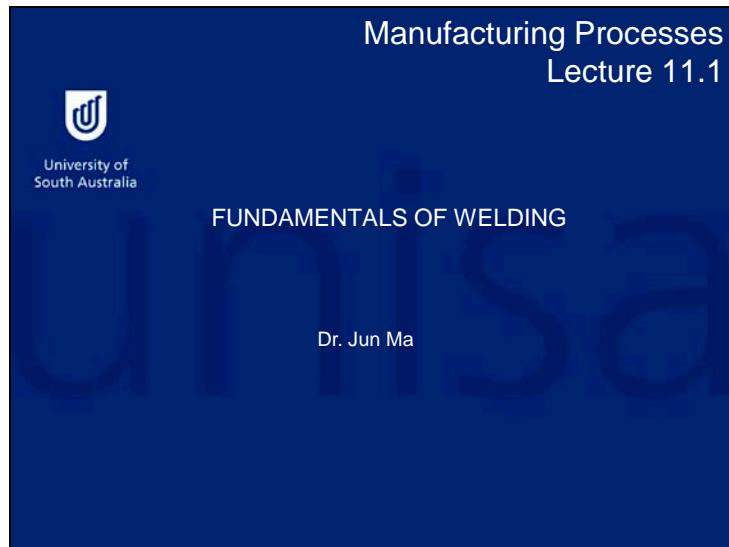


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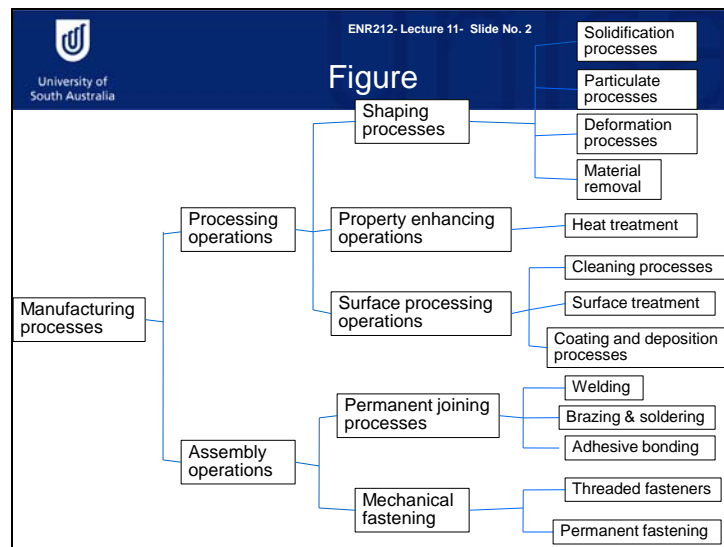
Slide 1



Hello, and welcome to the final lecture summary for Manufacturing Processes. (This lecture covers material from chapters 30 and 32 of the textbook.) In this lecture summary, we will introduce welding, brazing, soldering and adhesive bonding. The lecture will be in two parts: in this part, we will look at the fundamentals of welding.

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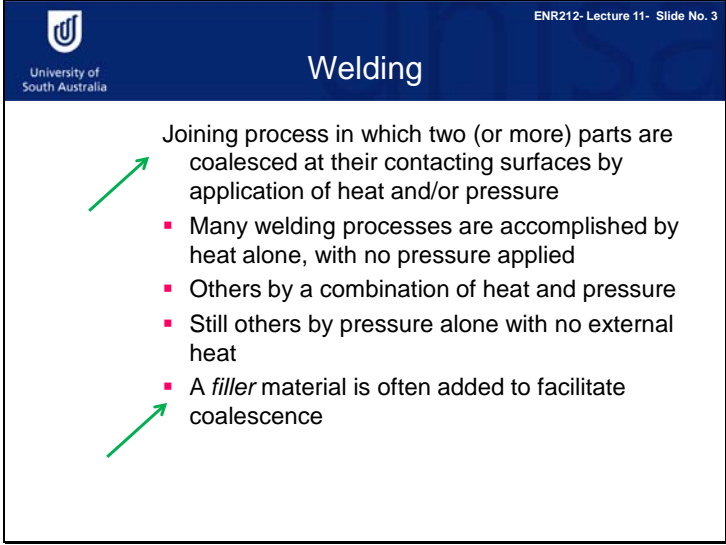
Slide 2



First, let us review what we have learnt about the classification of manufacturing processes. Manufacturing processes consist of processing operations and assembling operations. The processing operations include shaping processes, property enhancing operations and surface processing operations. Of these three, shaping processes are the focus of this unit. This lecture covers permanent joining processes which belong to assembling operations; these permanent joining processes include welding, brazing, soldering and adhesive bonding.

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Slide 3



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Welding

Joining process in which two (or more) parts are coalesced at their contacting surfaces by application of heat and/or pressure

- Many welding processes are accomplished by heat alone, with no pressure applied
- Others by a combination of heat and pressure
- Still others by pressure alone with no external heat
- A *filler* material is often added to facilitate coalescence

Welding is defined as a materials joining process in which two (or more) parts are coalesced at their contacting surfaces by an application of heat, or of pressure, or a combination of both.

