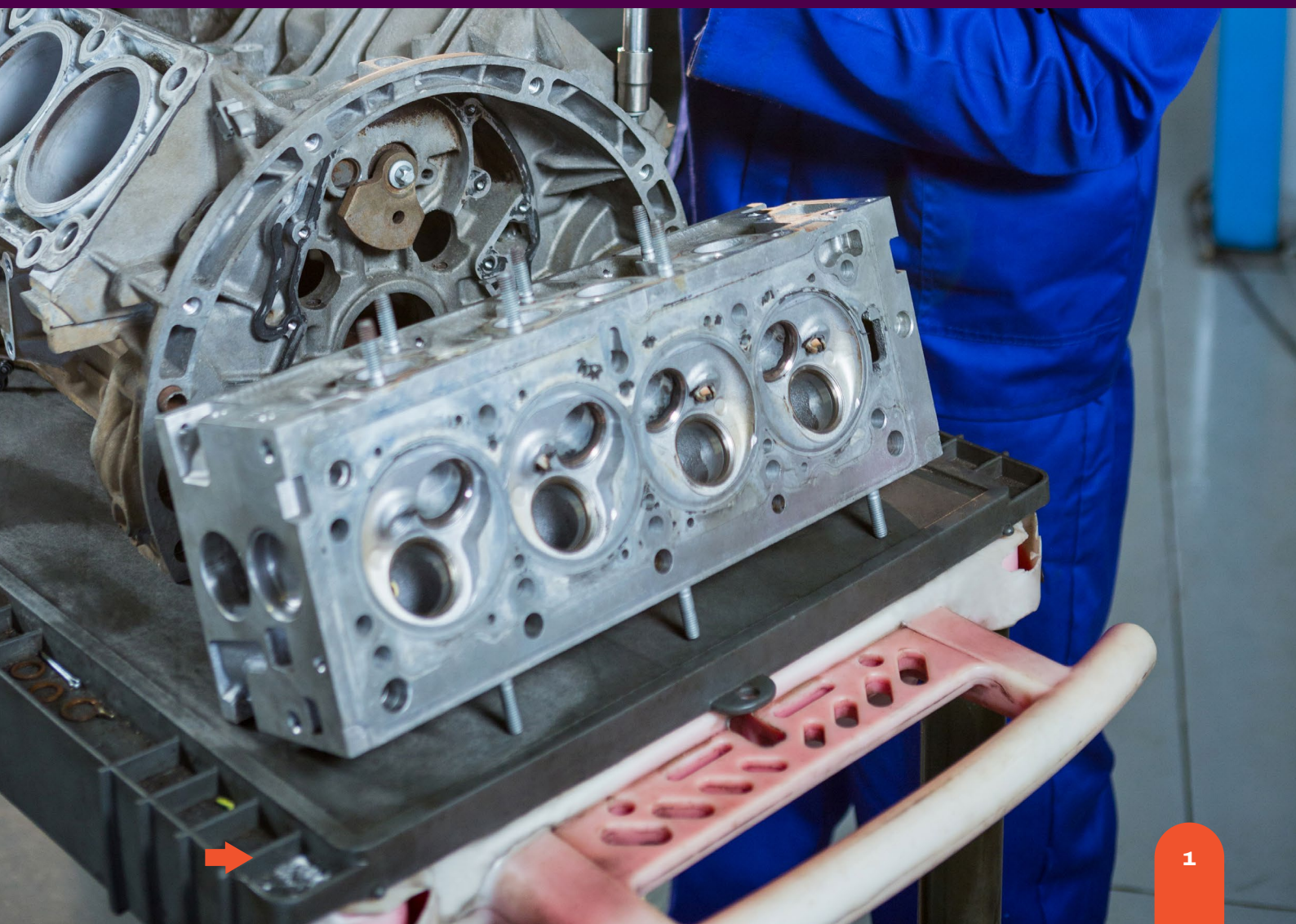
SECTION

4

BOARDS, VEHICLE TRANSMISSION SYSTEM, PROFESSIONALS, CIRCUITS & ARC WELDING



UNIT 1

WOODWORK TECHNOLOGY

Material and Artefacts Production Woodwork Industry in Ghana

INTRODUCTION

Manufactured boards, crafted from both wood and non-wood residues, play a crucial role in modern construction and furniture industries. As natural resources become increasingly scarce and environmental concerns grow, these engineered materials offer a sustainable and efficient solution. By utilising wood chips, sawmill shavings etc., manufactured boards reduce waste and maximise the use of available resources. Understanding the various types of these boards—such as plywood, laminboard, blockboard, battenboard, chipboard, particleboard, hardboard, and oriented strand board (OSB), highlights their distinct properties and applications. This knowledge is essential for making informed decisions in material selection, promoting sustainable practices, and advancing innovations in the building and manufacturing sectors.

At the end of this section, you will be able to:

Explain the types of manufactured boards made from Wood and non-wood residues

Key Ideas

Manufactured boards, made from both wood and non-wood residues, are essential in various construction and furniture applications. Manufactured boards from wood and non-wood residues come in different types with specific uses**:**

- Plywood: Made from layered wood veneers with alternating grains, it is strong and stable for construction, furniture, and cabinetry.
- Laminboard: Thin veneers around a core of narrow wood strips, ideal for lightweight doors and panels.
- Blockboard: Softwood strips between hardwood veneers, providing strength for doors, tabletops, and shelving.
- Battenboard: Similar to blockboard but with wider core strips, used for sturdy furniture and partitions.
- Chipboard: Made from wood chips bonded with resin, economical for low-cost furniture and flooring.
- Particleboard: Is a type of manufactured wood product made from wood chips, sawdust, or other wood particles that are bonded together with resin and pressed into sheets.
- Hardboard (Insulation board): Compressed wood fibres into dense sheets, used for furniture

backing and insulation.

- Oriented Strand Board (OSB): Layered wood strands, a strong, cost-effective alternative to plywood for sheathing, flooring, and roofing.

TYPES OF MANUFACTURED BOARDS

Manufactured Boards/Engineered Wood: These boards are created by binding together real wood pieces, scrap wood, shredded fibres, or sawdust with adhesives. Engineered wood is designed to mimic the appearance and behaviour of natural wood while offering enhanced strength and durability. It consists of multiple layers, or plies, arranged in different directions to provide exceptional stability. This material is widely used in construction, furniture, and various other applications. These boards are efficient and versatile, meeting various construction and furniture needs. Overall, manufactured boards optimise resource efficiency and sustainability in material production. The following are the types of Manufactured Boards**:**

Plywood

This board is made by glueing an odd number of thin wood veneers together, with the grain of each adjacent layer oriented perpendicular to the others. The veneers are thin slices of wood obtained either through rotary cutting or slicing from logs. This cross-graining technique gives plywood its strength, stability, and resistance to warping.

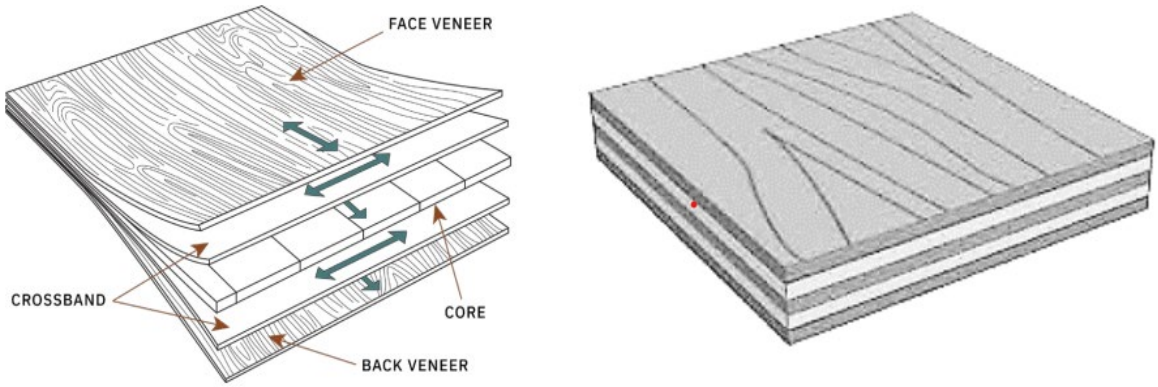


Fig. 4.1.1 Plywood (Source: Plywood - Search (bing.com)

Key Features of Veneers in Plywood

Veneers in plywood are thin wood slices, about 1/8 inch thick, glued together in layers with grains running perpendicular to each other (cross-grain orientation). This structure enhances strength, making plywood resistant to cracking, warping, and splitting. Typically, plywood has an odd number of layers (3, 5, or 7) to maintain balance and prevent warping.

Key features comprise:

a. Layered construction involves bonding thin wood veneers with alternating grain directions. This cross-grain structure enhances the plywood's strength, stability, and resistance to warping.

b. An odd number of layers in plywood means using an odd number of veneer layers (e.g., 3, 5, 7) to ensure the outer layers align. This ensures balance, prevents warping, and keeps the plywood stable.

c. Face veneers are the outermost layers of plywood, made from higher quality wood. They are preferred for their appearance, providing a smooth, attractive finish and surface.

d. Core veneers are the inner layers of plywood, typically made from lower-quality wood to provide structural integrity. They offer the necessary strength and stability, supporting the face veneers and ensuring durability.

e. The grading system in plywood rates veneers based on their quality and appearance. Higher grades have fewer defects and are used for visible surfaces, while lower grades are for less visible uses.

