexity of geometry of the component, number of units to be produced, properties of the materials (physical, chemical, mechanical and dimensional properties) to be processed and economics. Based on the approach used for obtaining desired size and shape by different manufacturing processes; these can be termed as positive, negative and or zero processes.

- Casting: zero process
- Forming: zero process
- Machining: negative process
- Joining (welding): positive process

Casting and forming are categorized as zero processes as they involve only shifting of metal in controlled (using heat and pressure singly or in combination) way from one region to another to get the required size and shape of product. Machining is considered as a negative process because unwanted material from the stock is removed in the form of small chips during machining for the shaping and sizing of a product purpose. During manufacturing, it is frequently required to join the simple

shape components to get desired product. Since simple shape components are brought together by joining in order to obtain desired shape of end useable product therefore joining is categorized as a positive process. Schematic diagrams of few typical manufacturing processes are shown in Fig. 1.1.

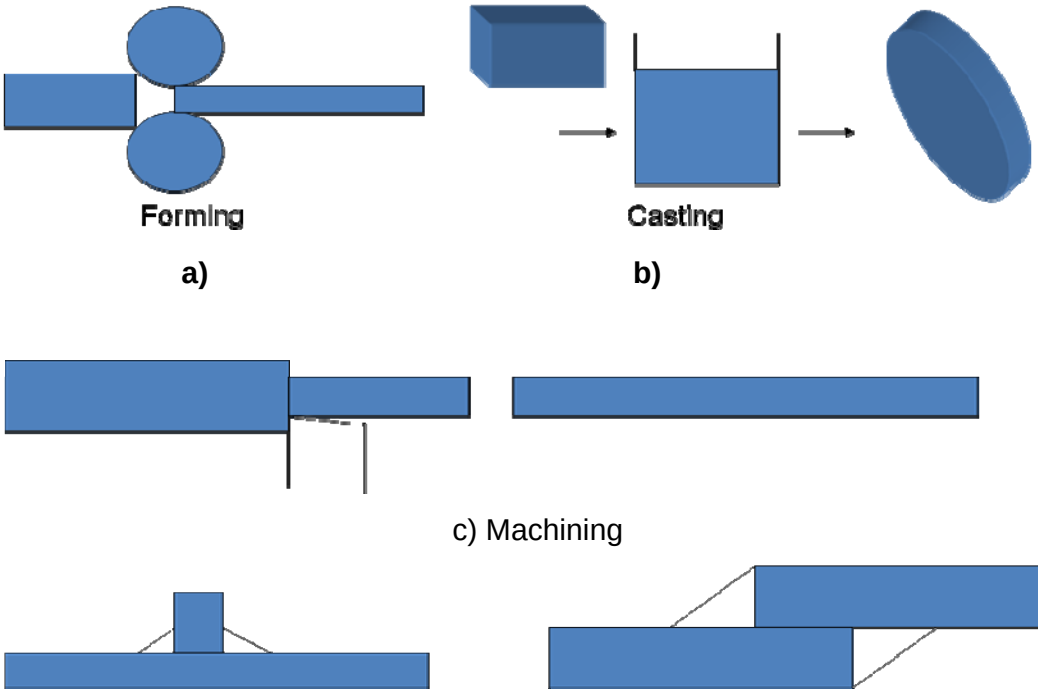

Fig. 1.1 Schematic diagram showing shaping approaches using different manufacturing processes a) forming, b) casting, c) machining and d) joining

1.2 Selection of Joint

The fabrication of engineering systems frequently needs joining of simple components and parts. Three types of joining methods namely mechanical joining (nuts & bolts, clamps, rivets), adhesive joining (epoxy resins, fevicol), welding (welding, brazing and soldering) are commonly used for manufacturing variety of engineering product/component. Each type of joint offers different load carrying capacity, reliability, compatibility in joining of similar or dissimilar materials besides their fitness for use in different environments and cost. It will be appropriate to consider following aspects while selecting type of joints for an application:

a) type of joint required for an application is temporary or permanent

b) Whether similar or dissimilar materials are to be joined in order to take care of the compatibility aspect as metallurgical incompatibility can be disastrous for performance of the joints
c) Physical, chemical metallurgical properties of materials to be joined
d) requirements of the service from the joint under special conditions of temperature, corrosion, environment, and reliability
e) type and nature of loading conditions (static and dynamic loading under tension, shear, compression, bending etc.)
f) economy or cost effectiveness is one most important factors influencing the selection of joint for manufacturing an engineering component

1.3 Welding and its comparison with other manufacturing processes

Welding is one of the most commonly used fabrication techniques for manufacturing engineering components for power, fertilizer, petro-chemical, automotive, food processing, and many other sectors. Welding generally uses localized heating during common fusion welding processes (shielded metal arc, submerged arc, gas metal arc welding etc.) for melting the faying surfaces and filler metal. However, localized and differential heating & cooling experienced by the metal during welding makes it significantly different from other manufacturing techniques:

- Residual stresses are induced in welded components (development of tensile residual stresses adversely affects the tensile and fatigue properties of work piece)
- Simple shape components to be joined are partially melted
- Temperature of the base metal during welding in and around the weld varies as function of time (weld thermal cycle)
- Chemical, metallurgical and mechanical properties of the weld are generally anisotropic
- Reliability of weld joint is poor.
- Little amount of metal is wasted in the form of spatter, run in and run off
- Process capabilities of the welding in terms of dimensional accuracy, precision and finish are poor.
- Weld joints for critical applications generally need post weld treatment such as heat treatment or mechanical working to get desired properties or reline residual stress.