A filler material is often added to facilitate coalescence.

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Slide 4

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Faying Surfaces in Welding

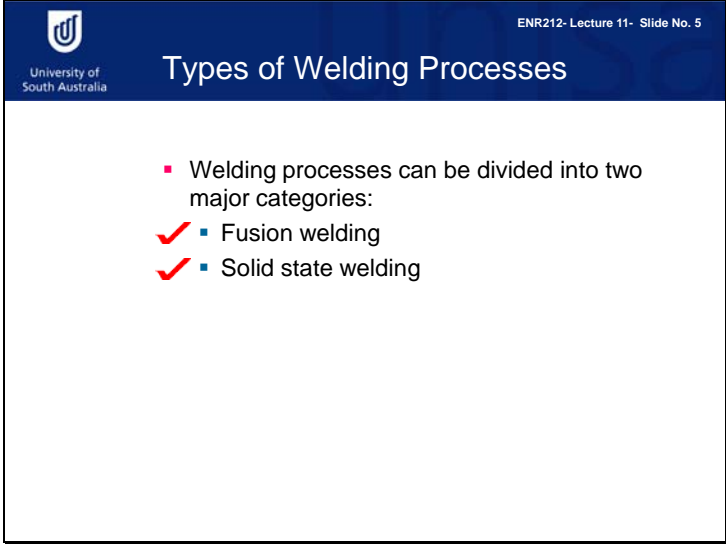
The part surfaces in contact or close proximity that are being joined

- Welding is usually performed between faying surfaces of parts made of the same metal
- However, some welding operations can be used to join some dissimilar metals

Welding is usually performed on parts made of the same metal. However, in some cases, depending on the application, welding operations are also used to join dissimilar metals.

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Slide 5



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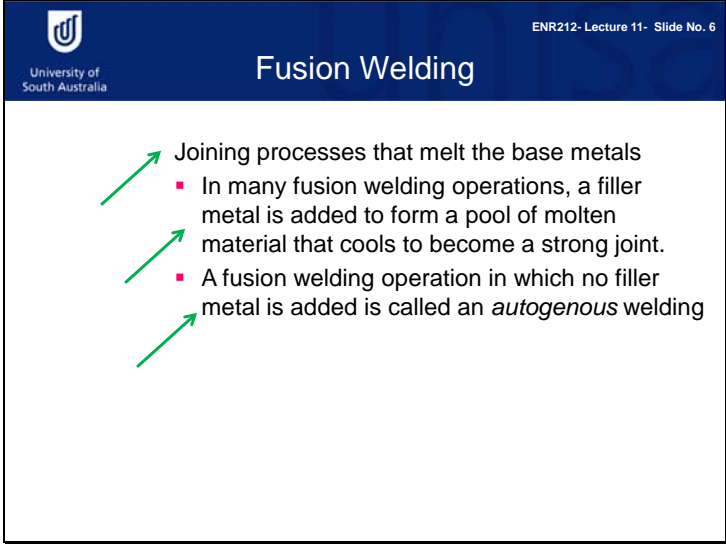
Types of Welding Processes

- Welding processes can be divided into two major categories:
 - ✓ ▪ Fusion welding
 - ✓ ▪ Solid state welding

Welding processes can be divided into two major categories, depending on the working temperature: fusion welding and solid state welding.

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Slide 6



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Fusion Welding

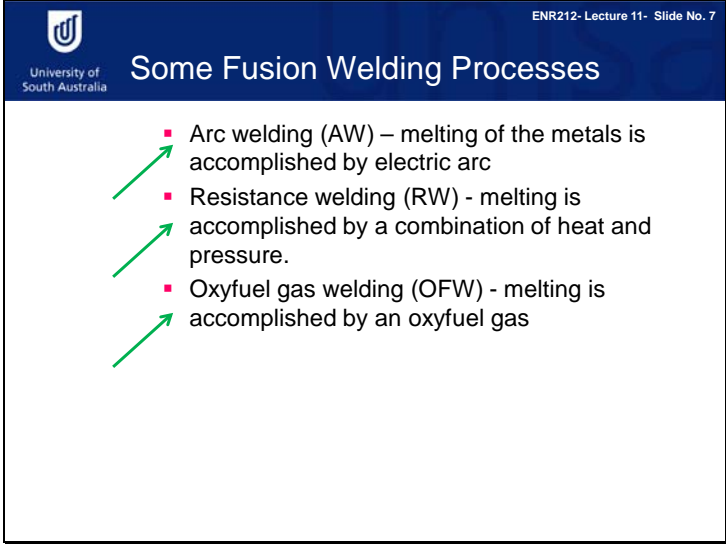
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- Joining processes that melt the base metals
 - In many fusion welding operations, a filler metal is added to form a pool of molten material that cools to become a strong joint.
 - A fusion welding operation in which no filler metal is added is called an *autogenous* welding

Fusion welding is a joining process that uses heat to melt the base metals. This is done through the application of heat alone or through a combination of heat and pressure. In many fusion welding operations, a filler metal is added to form a pool of molten material that cools to become a strong joint. A fusion welding operation in which no filler metal is added is called an autogenous welding.