This combination makes plywood strong and visually appealing, making it suitable for various uses, from construction to furniture.

Activity 4.1.1

Scenario:

As a member of a design team for eco-friendly furniture, your task is to choose the best plywood for different components. To decide, you need to understand how veneers affect the quality and look of plywood.

Materials Needed:

- Veneer plywood samples
- Internet-enabled devices (tablets/laptops)
- Digital cameras or smartphones
- Notebooks and pens

Activity Guidelines:

1. Form groups of 4 classmates.
    - Explain what veneer plywood is and its common uses.
    - Discuss the importance of understanding its features for various applications.
2. Use digital resources (e.g., online articles, videos, databases) to find information on:
    - The purpose of veneers in plywood.
    - How veneers affect the strength, appearance, and cost of plywood.

- Summarize at least two key features of veneers and their impact on plywood quality.

3. Based on your research, design a sample furniture component (e.g., chair seat, table top) using different types of plywood veneers. Consider aesthetics, durability, and environmental impact.
4. Use digital design software or online plywood design simulators to create your design.
5. Create a digital mock-up of your furniture component and explain your choice of veneer and its benefits.
6. Present your digital design, explaining your veneer choice and the two key features you identified.
7. Conduct a peer review session to get feedback on the designs, focusing on the effectiveness of the chosen veneer features.
8. Create a small physical prototype of your design using sample plywood veneers.
9. Test the prototype for strength, appearance, and usability.
10. Reflect on how different veneers and your initial research influenced the prototype.
11. Discuss group findings in class, focusing on how veneers affected design and performance.
12. Share insights on the role and importance of veneers in plywood for real-world applications.

Activity 4.1.2

Scenario

You are part of a team at a custom plywood furniture company. Your task is to create a detailed report on veneer features in plywood for a new product line.

Materials needed:

- Whiteboard, markers, sticky notes, discussion prompts, flip charts
- Computers/tablets with internet access
- Samples of veneer plywood, solid wood, adhesives, cutting tools
- Presentation tools (e.g., projector, slides), report templates

Activity Guidelines:

1. Form groups of 4 classmates.
2. Research veneers in plywood using online resources (e.g., academic journals, industry websites, educational videos). Focus on:
   - How veneers impact the aesthetic qualities of plywood.
   - The role of veneers in enhancing the strength and stability of plywood.
   - How veneers affect the cost and environmental considerations of plywood.

3. Create a digital presentation or report summarizing your findings, highlighting the three features with examples or case studies.
4. Design a digital presentation or interactive report using tools like PowerPoint or Google Slides.
5. Present your findings to the class with visual aids and data.
6. Create a small physical model or sample board showcasing different types of plywood veneers. If possible, include samples for comparison.
7. Examine how different veneers affect plywood's appearance, strength, and cost. Test samples for durability and finish.
8. Record your findings and include them in a final report or presentation. Demonstrate the physical samples during your presentation.
9. Reflect on the findings in a group discussion. Discuss how veneer features impact plywood quality and usability, and their influence on design choices.
10. Critique each group's presentations and models. Provide constructive feedback on clarity and effectiveness.
11. Share key insights and lessons learned from the activity. Reflect on how understanding veneer features affects design and manufacturing decisions.
12. Discuss how the information can be applied to future projects or product development.

Laminboard

This material has two elements, the centre part (core) is made of about 10mm thick strips of softwood of lower grade. The outer part has a veneer applied with the grain at right angles to the strips of the core. This construction provides a lightweight and stable panel. Its layered design enhances durability while maintaining a smooth surface finish**.**

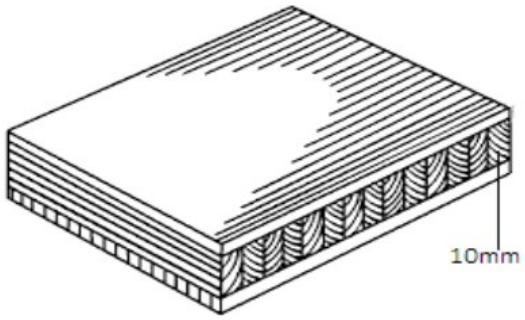


Fig 4.1.2: Laminboard

Blockboard

Made up of a core of wood strips placed edge to edge and sandwiched between veneers of hardwood. It is formed by combining a solid timber core with two outer-facing veneers such that their grain is at right angles and forms a solid, strong product. This construction provides strength and resistance to bending. Its design ensures durability and reduces the likelihood of warping or deformation.

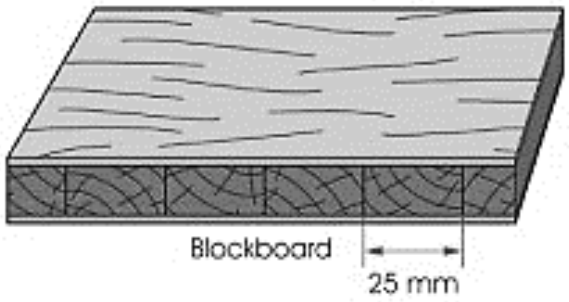


Fig 4.1.3: Blockboard

Battenboard

It is a type of engineered wood where a core of wide wooden strips or battens is enclosed between two layers of veneers or panels. This construction offers strength and stability, making it suitable for large surfaces. Its design helps prevent bending and provides a sturdy, durable surface.

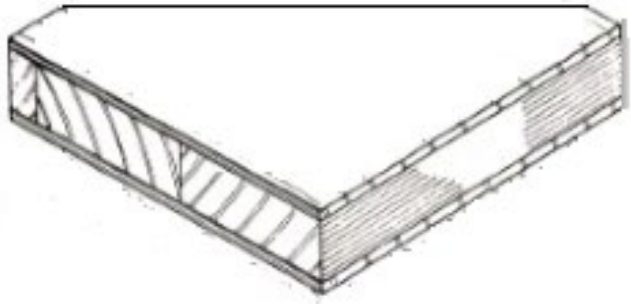


Fig 4.1.4: Battenboard

Table 4.1.1: Distinction between laminboard, blockboard and battenboard:

Key areas	Laminboard	Blockboard	Battenboard
Core Size	Laminboard has the thinnest core strips	Blockboard has medium-sized blocks	Battenboard has the widest battens
Weight and Stability	Laminboard is lighter and smoother	The blockboard is lighter and offers good stability	The battenboard is heavier and more rigid, providing greater strength and support.
Typical Applications	Laminboard is used for fine furniture	Blockboard for doors and shelves	Battenboard for large, strong panels

Activity 4.1.3

Scenario

You are part of a product development team designing modular storage units for a furniture company. Your team needs to choose the best board type (laminboard, blockboard, or battenboard) for different components. To make an informed decision, you will explore the differences between these board types.

Materials needed:

- Digital devices (laptops or tablets with internet access)
- Whiteboard, markers, and presentation software (e.g., PowerPoint)
- Samples of laminboard, blockboard, and battenboard
- Videos and pictures

Activity Guidelines:

1. Form groups of 4 classmates.
2. Research laminboard, blockboard, and battenboard using digital resources (articles, reports, videos). Focus on:
   - Material Composition: What each board is made of.
   - Strength and Durability: Performance under stress and usage.
   - Cost and Environmental Impact: Costs and environmental considerations.
   - Common Applications: Typical uses in furniture or construction.
3. Create a digital presentation or detailed report highlighting the differences, including visual aids and real-world examples.
4. Develop a digital comparison chart or interactive presentation showing key differences and applications. Use tools like spreadsheets, infographics, or presentation software.
5. Present your comparison to the class with visual aids (diagrams, photos, tables).
6. Obtain samples or create mock-ups of the boards. Conduct hands-on tests to evaluate properties like strength, weight, and surface finish.
7. Analyse the performance of each board type by assembling a small prototype or testing them under load.
8. Document your findings and include them in your final presentation or report. Demonstrate the physical samples, highlighting their strengths and weaknesses.
9. Participate in a group discussion to reflect on the findings and discuss how each board type's properties influence its use in different parts of the storage unit.
10. Engage in a peer review session to provide feedback on each other's presentations and practical demonstrations. Discuss how well each board type meets the project criteria and justify your recommendations.

11. Join a class-wide discussion to share insights and conclusions about the three board types. Reflect on how the differences between laminboard, blockboard, and battenboard affect their suitability for various applications.
12. Summarise key learnings and discuss how understanding these differences can impact material selection in real-world scenarios.

Chipboard

This material is made up of fine particles of wood or chips, sawdust or other wood particles which have been compressed together and bonded by a synthetic resin adhesive. While chipboard is cost-effective and versatile, it is less durable and more susceptible to moisture damage compared to other wood products. Despite these limitations, its affordability makes it a popular choice for a range of applications.

Fig 4.1.5: Chipboard

Particleboard

It is an engineered wood product made from wood particles, such as chips and sawdust, that are bonded together with resin under heat and pressure. Although particleboard is economical, it is less strong and more prone to moisture damage compared to other wood products. Despite these drawbacks, its affordability and ease of use make it a common choice for many applications. It is like a chipboard, but the chippings used in the manufacture are much smaller.