- Problem related with ductile to brittle transition behaviour of steel is more severe with weld joints under low temperature conditions.

1.4 Selection of welding process

A wide range of welding processes are available to choose. These were developed over a long period of time. Each process differs in respect of their ability to apply heat for fusion, protection of the weld pool and soundmen of welds joint the so performance of the weld joint. However, selection of a particular process for producing a weld joint is dictated by the size and shape of the component to be manufactured, the metal system to be welded, availability of consumables and machines, precision required and economy. Whatever process is selected for developing weld joint it must be able to perform the intended function for designed life. Welding processes with their field of applications are given below:

- Resistance welding: Automobile
- Thermite welding: Rail joints in railways
- Tungsten inert gas welding: Aerospace and nuclear reactors
- Submerged arc welding: Heavy engineering, ship building
- Gas metal arc welding: Joining of metals (stainless steel, aluminium and magnesium) sensitive to atmospheric gases

1.5 Advantages and Limitation of Welding as a Fabrication Technique

Welding is mainly used for the production of comparatively simple shape components. It is the process of joining the metallic components with or without application of heat, pressure and filler metal. Application of welding in fabrication offers many advantages, however; it suffers from few limitations also. Some of the advantage and limitations are given below.

Advantages of welding are enlisted below:

1. Permanent joint is produced, which becomes an integral part of work piece.
2. Joints can be stronger than the base metal if good quality filler metal is used.
3. Economical method of joining.
4. It is not restricted to the factory environment.

Disadvantages of welding are enlisted also below:

1. Labour cost is high as only skilled welder can produce sound and quality weld joint.

2. It produces a permanent joint which in turn creates the problem in dissembling if of sub-component required.
3. Hazardous fumes and vapours are generated during welding. This demands proper ventilation of welding area.
4. Weld joint itself is considered as a discontinuity owing to variation in its structure, composition and mechanical properties; therefore welding is not commonly recommended for critical application where there is a danger of life.

1.6 Applications of welding

General applications

- The welding is widely used for fabrication of pressure vessels, bridges, building structures, aircraft and space crafts, railway coaches and general applications besides shipbuilding, automobile, electrical, electronic and defense industries, laying of pipe lines and railway tracks and nuclear installations.
- Specific components need welding for fabrication includes

1. Transport tankers for transporting oil, water, milk etc.
2. Welding of tubes and pipes, chains, LPG cylinders and other items.
3. Fabrication of Steel furniture, gates, doors and door frames, and body
4. Manufacturing white goods such as refrigerators, washing machines, microwave ovens and many other items of general applications

The requirement of the welding for specific area of the industry is given in following section.

Oil & Gas

1. Welding is used for joining of pipes, during laying of crude oil and gas pipelines, construction of tankers for their storage and transportation. Offshore structures, dockyards, loading and unloading cranes are also produced by welding.

Nuclear Industry

2. Spheres for nuclear reactor, pipe line bends, joining of pipes carrying heavy water require welding for safe and reliable operations.

Defense industry

3. Tank body fabrication, joining of turret mounting to main body of tanks are typical examples of applications of welding in defense industry.

Electronic industry

4. Electronic industry uses welding to limited extent e.g. joining leads of special transistors but other joining processes such as brazing and soldering are widely used.
5. Soldering is used for joining electronic components to printed circuit boards (PCBs).
6. Robotic soldering is very common for joining of parts to printed circuit boards of computers, television, communication equipment and other control equipment etc.

Electrical Industry

7. Components of both hydro and steam power generation system, such as penstocks, water control gates, condensers, electrical transmission towers and distribution system equipment are fabricated by welding. Turbine blades and cooling fins are also joined by welding.

Surface transport

8. Railway: Railway uses welding extensively for fabrication of coaches and wagons, repair of wheel, laying of new railway tracks by mobile flash butt welding machines and repair of cracked/damaged tracks by thermite welding.
9. Automobiles: Production of automobile components like chassis, body and its structure, fuel tanks and joining of door hinges require welding.

Aerospace Industry

10. Aircraft and Spacecraft: Similar to ships, aircrafts were produced by riveting in early days but with the introduction of jet engines welding is widely used for aircraft structure and for joining of skin sheet to body.
11. Space vehicles which have to encounter frictional heat as well as low temperatures require outer skin and other parts of special materials. These materials are welded with full success for achieving safety and reliability.

Ship Industry

12. Ships were produced earlier by riveting. Welding found its place in ship building around 1920 and presently all welded ships are widely used. Similarly submarines are also produced by welding.

Construction industry

13. Arc welding is used for construction of steel building structures leading to considerable savings in steel and money.
14. In addition to building, huge structures such as steel towers also require welding for fabrication.

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