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Slide 7



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Some Fusion Welding Processes

- Arc welding (AW) – melting of the metals is accomplished by electric arc
- Resistance welding (RW) - melting is accomplished by a combination of heat and pressure.
- Oxyfuel gas welding (OFW) - melting is accomplished by an oxyfuel gas

Fusion welding processes are further classified according to the source of heat. Arc welding (AW) refers to a group of welding processes in which metals are melted by an electric arc. In resistance welding (RW), the melting is due to a combination of heat and pressure. The heat is generated by electrical resistance to the current flow at the junction to be welded. In oxyfuel gas welding (OFW), the melting is accomplished by an oxyfuel gas, such as a mixture of oxygen and acetylene.

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Solid State Welding

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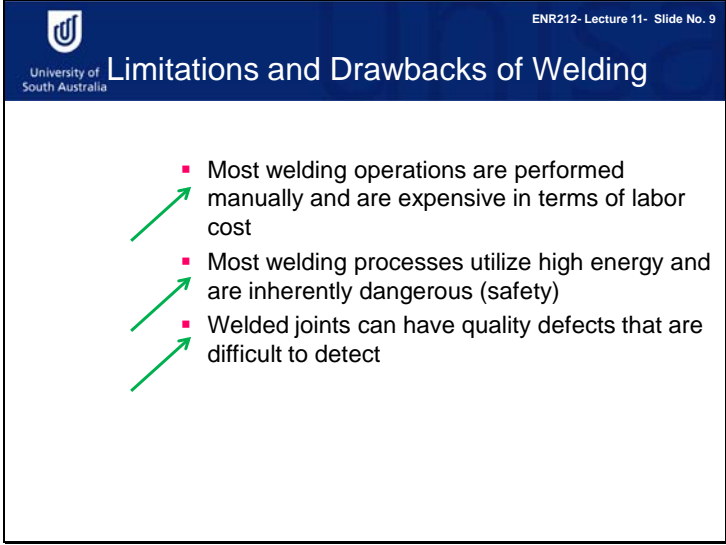
Joining processes in which coalescence results from application of pressure alone or a combination of heat and pressure

- If heat is used, temperature is below melting point of metals being welded
- No filler metal is added in solid state welding

Solid state welding refers to joining processes in which the coalescence results from the application of pressure alone, or from a combination of heat and pressure. If heat is used, the temperature is below the melting point of the metals being welded. No filler metal is added in solid state welding.

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Slide 9



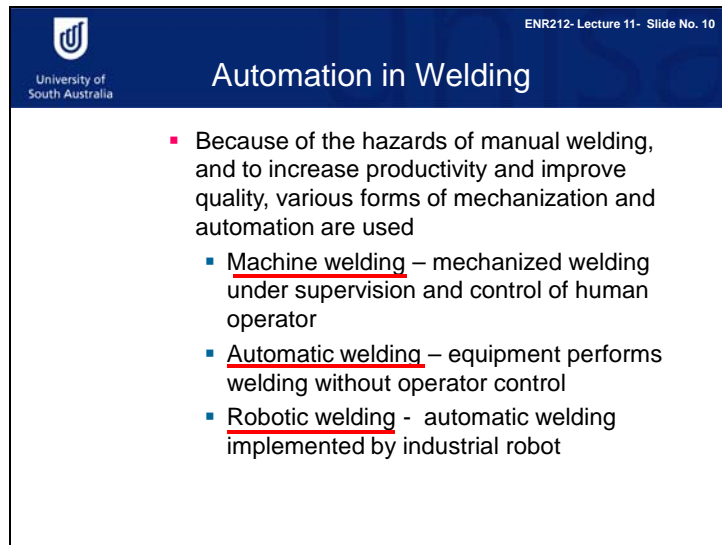
The slide features a dark blue header with the University of South Australia logo on the left and the text 'ENR212- Lecture 11- Slide No. 9' on the right. The main title 'Limitations and Drawbacks of Welding' is centered in the header. The body of the slide is white and contains a bulleted list of three points, each preceded by a green arrow pointing to the right.

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Limitations and Drawbacks of Welding

- Most welding operations are performed manually and are expensive in terms of labor cost
- Most welding processes utilize high energy and are inherently dangerous (safety)
- Welded joints can have quality defects that are difficult to detect

There are several limitations to welding. Firstly, most welding operations are performed manually and are therefore expensive in terms of labor cost. Secondly, most welding processes use high temperatures, which can be a safety hazard. Finally, welded joints can have quality defects that are difficult to detect.