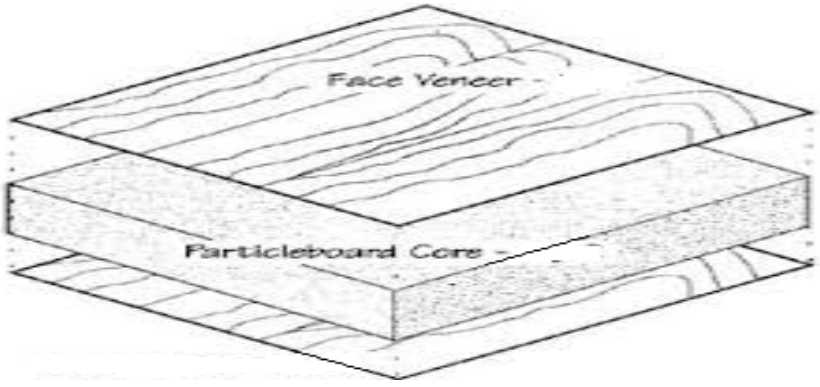


Fig 4.1.6: Particleboard

Hardboard/Insulation board

Hardboard is a dense, engineered wood product made of wood pulp in place of veneers or chips. The wood pulp is mixed with resin, heated and then compressed into a flat sheet. It has a smooth surface and is highly durable. It provides a solid, reliable surface and is valued for its durability and ability to hold up well under various conditions.

Fig 4.1.7: Hardboard

Oriented strand board (OSB)

OSB is an engineered wood product made from wood strands or flakes (shavings) that are arranged in layers and bonded together using adhesives and wax. This construction gives OSB its strength and durability. OSB's design allows for strong load-bearing capabilities and resistance to warping, making it a versatile choice in construction.

Fig 4.1.8: Oriented strand board (OSB)

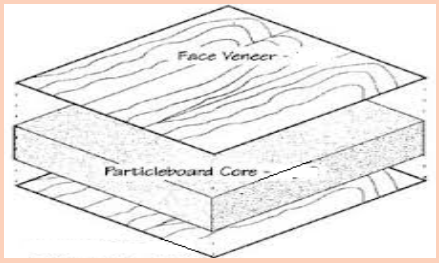
Manufactured boards from wood and non-wood residues offer diverse materials for various applications. Plywood, with its cross-laminated veneers, is strong and stable, ideal for construction and furniture. Laminboard and Blockboard are lightweight and durable, suitable for doors and panels, while Battenboard is robust for large furniture pieces. Chipboard is economical for low-cost furniture and flooring underlayment. Particleboard, also made from wood particles, is versatile for cabinetry and furniture but less durable. Hardboard provides a dense, smooth surface for panelling and insulation. Oriented Strand Board (OSB) is a strong, cost-effective alternative to plywood for structural uses. These materials efficiently utilise residues, meeting diverse needs in construction and furniture making.

Review Questions

1. Imagine you are working on a project to design eco-friendly furniture. Your task is to choose materials that are both sustainable and durable. Given this, identify at least three types of manufactured boards that you could use, which are made from wood and non-wood residues. How would each type of board contribute to the sustainability of your project?
2. You are designing a presentation on different types of manufactured boards for a woodworking class. As part of your presentation, you need to illustrate the internal structure of at least three types of manufactured boards. How would you sketch the structure of each type to clearly show their composition and layers?
3. Imagine you are advising a construction company in Ghana on incorporating engineered wood into their infrastructure projects. How would you discuss the various uses and benefits of engineered wood in the Ghanaian infrastructure industry, considering factors like cost, sustainability, and structural performance?
4. What are the key differences in structure and application between Plywood, Laminboard, and Blockboard?
5. How do Chipboard and Particleboard differ in terms of composition, durability, and common uses?
6. Why is Oriented Strand Board (OSB) considered a cost-effective alternative to Plywood in structural applications?

Answers to Review Questions

1.
   - Particle Board: Made from wood chips, sawmill shavings, and resin. It is an affordable option and utilises wood residues effectively.
   - Batten Board: Constructed from strips of wood, often combined with adhesives or other materials. It is used in various applications, including wall panelling, and helps in utilising wood residues.
   - Oriented Strand Board (OSB): Composed of wood strands and adhesive, oriented in layers for strength. It effectively uses larger wood pieces and residues, making it a strong and sustainable choice.
2. Sketches for selected manufactured boards are shown below:
   - Particle Board:



   - Hardboard:

   - Oriented Strand Board (OSB):

3.
   - **Cost-Effectiveness**: Engineered wood, such as plywood and oriented strand board (OSB), often costs less than traditional solid wood and can be more affordable for large-scale projects. Its consistent quality and ease of production contribute to reduced material costs.

- **Sustainability**: Engineered wood products utilise wood residues and by-products, which helps in reducing waste and promoting sustainable forestry practices. This aligns with the growing emphasis on environmental responsibility in the Ghanaian infrastructure industry.
- Structural Performance: Engineered wood offers excellent strength-to-weight ratios and can be used in various structural applications, such as beams, panels, and flooring. Its uniform properties ensure reliable performance, which is crucial for infrastructure projects like bridges, buildings, and housing.
- **Local Adaptation**: Engineered wood can be adapted to local conditions and needs. For example, products like cross-laminated timber (CLT) could be used in high-rise buildings, which is suitable for urban development in cities like Accra. Additionally, its resistance to environmental factors can be beneficial in Ghana's diverse climate.

4. **Key Differences in Structure and Application**:
   - Plywood: Made of thin wood veneers glued together in layers with grains at right angles. Used for furniture, flooring, and construction.
   - Laminboard: Consists of thin strips of wood glued together and sandwiched between veneers. Used for lightweight furniture and interior fittings.
   - Blockboard: Made of wooden strips sandwiched between veneers.
5. **Differences Between Chipboard and Particleboard:**
   - Composition: Both are made from wood particles bonded with resin, but chipboard has larger particles.
   - Durability: Particleboard is generally less durable and more prone to moisture damage.
6. **OSB as a Cost-Effective Alternative to Plywood**:
   - Cost: OSB is cheaper than plywood.
   - Strength: Comparable structural stability to plywood.

Extended Reading

- Jackson Albert, Day David, (1989). Collins Complete Wood Worker's Manual, Harper Collins Publishers, pages 34-38.
- Oriented Strand Board (OSB). APA - The Engineered Wood Association. Retrieved from https://www.apawood.org/oriented-strand-board-osb
- Walton, J., (1970). Woodwork Theory in and Practice (metric edition) pages 362-366.

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1. Jackson Albert, Day David, (1989). Collins Complete Wood Worker's Manual, Harper Collins Publishers.
2. Oriented Strand Board (OSB). APA - The Engineered Wood Association. Retrieved from https://www.apawood.org/oriented-strand-board-osb
3. Walton, J., (1970). Woodwork Theory in and Practice (metric edition).
4. www.woodworkingnetwork.com

Glossary

- **Battenboard**: Board made from strips of wood, often used in wall panelling and exterior siding.
- **Blockboard**: Board made from strips of softwood glued edge-to-edge, sandwiched between hardwood veneers.
- **Chipboard**: Low-density board made from wood chips, sawdust, and shavings bonded with resin.
- **Hardboard**: Dense, strong board made from compressed wood fibres.
- **Manufactured Board**: Engineered wood material made by bonding wood particles, fibres, veneers, or residues with adhesives.
- **Oriented Strand Board (OSB)**: Strong, durable wood product made by layering wood strands in specific orientations and bonding them with adhesives.
- **Particle Board**: Low-density board made from wood chips, sawdust, and shavings bonded with resin.
- **Plywood:** Engineered wood product made from thin layers of wood veneer glued with the grain of each layer at right angles to the next.
- **Resin**: Synthetic or natural adhesive used to bond wood particles, fibres, or veneers.
- **Veneer**: Thin layers of wood glued together to form plywood or used as a surface layer for engineered wood products.

UNIT 2

AUTOMOTIVE TECHNOLOGY

Introduction to Vehicle Technology

INTRODUCTION

The transmission system (also called the power train) refers to the mechanism that transmits power or torque from the engine to the road wheels. The power generated by the engine is passed (transferred) through the transmission system to move the road wheels. It is one of the basic but necessary systems of the automobile. the engine is of very little use without the transmission system because it is the transmission system that keeps the vehicle moving. The transmission system is one of the systems that the driver takes control of and manipulates. He or she does so by varying and determining the speed at which the vehicle should move. We will explore the major components of the transmission system in this unit.

At the end of this section, you will be able to:

Identify the components of vehicle transmission systems and explain their functions.

Key Ideas

- The transmission system is crucial in transferring power from the engine to the road wheels.
- There are various transmission systems, including manual, automatic, continuously variable and automated manual transmissions.
- The transmission system is made up of several key components, such as the clutch, gearbox, propeller shaft, universal joints, final drive, differential, and drive shafts, which work together to ensure the vehicle operates smoothly.
- Manual transmission requires the driver's effort to change gears, while automatic transmission adjusts gears based on factors like speed and load.

COMPONENTS OF VEHICLE TRANSMISSION SYSTEMS

The transmission system transmits power from the engine to the road wheels. It also enables the vehicle to accelerate forward or backwards or to change speeds. It consists of several components that are arranged in an interconnected manner between the engine and the road wheels.

The engine may be mounted along or across the central axis of the vehicle. When the engine is mounted lengthwise in the vehicle, it is called longitudinal layout. The other arrangement where the engine is placed across the chassis frame of the vehicle is known as the transverse layout. Vehicles with transverse layout do not use a propeller shaft and also do not need to turn the drive lines through 90 degrees, as all the shafts are parallel to the axes of the road wheels.

Types of Transmission System

Some common types of transmission systems are manual transmission, automatic transmission, continuously variable transmission, and automated manual transmission. The popular ones are the manual and the automatic.

Manual transmission (MT)

This type of transmission requires the driver's effort to change gears and vary the speed of the moving vehicle. It was the first transmission system to be invented and used in automobiles. A clutch is used to couple (engage) or decouple (disengage) the transmission from the engine's power. They are very simple in construction and comparatively cheaper.

Watch the video: 'How Manual Transmission Works' at:

https://www.youtube.com/watch?v=TUpeMYTj1O8

Automatic transmission (AT)

In this type of transmission, gear changing is done automatically by the vehicle, depending on several factors such as vehicle speed, engine load, and road conditions. The automatic transmission uses a torque converter to perform the work of a clutch in a manual transmission system. The torque converter contains the transmission fluid.

Watch the video: 'How Automatic Transmission Works' at:

https://www.youtube.com/watch?v=u_y1S8C0Hmc

Continuously Variable Transmission (CVT)

This type of transmission uses cone-shaped pulleys and a belt or chain to transmit drive from the engine's output drive to the road wheels. One of the pulleys (primary pulley) is connected to the engine whilst the other (secondary pulley) is connected to the vehicle's drive shaft. The pulleys adjust themselves automatically depending on driving conditions. The adjustment increases or decreases the diameters of the pulleys. When the primary pulley increases, the secondary pulley diameter decreases, resulting in an increased gear ratio. Similarly, when the primary pulley diameter decreases, it results in an increase in the secondary pulley diameter, thereby providing a reduced gear ratio.

Watch the video: 'How Continuously Variable Transmission Works' at:

https://www.youtube.com/watch?v=PEq5_b4LWNY

Automated Manual Transmission (AMT)

Automated manual transmission (AMT), or automated shift transmission (AST), combines elements of both manual and automatic transmissions to simplify transmission operations and increase economic operation. Gear shifting may be performed manually by the driver but without the need for a clutch pedal, or automatically by pneumatic, hydraulic, or electrical means.

Watch the video: 'How Automated Manual Transmission Works' at:

https://www.youtube.com/watch?v=D5yp-o_JTBA

Identification of Components of The Vehicle Transmission System

Transmission starts at the flywheel and continues through the transmission system to drive the road wheels. The transmission mechanism consists of the following components:

1. clutch or torque converter
2. gearbox
3. propeller shaft
4. universal joints
5. final drive & differential
6. drive shafts/drive axle
7. road wheels & tyres

The manual transmission system with a conventional layout will be discussed in detail in this section. This configuration or arrangement is commonly used in front engine rear wheel drive vehicles. The power from the engine must be turned through an angle of 90 degrees to drive the road wheels to complete the drivetrain.

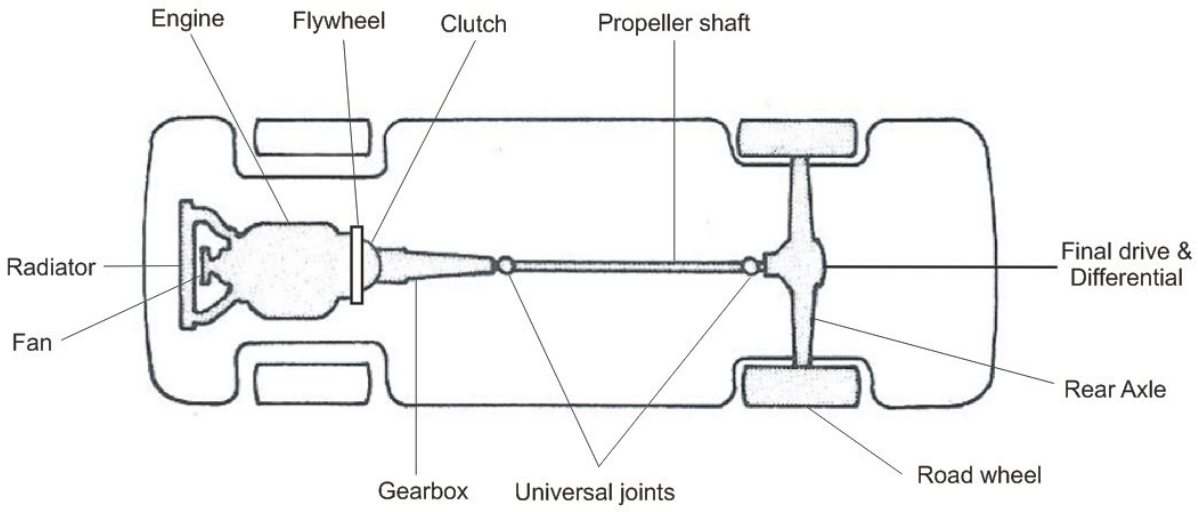

Fig 4.2.1: Layout of conventional transmission system

Clutch

The clutch is located between the engine's flywheel and the gearbox. It provides a means of disconnecting the engine power from the gearbox. It also provides a means of gradually connecting the torque from the engine to the gearbox during take-off. In other words, it permits the driver to engage or disengage the engine from the rest of the transmission system by depressing the clutch pedal. The drive must be temporarily interrupted while the gear trains are being changed to prevent damage and this is the reason for the use of the clutch to couple and uncouple the engine and the transmission. Automatic transmissions use a torque converter in place of a clutch.

The manual clutch provides the following functions:

1. To engage and disengage the engine power from the transmission during gear changing without having to stop the vehicle.
2. Smooth gear changes without grinding or damaging the gears.
3. To transmit power from the engine to the wheels through the rest of the transmission.
4. Smooth take off/start from rest.
5. To protect the gearbox and the other transmission components from damage by absorbing and distributing the load from the engine to the transmission.
6. To allow the engine to continue running while the vehicle remains stationary.

Parts of the clutch assembly

The clutch assembly of a manual transmission consists of the following major parts:

a. clutch plate (driven plate): A disc with a high heat-resistant friction material facing that is sandwiched between the engine's flywheel and the pressure plate. It is supported on the splines of the gearbox input shaft.

b. pressure plate: a heavy metal that presses against the clutch disc.

c. diaphragm spring: a conical-shaped spring attached to the pressure plate to apply thrust or force on the clutch disc to be in firm contact with the flywheel.

d. cover: serves as a housing to protect the pressure plate and the clutch disc.

e. release bearing (throw-out bearing): pushes against the spring temporarily to release the pressure plate from the clutch disc.

f. release fork: holds and moves the release bearing when the clutch pedal is depressed.

Figure. 4.2.2: A clutch assembly (www.ebay.com)

Watch the video: 'How a Clutch Works' at the link below:

https://www.youtube.com/watch?v=PmQnV1oxfe8

Activity 4.2.1

Experiment to show how a friction clutch works

Materials needed

- 5 mm thick plywood
- 2 pcs Ø25 mm PVC pipe 150 mm long
- 300 mm long metal rod or wooden dowel equal to the internal diameter of the pipe
- Super glue
- Drill and bits
- 2 pairs of Vee blocks

Activity steps

CAUTION: Wear your PPE and adhere to safety precautions regarding the use of tools and equipment.

1. Cut 2 pcs (a and B) Ø100 mm and 1 pc Ø80 mm diameter circular shapes from the plywood. (You may use plastic objects that are readily available)
2. Drill holes in the centres of the 2 Ø100 mm plywood discs.
3. Insert each of the pipes in the hole such that the end of the pipe flushes with the surface of the plywood.
4. Apply a little glue to strengthen the joints.
5. Drill another hole equal to the diameter of the metal rod (or dowel) in the centre of the 80 mm disc.

N.B: Follow the diagram below to assemble the parts:

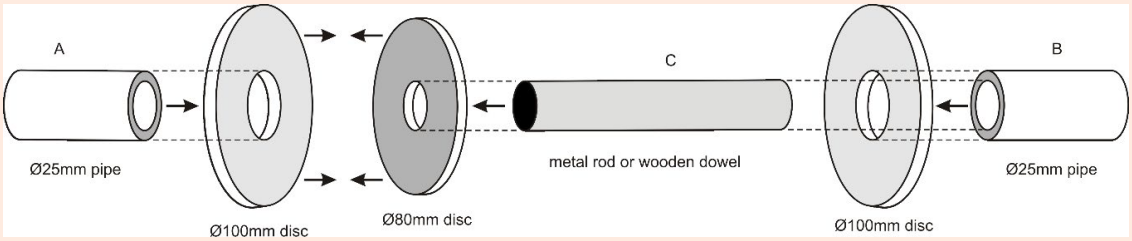

Figure. 4.2.3: Friction clutch operation assembling guide

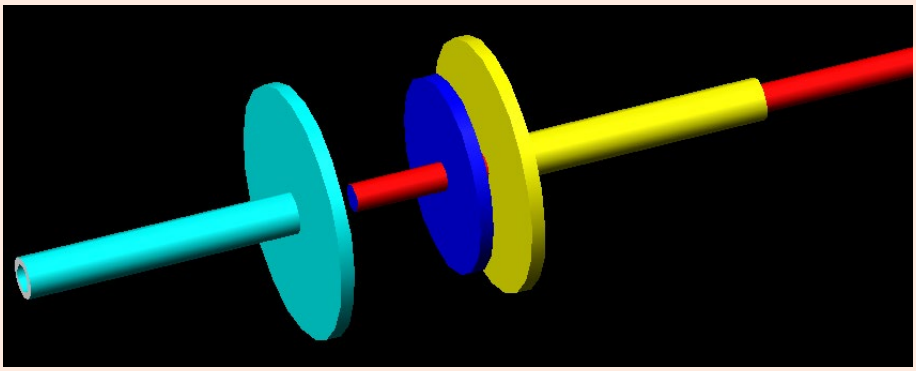

Figure. 4.2.4: Clutch simulation installation

6. Insert the rod to extend about 50 mm through the hole.
7. Apply a little glue to bond the two pieces together.
8. Insert the longer end of the rod into pipe B.
9. Place the 50 mm long end of the rod into pipe A.
10. Support the two pipes A and B on the Vee blocks.
11. Press the two pipes with the 100 mm discs against each other while rotating pipe A. Write down your observation.
12. Release the pressure on pipe A and rotate again. Write down your observation.
13. Read out and discuss your observations with your colleagues.