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Automation in Welding

- Because of the hazards of manual welding, and to increase productivity and improve quality, various forms of mechanization and automation are used
 - Machine welding – mechanized welding under supervision and control of human operator
 - Automatic welding – equipment performs welding without operator control
 - Robotic welding - automatic welding implemented by industrial robot

To overcome these three limitations, three types of welding have been developed: machine welding, automatic welding and robotic welding.

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Slide 11

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The Weld Joint

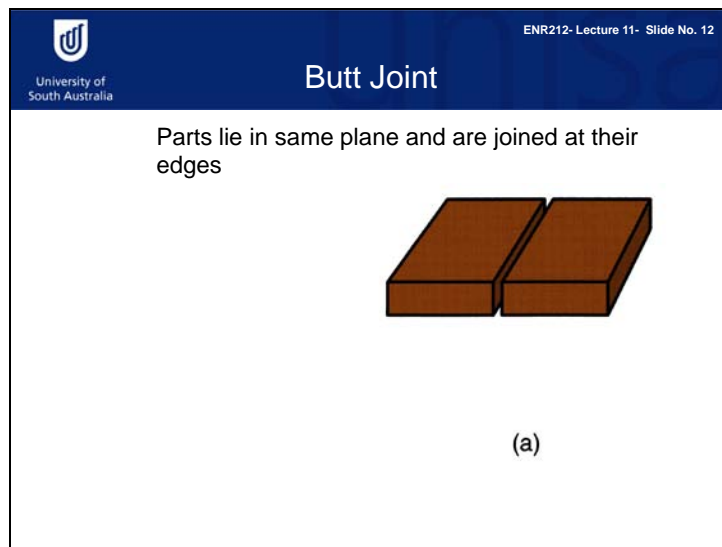
The junction of the edges or surfaces of parts that have been joined by welding

- Five types of joints
 1. Butt joint
 2. Corner joint
 3. Lap joint
 4. Tee joint
 5. Edge joint

Welding produces a solid connection between two pieces, called a weld joint, which is the junction of the edges or surfaces of parts that have been joined by welding. There are five types of joints: butt joint, corner joint, lap joint, tee joint, and edge joint.

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Slide 12



In a butt joint, parts lie in the same plane and are joined at their edges.

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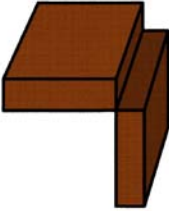
Slide 13

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Corner Joint

Parts form a right angle and are joined at the corner of the angle



(b)

The parts in a corner joint form a right angle and are joined at the corner of the angle.

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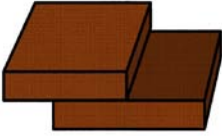
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Lap Joint

Consists of two overlapping parts



(c)

The lap joint consists of two overlapping parts.

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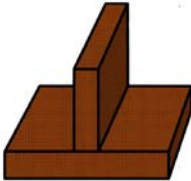
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Tee Joint

One part is perpendicular to the other in the approximate shape of the letter "T"



(d)

In the tee joint, one part is perpendicular to the other in the approximate shape of the letter "T".

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Edge Joint

Joint between edges of two or more parallel or almost parallel parts.

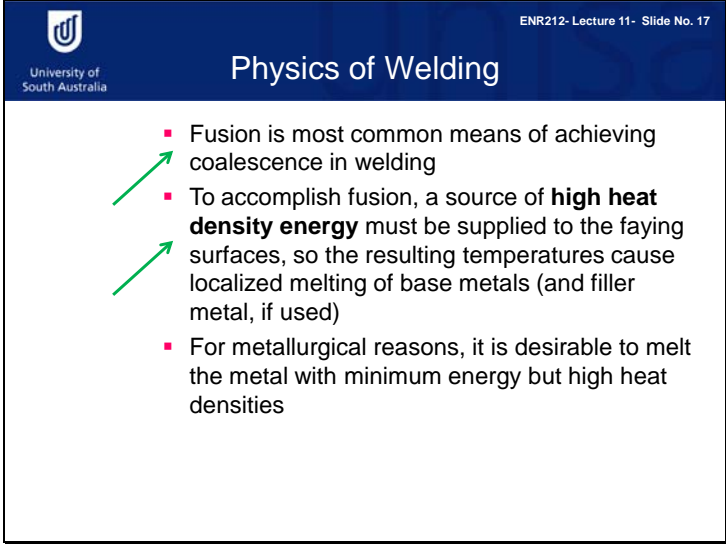


(e)

An edge joint is a joint between the edges of two or more parallel or almost parallel members. Note that these types of joints are potential assessment topics for this unit.