Extended Activity

1. Based on the experiment, describe how the clutch couples and uncouples the engine and the gearbox input shaft.
2. What components in a typical manual transmission system are represented by the parts labelled A, B and C in your experiment as shown in Figure 4.2.3 above?

Gearbox

The gearbox (also known as the transmission box) is the second component of the drivetrain in an automobile. It is a box or case containing a series of gear ratios. The driver selects different speeds to suit different driving conditions. The gears are rotated by different shafts

that run parallel to each other in the gearbox. The different shafts in the gearbox are:

1. input shaft (or primary shaft): transfers the engine drive that is transmitted to the clutch to the gearbox. It has a gear (clutch gear) that drives another gear on the layshaft. The clutch disc or driven plate is supported on the input shaft using splines.
2. counter shaft (or lay shaft): contains a series of gears that function as driver gears for all the output gear ratios. The gears are fixed on this shaft and rotate with it.
3. output shaft (or main shaft): contains all the gears which provide the output speeds. The gears are freewheeling, but the selected output gear is locked to the main shaft by locking collars that spin with the output shaft.
4. idler gear shaft: contains the idler gear that produces the reverse direction. The idler gear causes the driver and driven gear to move in the same direction without any change in speed output.

Each of the shafts has one or more gears mounted on it. The sets of gears used in the gearbox have one or more of the following gear teeth types:

a. spur gears
b. Helical gears
c. Double helical

Watch video: 'Different types of Gear Teeth' at:

https://www.youtube.com/watch?v=iYZR8oAr0cY

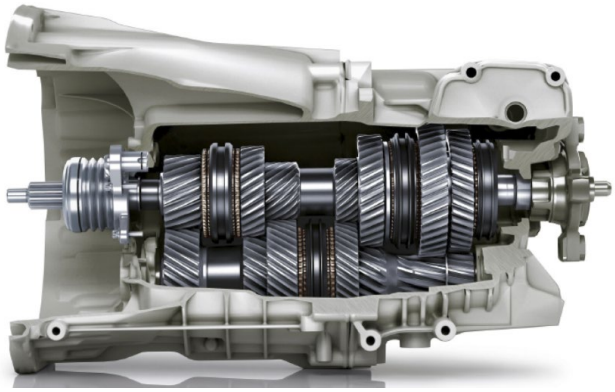

Figure. 4.2.5: A manual gearbox

Functions of the Manual Gearbox

The functions of the manual gearbox include the following:

a. It provides the torque needed to move the vehicle under a variety of road and load conditions. A lower gear ratio provides more torque but slower speed, whilst a higher gear ratio provides less torque but faster speed.
b. It allows the driver to manually have control over the driving speed of the vehicle so as to improve fuel efficiency.
c. It provides a means of reversing the direction of the vehicle.
d. It enables the transmission to be completely disconnected from the engine by selecting a neutral position.

Extended Activity

Watch the video: 'How a Manual Transmission and Clutch Works' at the link below:

https://www.youtube.com/watch?v=o1ED4FQjDGk&t=335s

1. Briefly describe a vehicle transmission system.
2. How does the manual transmission differ from the automatic type?

Propeller Shaft

The propeller shaft (also called prop shaft) is a component of the transmission system that connects the gearbox to the final drive in a front engine, rear-wheel drive arrangement. It comes in two forms: a solid type and a tubular type. The solid type sags or bows because of the weight. Sagging is very minimal in the tubular type because it is lighter in weight. A tubular section propeller shaft is normally used because it has the following advantages:

1. Low weight.
2. High resistance to misalignment, especially sag.
3. Good torsional strength (a tubular shaft is only slightly weaker than a solid shaft of similar diameter).
4. Low resistance (low inertia) to changes in angular speed that arise when a Hooke-type coupling is used to drive the shaft.

Figure. 4.2.6: A propeller shaft

The propeller shaft is often a one-piece or two-piece in construction, depending on the distance between the gearbox and the rear axle. A two-piece propeller shaft is connected to a centre support bearing encased in a rubber bushing to absorb the vibrations. Using a two-piece construction can prevent a condition called *whip*, which is common with long propeller shafts. Whip is a term used to describe the bowed deformation of a propeller shaft which causes excessive whirling or vibration.

Requirements of a Propeller Shaft

a. It must be strong to resist shocks and the twisting action of the driving torque.

b. It must resist the natural tendency to sag under its own weight because vibration occurs when the centre of gravity does not coincide with the axis of the shaft.

Sliding Joint

As the rear axle moves up and down or twists at an angle through torque reaction, the distance between the axle and the transmission system will alter. To ensure that the propeller shaft can adjust to this change in length, a sliding joint (or slip joint) is fitted to the transmission end. This arrangement incorporates a splined joint that allows the propeller shaft to move in and out of the transmission output shaft during axle movements.

Universal Joints

A universal joint, sometimes called a Carden joint, allows the drive to be transmitted through a variable angle. There are two main groups of universal joints: variable velocity and constant velocity types. The output shaft of variable velocity universal joints does not rotate at the same speed as the input shaft through 360 degrees when the drive is transmitted through an angle. Variable velocity universal joints, on the other hand, maintain the same speed between the input shaft and the output shaft irrespective of the angle through which the shaft is transmitting.

Figure. 4.2.7: Universal joint

Watch video: 'Propeller shaft and Universal joint in operation' at:

https://www.youtube.com/watch?v=y8QaD8NJLxM

Activity 4.2.2

How the propeller shaft and universal joints work

Materials needed

- 2 cross Tee (can be cut from a wire mesh)
- Ø25 mm PVC pipe or wooden rod 350 mm
- Ø25 mm PVC pipe or wooden rod 100 mm
- 4 pcs PVC couplers
- Tape measure/rule
- Hacksaw
- Drill & bit
- Glue

Activity Steps

CAUTION: Handle sharp tools with caution.

1. Measure, mark out and cut grooves at opposite sides of one end of the PVC couplers with a hacksaw.
2. Drill holes in the fingers of the couplers.

3. Join each pair of couplers with a cross Tee to form a joint.
4. Screw on the two joints to each end of the 350 mm long pipe/rod.
5. Attach one of the joints to the end of pipe B in your first experiment and the other joint to the 100 mm pipe or wooden rod. Use glue to strengthen the bond.
6. Rotate pipe B while holding the 100 mm end pipe and varying the angles between the 3 pipes.
7. Record your observations and share them with your group members.

Extended Activity: Class Exercise

Based on your experiment:

1. Illustrate with sketches how the universal joints help to transmit drive at an angle to the axis of the gearbox input shaft.
2. Discuss the areas outside the automobile industry where universal joints can be made useful.

Final Drive & Differential

The final drive consists of a set of gears: pion gear and crown gear. It serves as the last point of gear reduction between the gearbox and the drive shafts. In a conventional vehicle layout, the final drive is mounted on the rear axle. A pinion gear at the end of the propeller shaft drives a crown gear in the axle casing. The pinion and crown may be designed with either bevel gears or worm and wheel.

The final drive provides the following functions:

1. it transmits the drive through an angle of 90 degrees between the propeller shaft and the drive shafts;
2. it provides a gear ratio that reduces the speed at which the gearbox output shaft rotates.

Final drives are designed with worm type called worm and wheel whereas the generally used bevel types are:

a. Straight bevel,
b. Spiral bevel, and
c. Hypoid bevel.

Figure. 4.2.8: A spiral bevel final drive assembly

Watch the video: 'Final Drive Gears Explained' at:

https://www.youtube.com/watch?v=bOowIc54vL4

The Differential

The differential is a device that splits the drive torque and distributes it to the two road wheels. It also ensures that each wheel rotates independently of the other and at different speeds. The reason for this provision is to allow the vehicle to negotiate turns or corners easily without the tyres scrubbing over the road surface. When a vehicle is cornering, the wheels of the vehicle rotate at different speeds, making the outer wheel turn faster than the inner wheel.

Figure 4.2.9: Final drive and differential assembly

The complete differential consists of a differential cage bolted to the crown wheel of the final drive. The cage supports the sun wheels on plain bearings. The drive is transmitted from the crown wheel to the sun gears via the cross pin and the planet gears.

Watch the video: 'How Differential Works' at:

https://www.youtube.com/watch?v=gIGvhvOhLHU

Activity 4.2.3

Model an activity to demonstrate the working of the final drive.

Materials Needed

- 2 cotton reels or empty milk cans
- Metal rod

Activity Steps

CAUTION: Handle sharp tools with caution.

1. Bend the metal rod to form an 'L' shape with one end longer than the other.
2. Place one reel on the shorter end of the metal rod.
3. Place the other reel on the longer end of the metal rod to sit on the first reel.
4. Roll or push the reel on the shorter end forwards and backwards on a flat surface.
5. Record your observations.

Extended Activity: Class Exercise

Describe the outcome of the experiment in your exercise book.