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Slide 17



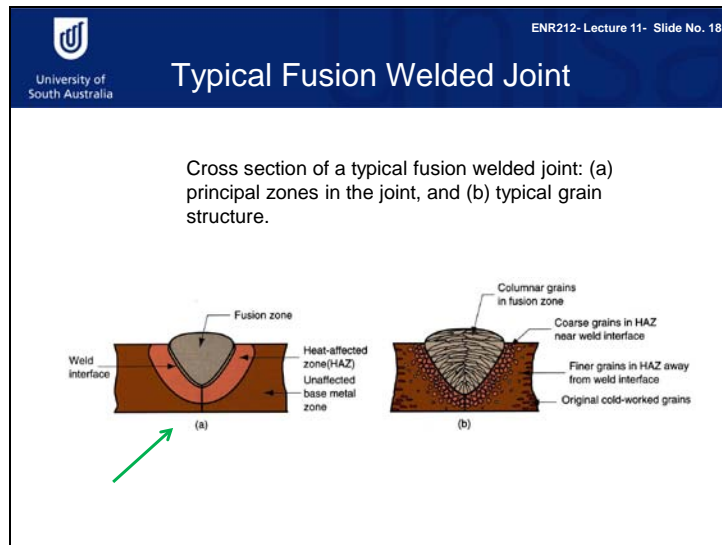
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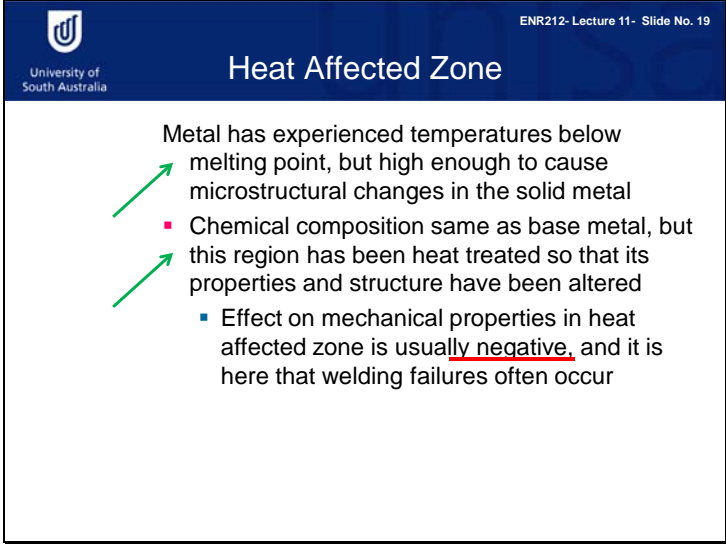
Physics of Welding

- Fusion is most common means of achieving coalescence in welding
- To accomplish fusion, a source of **high heat density energy** must be supplied to the faying surfaces, so the resulting temperatures cause localized melting of base metals (and filler metal, if used)
- For metallurgical reasons, it is desirable to melt the metal with minimum energy but high heat densities

Fusion is by far the most common means of achieving coalescence in welding. In fusion, the faying surfaces of base metal are melted with or without addition of filler metal by a source of high-density heat energy. Heat density can be defined as an amount of power transferred to a work material per unit surface area.



As shown in this figure, a typical fusion-weld joint consists of three zones: the fusion zone, the heat-affected zone and unaffected base metals zone. The fusion zone consists of a mixture of filler metal and base metal that has completely melted. Between the fusion zone and the heat affected zone is a weld interface, which is a narrow boundary that separates the fusion zone from the heat-affected zone.



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Heat Affected Zone

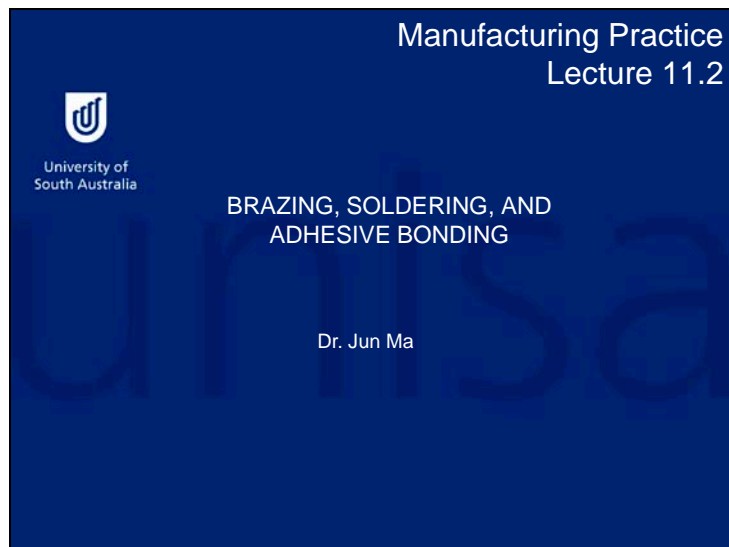
Metal has experienced temperatures below melting point, but high enough to cause microstructural changes in the solid metal

- Chemical composition same as base metal, but this region has been heat treated so that its properties and structure have been altered
- Effect on mechanical properties in heat affected zone is usually negative, and it is here that welding failures often occur