Drive Shafts

Drive shafts or half shafts transmit drive from the final drive to the road wheels. All drive arrangements require drive shafts. The drive shafts in a front-mounted engine, with rear wheel drive may be supported in an axle casing or exposed. The drive shafts can be tubular or solid in design, depending on the type of vehicle and weight consideration factors.

Figure. 4.2.10: Driveshaft

Rear Axle

A rear axle may be described as dead or alive. A live axle offers support to the vehicle's weight and also contains the final drive, differential and drive shafts that transmit power to the road wheels. A dead axle supports the weight of the vehicle and also provides mounting points for the non-driven wheels.

Fig. 4.2.11: A live rear axle

Road Wheels & Tyres

The wheel is that circular metal disc that is bolted to and rotates with the axle hub and rolls to propel the vehicle. The material for the wheel must be strong enough to withstand acceleration, braking, and cornering forces. It has a rim on its outer edge which secures the tyre in place. The wheel acts together with the tyre to support the weight of the vehicle.

Fig. 4.2.12: Road wheels

The Tyre

The tyre is the pneumatically operated component that surrounds the wheel rim and transfers the load of the vehicle through the wheel to the road or ground. It provides a flexible cushion that absorbs shocks and vibrations. It also provides traction on the road surface. The acceleration, braking and cornering forces that are exerted on the wheel are transferred to the road through the tyre.

Fig. 4.2.13: A tyre

Activity 4.2.4

Educational Game

1. Visit the website below to access a crossword puzzle on the transmission system. Click on 'PLAY' to commence the game.

https://www.educaplay.com/learning-resources/5780321-transmission_system.html

NOTE: You can create an account so you can compete with a friend and also have your score recorded.

2. Compare your results with your friends' performance.
3. Retake the quiz often t to achieve a higher score.

Activity 4.2.5

1. Follow the link below to answer multiple-choice questions on the transmission system.

   https://play.howstuffworks.com/quiz/transmission-quiz
2. Click on 'START QUIZ' to answer all 35 questions.

   NOTE: You must complete all questions to see your total score.
3. Compare your results with your friend's results.
4. Retake the quiz often to achieve a higher score.

Activity 4.2.6

Visit the school's auto workshop or a nearby mechanic shop in the community to study the manual transmission system.

CAUTION: Observe all workshop safety rules and regulations.

1. Try and examine the various components of the transmission system of an available vehicle.
2. Describe the type of vehicle you examined and also describe how the components are arranged.
3. Discuss your answer with the entire class.

Review Questions

1. Briefly describe the vehicle transmission system.
2. Discuss three advantages and disadvantages of the conventional vehicle design.
3. Clutch discs have friction facings on both sides of the plate. In the past, the friction material was manufactured from asbestos because of its high coefficient of friction. The material was later found to be dangerous to the health of humans and has since been replaced by other materials that are environmentally friendly. Identify areas in your school or home or any other area in your community where the use of asbestos is still relevant and suggest ways by which the negative effects of asbestos can be avoided.
4. What negative environmental impacts are associated with the use of the manual transmission system?
5. List at least three types of vehicle transmission systems.
6. Identify at least five components of a vehicle transmission system and briefly explain the function of each one of them.

Answers to Review Questions

1. The vehicle transmission system consists of several components that work together to transfer the engine power to the road wheels to enable the vehicle to move. The components include the clutch, gearbox, propeller shaft, universal joints, final drive, differential, drive shafts, road wheels and tyres.
2. **Discuss Three Advantages and Disadvantages of the Conventional Vehicle Design**

   The advantages of the conventional vehicle design include the following:

   - It is more durable and robust on the road.
   - It is easier to maintain and service.
   - There is fair load distribution as the engine is located at the front and the final drive, differential, drive shafts and axle are also located at the rear of the vehicle.

   The disadvantages include the following:

   - The numerous parts tend to make it comparatively heavy.
   - It has a high production cost.
   - It requires more experience to drive.
3. Asbestos may still be found in older buildings, particularly in insulation, roofing, and flooring materials. To avoid the negative effects of asbestos:
   - Conduct inspections in older buildings to identify the presence of asbestos material, e.g. Roofing sheets.
   - Shield all asbestos-containing devices to prevent fibres and particles from becoming airborne.
   - Always handle asbestos-containing materials with great care.
   - Do not disturb or tamper with materials that may contain asbestos, as this can release harmful fibres.
4. The use of manual transmission systems can contribute to negative environmental impacts such as:
   - Poor gear-shifting techniques can lead to higher fuel consumption and increased emissions.
   - Frequent gear shifting and improper use can lead to wear on the clutch and transmission components, which may require more frequent repairs and replacement of parts.
   - Manual transmission vehicles use gear oil, which can be harmful if not disposed of properly, contributing to soil and water contamination.
5. **List at Least Three Types of Vehicle Transmission Systems**

- **Manual Transmission:**
- **Automatic Transmission:**
- **Continuously Variable Transmission**

6. Identify at least five components of a vehicle transmission system and briefly explain the function of each.
   - **Clutch:** engages and disengages the engine from the transmission to allow for smooth gear changes.
   - **Gearbox:** contains the gears that adjust the torque and speed delivered to the wheels.
   - **Driveshaft:** Transfers power from the transmission to the differential or directly to the wheels.
   - **Differential:** distributes power between the wheels, allowing them to rotate at different speeds when turning.
   - **Propeller shaft:** Propeller shaft: connects and transmits drive between the gearbox and the final drive in a front engine, rear-wheel drive arrangement.

Extended Reading

- Types of Car Transmission Systems: All You Need to Know

https://blog.onlineautomotive.co.uk/car-transmission-types/

- How Manual Transmissions Work: Explained in an Easy Way

https://carfromjapan.com/article/car-maintenance/how-manual-transmissions-work-explained-easy-way/

- How a Manual Transmission Works

https://auto.howstuffworks.com/transmission.htm

- Manual Transmission: Know Diagram, Parts, Working, Types, Advantages, & Disadvantages

https://testbook.com/mechanical-engineering/manual-transmission-definition-and-types#:~:text=Manual%20transmission%20components%20include%20a,Clutch%20Pedal

References

1. Hillier, V. A. W. (2012). Fundamentals of motor vehicle technology (6th ed.). Nelson Thornes: Cheltenham, London,
2. Reif, K. (2014). Fundamentals of Automotive and Engine Technology. Springer Vieweg: Friedrichshafen, Germany.

UNIT 3

BUILDING CONSTRUCTION TECHNOLOGY

Pre-construction Activities

INTRODUCTION

The success of every building construction work depends to a great extent on the professionals involved. Gaining knowledge of the roles of the various professionals will increase understanding of the importance of pre-construction activities and personnel involved in building construction projects.

At the end of this section, you will be able to:

Describe the roles of professionals in building construction projects.

Key Ideas

- The main activities of building construction projects evolve around the various professionals.
- The professionals play very distinctive roles to ensure the desired end product is met.
- The roles that these professionals play in building construction projects are always complimentary in nature.
- The success of the project will depend on the composite efforts of all the professionals involved.

THE ROLES OF THE PROFESSIONALS IN BUILDING CONSTRUCTION PROJECTS

The professionals involved in building construction projects include architects, quantity surveyors, structural engineers, electrical/mechanical/plumbing engineers and contractors. These professionals perform specific roles for which they are recognised. Table 4.3.1 shows these professionals and the specific roles they play during building construction projects. The pictures in Figure 4.3.1, show professionals on building construction sites.

Table 4.3.1: Roles of Professionals Involved in Building Construction Projects

PROFESSIONALS	RESPECTIVE ROLES OF THE PROFESSIONALS
ARCHITECT	• Creates functional and aesthetic building designs. • Works with clients and engineers to refine and implement designs.
QUANTITY SURVEYOR	• Estimates costs and prepares budgets for the project. • Manages contracts and ensures compliance with regulations.
STRUCTURAL ENGINEER	• Design safe and durable building structures. • Works with architects to align structural integrity with design.
ELECTRICAL/ MECHANICAL / PLUMBING ENGINEERS	• Designs electrical, mechanical, and plumbing systems. • Ensures systems fit well within the overall building design
CONTRACTORS	• Manages the actual building process and labour. • Ensures construction meets standards and project specifications.

Figure 4.3.1: Professionals at Building construction sites

Appropriate Operative Technical Terms used by Professionals in the Building construction industry

The basic activities of professionals involved in the building construction industry are usually identified with certain words. These words are referred to as the appropriate operative technical terms. Table 4.3.2 indicates some of the operative technical terms used by the professionals in their basic activities.

Table 4.3.2: Appropriate operative technical terms of basic activities of professionals

Operative Technical Terms	Description of Appropriate Operative Technical Terms used by building construction Professionals
Blueprints	Detailed technical drawings that outline the design, dimensions, and specifications of a building construction project.
Bill of Quantities (BOQ)	A document that itemises all the materials, parts, and labour required for a construction project and their costs.

Operative Technical Terms	Description of Appropriate Operative Technical Terms used by building construction Professionals
Change Order	A document that modifies the original construction contract by detailing changes in scope, cost, and schedule of the project.
Construction Manager/ Management	A professional or firm responsible for overseeing and managing the design, contracting, and construction aspects of a project.
Critical Path Method (CPM)	A project management tool that outlines the sequence of essential tasks and calculates the minimum completion time for a project.
Punch List	A list of tasks and items that need to be completed or corrected before a construction project can be considered finished.
Request for Information (RFI)	A formal process by which contractors ask architects or clients for clarification on construction documents.
Submittals	Documents, samples, and mock-ups provided by the contractor to the architect or engineer for approval before implementation of a project.
Value Engineering	A process that aims to optimise project costs without compromising on quality or functionality.
Work Breakdown Structure (WBS)	A project management tool that analyses or breaks down a project into smaller, manageable sections or tasks.

Activities performed by Professionals can lead to Checks and Balances in the Procurement system for Building construction projects

Professionals involved in building construction projects at the various stages of construction work perform many roles. However, there are instances in which the activities of the professionals involved in building construction projects result in quality outcomes.

Building construction projects involve procurement, a system through which all materials needed are obtained. It is interesting to note that certain activities undertaken by these professionals ensure checks and balances in the Procurement system for Building construction projects. Table 4.3.3 provides the details of some professional activities that can lead to ensuring accurate checks and balances in the procurement of materials for construction projects

Table 4.3.3: Professional Activities to ensure Checks and Balances in the Procurement system for Building construction projects

ACTIVITY	DESCRIPTION
SEPARATING DUTIES	• Different people handle different tasks in procurement. This helps prevent mistakes and fraud.

ACTIVITY	DESCRIPTION
GETTING APPROVALS	• Several teams must approve major decisions. This ensures that all aspects are reviewed.
REGULARLY CHECKING THE SYSTEM	• Audits are done to find mistakes and problems. This helps improve the procurement process.
MONITORING SUPPLIERS	• Suppliers are watched to ensure they deliver on time and meet quality standards.
FOLLOWING THE RULES	• Everyone must follow company policies and laws. This keeps the process fair for all.
BEING TRANSPARENT	• The procurement process is open and clear. This builds trust with everyone involved.
ENCOURAGING COMPETITION	• Multiple suppliers can bid for contracts. This helps get the best value for the project
TYING PAY TO PERFORMANCE	• Payments depend on meeting specific goals. This encourages suppliers to do their best work.

The Specific Professionals in the Building Design team and their roles

The professionals in the building design team have specific roles which are very important to ensure good decisions are taken at the start of the project. Table 4.3.4 shows the professionals for the building design team and provides a description of the specific role each plays in the team. Figure 4.3.2, shows pictures of some of the professionals during a building design meeting on inspection at a construction site.

Figure 4.3.2: Professionals in building design team meeting and on inspection at the site.

Table 4.3.4: specific professionals in the building design team and their roles

Professional	Roles
Architect	The lead designer is responsible for creating the overall concept and ensuring that the building is functional, safe, and aesthetically pleasing. They prepare design drawings, and specifications, and oversee the project through to completion
Structural Engineer	Ensures the building is structurally sound by designing the framework that supports the building. They work closely with the architect to ensure that the design can be safely constructed.
Civil Engineer	Manages the site design, including grading, drainage, and infrastructure, ensuring that the building integrates well with its surroundings
Mechanical, Electrical, and Plumbing (MEP) Engineers	Design systems related to heating, ventilation, air conditioning, electrical distribution, and plumbing, ensuring the building's utilities work efficiently and safely
Quantity Surveyor	Manages costs and budgets throughout the project, ensuring financial efficiency and cost control
The Client	In the design team, the client has the need for a building so he/she employs an architect and tells them what kind they want. The architect, who in most cases is the lead designer, designs the kind of building that meets the client's needs and interacts with the client throughout the project so that the building stays within the client's requirements and specifications.

Documents that lead to Tender and Selection of Contractors

The key document that leads to the tender and selection of contractors is the **tender document**. This document provides all the necessary information about the project, including the scope of work, terms and conditions, and criteria for evaluating bids. It serves as the basis for potential contractors to submit their offers. The tender document typically includes the following components:

Table 4.3.5: Document and activities leading to tender and selection of contractors

Terminology	Activities
Invitation to Tender (ITT)	This document invites potential bidders to participate, providing an overview of the project, objectives, and scope of work.
Instructions to Bidders	Guidelines for preparing and submitting bids, including the required format, evaluation criteria, and submission deadlines.

Terminology	Activities
Specifications	Detailed descriptions of the technical requirements, including materials, equipment, and services needed for the project.
Terms and Conditions	Legal and contractual obligations governing the relationship between the organisation and the contractor, covering payment terms, delivery schedules, and performance guarantees.
Evaluation Criteria	Specifies how bids will be assessed, considering factors such as price, quality, and contractor experience.
Contract Template	A sample contract outlining the terms and conditions that will be used if the bid is accepted.
Drawings and Bills of Quantities (BOQ)	Architectural and technical drawings, along with an itemised list of materials and costs, help contractors prepare accurate bids.
Preliminary Information	This includes any necessary pre-construction information and site management plans that contractors must consider.
Tender Return Slip	A label attached to the tender submission, indicating the return address and instructions for submission.

The Roles of the Design Team at the Pre-Contract Stage

The design team perform very important roles which are necessary to resolve issues relating to clarity about the project. The identification of the issues and finding solutions at this stage ensures that decisions taken for the commencement of the project are credible.

Table 4.3.6: The Roles of Design Team at Pre-Contract Stage

TERMINOLOGY	ACTIVITY
PROJECT SCOPE AND FEASIBILITY ASSESSMENT	• The design team checks the project details to make sure all client needs are met. They also conduct studies to see if the project is possible.
CONCEPT DEVELOPMENT	• The team creates initial design ideas based on client feedback and rules. They make drawings and 3D models to show what the project will look like.
DESIGN COORDINATION	• The design team collaborates with other experts to ensure everything fits together. They coordinate with engineers to meet safety and technical standards.

TERMINOLOGY	ACTIVITY
RISK MANAGEMENT	• The team looks for possible problems early on. This helps them plan ways to avoid issues and keep the project on time and within budget.
CLIENT ENGAGEMENT AND COMMUNICATION	• The team talks to clients early to share different ideas. Good communication helps solve any concerns or changes quickly.
PREPARATION FOR TENDERING	• The design team prepares important documents for contractors. This includes details and lists of materials needed for accurate bids.
QUALITY ASSURANCE	• The team makes sure the design meets quality standards and rules. They work with quality teams to maintain high standards throughout the process.
QUALITY ASSURANCE	• The team makes sure the design meets quality standards and rules. They work with quality teams to maintain high standards throughout the process.

The Roles of Building Team at Post-Contract Stage

The building team of professionals perform very important roles which are mainly linked to inspection to cross check the specifications of the project. The professionals in this team conduct a thorough examination of the building structure and identify all the shortfalls and provide recommendations for corrections. To ensure that all key aspects of the project meet the specified requirements and regulations, the professionals then embark on the activities as indicated in Table 4.3.7.

Table 4.3.7: The roles of building team at post-contract stage

TERMINOLOGY	ACTIVITY
COMMISSIONING	• The building team inspects the finished structure to ensure all systems work correctly. They check that installations meet the required standards.
TRAINING AND HANDOVER	• After inspections, the team trains the client or their representatives on how to use and maintain the building systems. This training helps the client manage the facility well.
PUNCH LIST MANAGEMENT	• The team creates a punch list that lists any remaining tasks or issues to fix before closing the project. This includes minor repairs and finishing touches.
DOCUMENTATION AND FINALISATION	• The team gathers all important documents, like warranties and operation manuals, and gives them to the client. This information is important for future reference and warranty claims.

TERMINOLOGY	ACTIVITY
CLOSURE AND LEGAL COMPLIANCE	• The team ensures all contracts are completed and there are no legal issues. They finalise agreements, settle payments, and ensure local regulations are followed.
POST-PROJECT REVIEW	• The team conducts a review to analyse what went well and what could be improved. This helps them learn lessons for future projects.

Activity 4.3.1

Using the appropriate operative technical terms, recall and explain the basic activities professionals perform as observed on construction sites.

Guidelines/Steps

1. Read about the appropriate operative technical terms and in groups search on the internet for more explanation.
2. State the appropriate operative technical terms in your notebook in preparation for the field trip to construction sites and offices for practical explanation from the professionals.
3. During the trip to the construction sites and offices, interact with the various professionals involved in building construction projects.
4. Enquire about the practical explanation of the appropriate operative technical terms which the professionals in building construction use in their day-to-day activities.
5. Prepare individual reports on the responses from the professionals.

   After the trip, present your reports for group discussion and confirm the key issues stated for clarity and consistency.

Activity 4.3.2

Based on your observation, list the professionals and classify them under the broad conceptual stages of pre-contract and post-contract.

Guidelines/ steps

1. Approach the professionals in their specific outlook and observe.
2. Enquire about the professional identity to understand the specific activities they undertake.
3. Find out the scope of their job prescription/work on the site.
4. Request for a briefing session and gallery walk to observe more about the site.

5. Prepare a detailed individual report on the list of the various professionals and their activities in building construction.
6. Ask the professionals to classify their activities under the broad conceptual stages of pre-contract and post-contract.
7. Prepare a report on the classification of the broad conceptual stages for pre-contract and post-contract projects and use the report for group discussion.
8. Gather the report as a portfolio and reference material.

The Activities Undertaken by Professionals in Building Construction

Broad conceptual stages of Pre-contract and post-contract

What are the broad conceptual stages of Pre-contract?

During the broad conceptual stage of the pre-contract, the key activities that are necessary and important for the professionals involved in building construction to undertake for a successful project take-off are made up of the following:

At the Pre-contract stage, the activities are:

1. Professionals create detailed plans and specifications to clarify project requirements before awarding contracts.
2. Tender documents are prepared, bids are solicited, and negotiations are conducted to select the right contractor for the project.