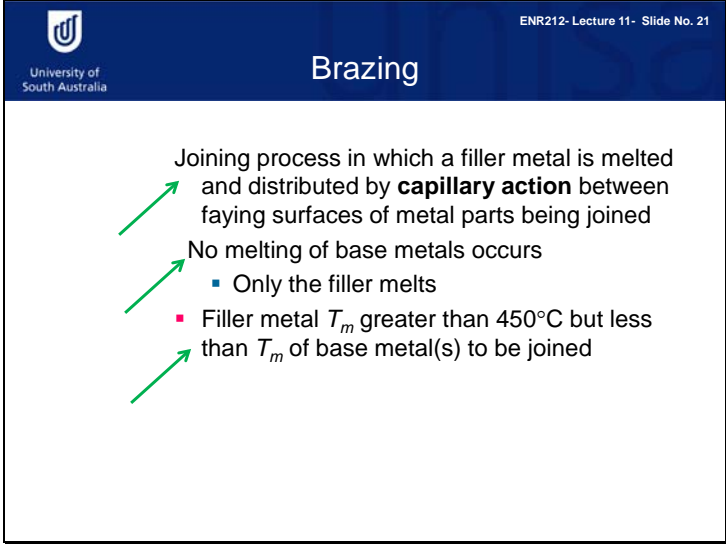
It is the heat-affected zone that experiences a temperature gradient. The chemical composition is same as the base metal, but this region has been heat treated, so that its properties and structure have been altered. In most cases, the mechanical properties in this zone just decrease, so it is here that welding failures often occur.

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Slide 20



Now, we will move onto the second part of this lecture. In this part (lecture summary 11b), we will look at brazing, soldering and adhesive bonding.



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Brazing

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Joining process in which a filler metal is melted and distributed by **capillary action** between faying surfaces of metal parts being joined

No melting of base metals occurs

- Only the filler melts
- Filler metal T_m greater than 450°C but less than T_m of base metal(s) to be joined

Brazing is a joining process in which a filler metal is melted and distributed by capillary action between the faying surfaces of the metal parts being joined. The capillary action, capillarity, capillary motion, and wicking refer to the ability of a substance to draw another substance into itself. In brazing, there is no melting of base metals, only of the filler metals. To be joined, the filler metal melting temperature must be greater than 450°C but must be less than the melting temperature of the base metals.

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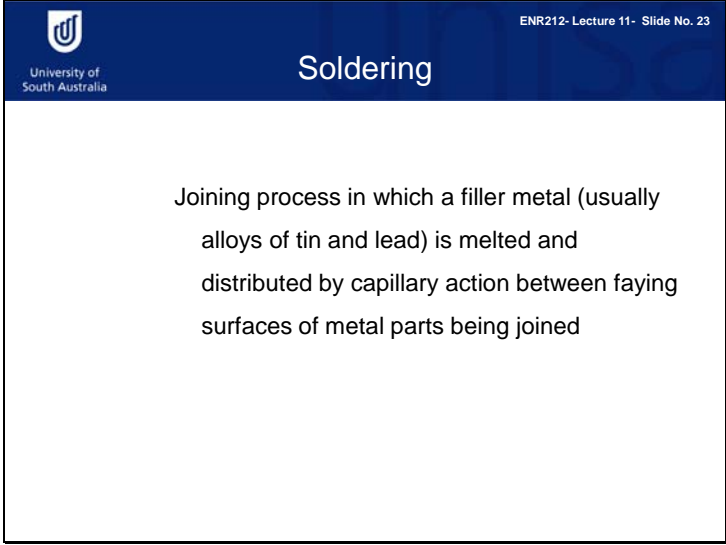
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Some Filler Metals for Brazing	
<u>Base metal(s)</u>	<u>Filler metal(s)</u>
Aluminum	Aluminum and silicon
Nickel-copper alloy	Copper
Copper	Copper and phosphorous
Steel, cast iron	Copper and zinc
Stainless steel	Gold and silver

This table shows you which metals are base metals and which are filler metals. If you compare the base metals and the filler metals, you will probably notice two things. First, filler metals are not as strong as base metals. Second, filler metals have lower melting temperatures than base metals.

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Slide 23



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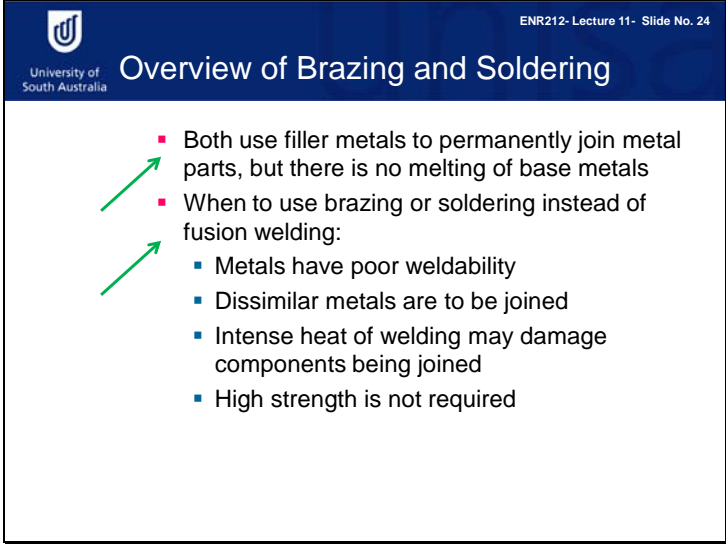
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Soldering

Joining process in which a filler metal (usually alloys of tin and lead) is melted and distributed by capillary action between faying surfaces of metal parts being joined

Soldering is defined as a joining process in which a filler metal is distributed by capillary action between the faying surfaces of the metal parts being joined. In soldering, the filler metal must have a melting point lower than 450 degrees.



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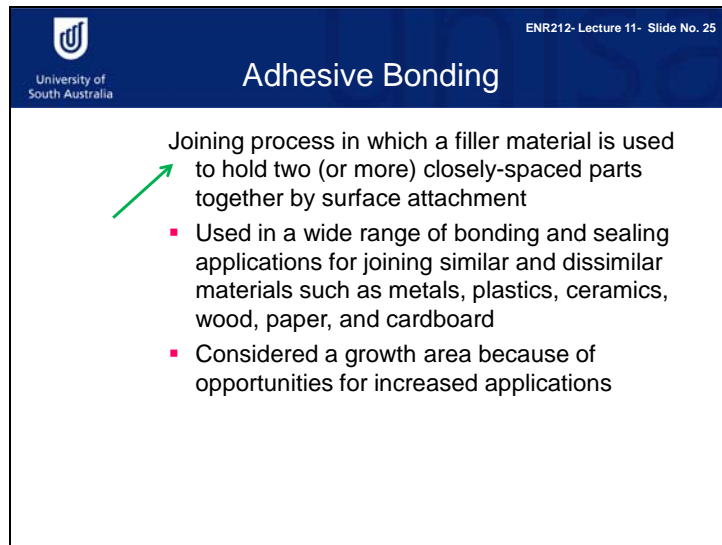
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Overview of Brazing and Soldering

- Both use filler metals to permanently join metal parts, but there is no melting of base metals
- When to use brazing or soldering instead of fusion welding:
 - Metals have poor weldability
 - Dissimilar metals are to be joined
 - Intense heat of welding may damage components being joined
 - High strength is not required

Brazing and soldering are used where metals have poor weldability, where dissimilar metals are to be joined, where intense heat of welding may damage the components being joined, or where high strength is not required.

So what is the difference between brazing and soldering? They both use filler metals to permanently join metal parts, with no melting of base metals. However, the melting point of the filler metals for brazing and soldering are different.



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Adhesive Bonding

Joining process in which a filler material is used to hold two (or more) closely-spaced parts together by surface attachment

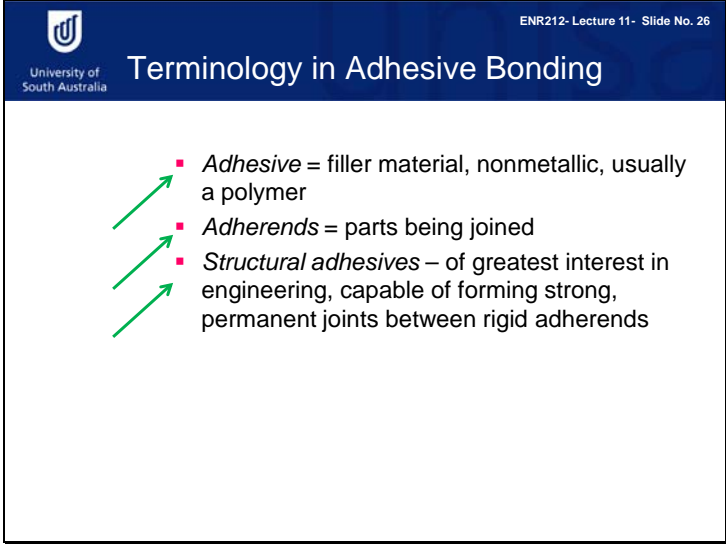
- Used in a wide range of bonding and sealing applications for joining similar and dissimilar materials such as metals, plastics, ceramics, wood, paper, and cardboard
- Considered a growth area because of opportunities for increased applications

Adhesive bonding is a joining process in which a filler material (which is often a polymer) is used to hold two or more closely spaced parts together by surface attachment.

Adhesive bonding is becoming more common for two reasons. First, adhesively bonded joints are strongest on the shear and tension. Second, adhesive bonding is low cost. It is much cheaper than mechanical fastening.

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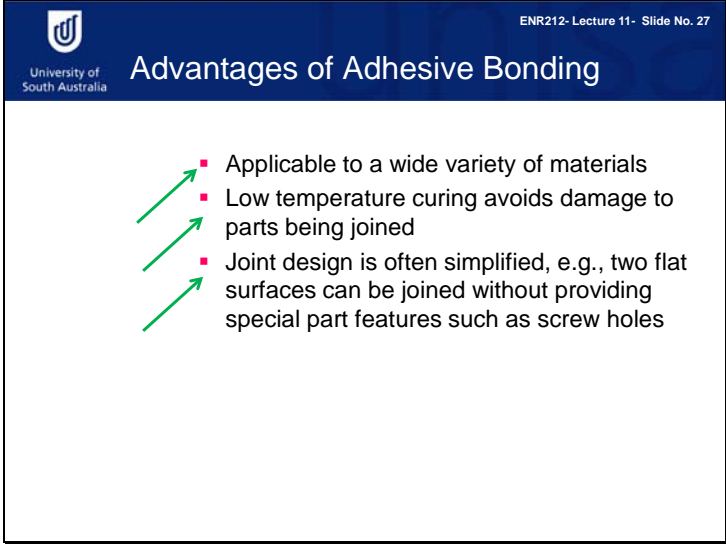
Terminology in Adhesive Bonding

- *Adhesive* = filler material, nonmetallic, usually a polymer
- *Adherends* = parts being joined
- *Structural adhesives* – of greatest interest in engineering, capable of forming strong, permanent joints between rigid adherends

You will need to understand these new terms. Adhesive is a filler material which is often a polymer. It is used to glue two or more parts together. The adherends are the parts being joined. The most important adhesives in engineering are structural adhesives.

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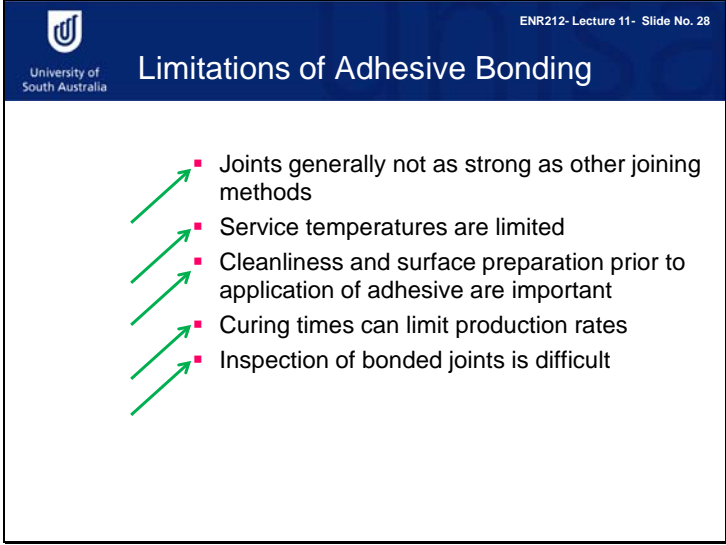
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Advantages of Adhesive Bonding

- Applicable to a wide variety of materials
- Low temperature curing avoids damage to parts being joined
- Joint design is often simplified, e.g., two flat surfaces can be joined without providing special part features such as screw holes

Adhesive bonding has a number of strengths. First, it is applicable to a wide variety of materials. Second, unlike welding, adhesive bonding just needs low temperatures to cure. Third, the joint design is simple.



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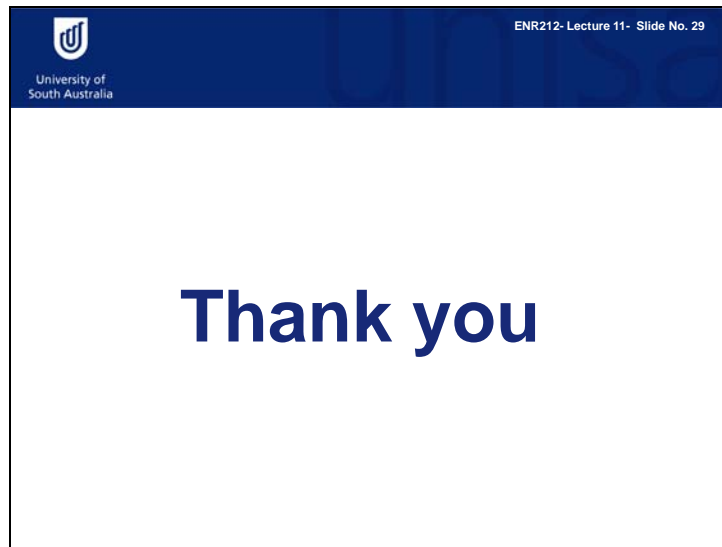
Limitations of Adhesive Bonding

- Joints generally not as strong as other joining methods
- Service temperatures are limited
- Cleanliness and surface preparation prior to application of adhesive are important
- Curing times can limit production rates
- Inspection of bonded joints is difficult

Adhesive bonding also has a few limitations. First, the adhesive joints are not as strong as in other joining methods, such as welding. Second, service temperatures are limited. Most adhesive bonding can not be used at temperatures higher than 100 degrees. Third, the surfaces in adhesive bonding need to be clean. Fourth, the adhesive bonding takes time to cure. Fifth, the inspection of bonded joints is difficult.

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Thanks for your attention.