During the broad conceptual stage of the post-contract, the key activities that are necessary and important for the professionals involved in building construction to undertake for successful project implementation and completion are made up of the following:

At the post-contract stage, the activities are:

1. The construction process is managed to ensure compliance with design specifications and monitor progress.
2. Professionals ensure that quality check is performed, and necessary documentation is handed over to the client after construction completion.

Activity 4.3.3

What activities performed by professionals can lead to the following;

1. checks and balances in the procurement system.
2. a product that is in line with quality expectations.
3. the budgetary requirements.
4. timeline needed for a project.

Guidelines/steps

a. Read about the four activities of the professionals concerning; checks and balances in the procurement system, product that is in line with quality expectations, budgetary requirements and timeline for a project.

b. Discuss the activities of the professionals in a mixed group to aid understanding.

c. Write an individual report about the four activities of the professionals involved in building construction projects.

Review Questions

1. List the main professionals involved in the design of a building
2. Explain the specific aspects of the main professionals involved in the design of a building product.
3. Categorise the construction task activities and protocols performed by professionals into the pre-contract and post-contract stages that can enhance the improvement of the work.
4. Explain how inspection by the Architect and the team of designers at the pre-contract stage can enhance the improvement of the work.

Answers to Review Questions

1. The list of main professionals involved in the design of a building are the Architect, Structural Engineer, Electrical/Mechanical Engineer and Quantity Surveyor.
2. The specific aspects of the main professionals involved in the design of a building product are as follows:

   Architect: Creates functional and aesthetic building designs that meet client needs and regulatory requirements and works with other professionals to prepare detailed construction documents.

   Structural Engineer: Designs safe and durable structures, ensuring they can withstand various loads and environmental conditions and collaborates with architects to ensure structural elements align with the overall design.

   Electrical/Mechanical Engineer: Designs electrical and mechanical systems to ensure safety, efficiency, and compliance with standards and works with architects and other engineers to integrate systems into the building design.

   Quantity Surveyor: Prepares budgets and estimates project costs, ensuring financial control throughout the project and manages contracts and ensures compliance with legal and regulatory standards.
3. The activities and protocols performed by professionals in pre-contract and post-contract stages that can improve the work are:

   At the pre-contract stage, improvement of the work can be enhanced when:

   - Professionals create detailed plans and specifications to clarify project requirements before awarding contracts.
   - Tender documents are prepared, bids are solicited, and negotiations are conducted to select the right contractor for the project.

   At the post-contract stage, improvement of the work can be enhanced when:

   - The construction process is managed to ensure compliance with design specifications and monitor progress.
   - Professionals ensure that the quality check is performed, and necessary documentation is handed over to the client after construction completion.
4. The inspection by the Architect and the inspection team of designers at the pre-contract stage enhance the improvement of the work through;

   - **Quality Assurance:** Early inspections help identify and fix design issues before construction starts, ensuring high-quality standards and reducing the need for costly changes later.
   - **Better Communication:** Inspections encourage discussions among architects, engineers, and clients, leading to a shared understanding of project goals and smoother decision-making.

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UNIT 4

ELECTRICAL AND ELECTRONIC TECHNOLOGY

Electronic Devices and Circuits

INTRODUCTION

Electricity and electronics are related to electrical energy, however, there are fundamental differences between the two options. Electricity is a broader and more general discipline that covers all aspects of electrical energy. Electronics, on the other hand, focuses on the design and the use of components to control the flow of electricity to perform specific tasks. Passive and active components will be used to draw the differences in the possibility of applications of electrical and electronic circuits.

At the end of this section, you will be able to:

Explain the concept of electrical and electronic circuits.

Key Ideas

- An electrical circuit is a complete set of passive electrical components that are connected together in a loop with a power source for the flow of electric current.
- Electronic circuits are a set of passive electrical and active components that are connected together in a loop with a power source, for the flow and control of electric current.

THE CONCEPT OF ELECTRICAL AND ELECTRONIC CIRCUITS

Electrical Circuit

An electrical circuit is a complete set of passive electrical components that are connected in a loop with a power source for the flow of electric current.

Components of an electrical circuit

A basic electrical circuit is made up of: a ***conductive path*** or ***connecting wires***, the ***source of power or battery***, a ***switch to open and close the circuit***, ***passive components*** such as *resistors*, *capacitors, inductors*, and an ***electric lamp or a bulb*** that serves as load.

The load is the circuit element that draws the electric power to perform a particular function. Passive circuit elements are components that do not need an external source to function as they only control the flow of electric current without amplification.

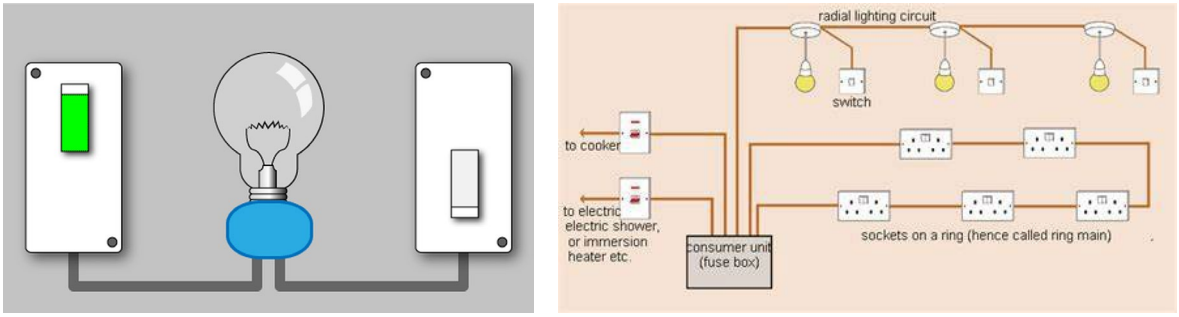

Fig. 4.4.1: Electrical circuit

Electronic circuits

Electronic circuits are a set of passive electrical and active components that are connected in a loop with a power source, for the flow and control of electric current.

Components of an electronic circuit:

A basic electronic circuit comprises: a ***conductive path or connecting wires***, a ***source of power or battery***, a ***switch***, to open and close the circuit, ***passive components***, and ***active components*** such as *diodes, transistors*, *integrated circuits* etc.

Active circuits require an external source of power for the control of current flow.

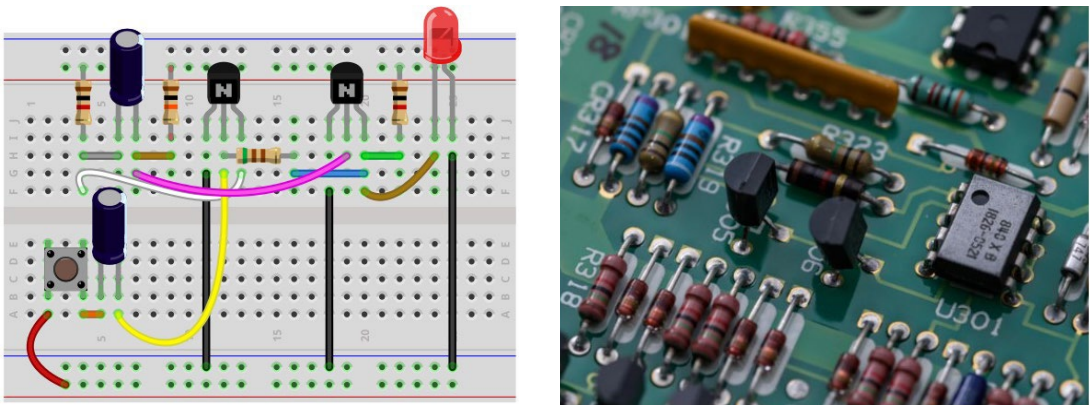

Fig. 4.4.2: Electronic circuit

Key Differences Between Electrical and Electronics Circuits

Table 4.4.1: Key differences between electrical and electronics circuits

Aspect	Electrical Circuits	Electronic Circuits
Definition	They convert electrical energy into heat, light and motion.	They use components to control the flow of electrons to perform specific tasks.
Components used	Passive components such as resistors, capacitors, inductors, switches, fuses etc.	Active components such as diodes, transistors, integrated circuits and passive components.
Complexity	Simpler, can be complex but straightforward.	Highly complex, provides a higher degree of sophistication and complexity. Higher levels of integration have made possible the design of powerful and flexible processors which provide highly intelligent and adaptable devices for the user in signal processing, logic operations etc.
Application	i. Power generation plants, ii. Electrical grids, in the transmission and distribution of electric power to domestic, and commercial facilities for the utilisation or conversion of electricity into heat, light and motion in such devices as electric kettles, lamps, fans, motors, transformers, etc. iii. Industrial facilities such as mining companies, clothing factories, breweries, food processing companies, etc.	i. Controls and instrumentation: Automation of industrial processes, digital voltmeter, ii. Telecommunications: Smart mobile phone personal digital assistant, P.D. A iii. Information technology: Computers, internet. iv. Medical science: Electrocardiographs or ECG, X-ray, v. Automobile industry: Electronic ignition system, electronic battery charger vi. Consumer electronics such as home heaters, smart television digital cameras etc. Defence: Infrared systems used to detect the location of enemy jet fighters etc.
Voltage levels	Typically operate at higher levels of voltage	Typically operates at a lower voltage level.
Power consumption	Higher power consumption	Lower power consumption

Safety	Less safe. Danger to thermal and shock hazards are very high.	Safer. Danger to thermal and shock hazards are very low. Exposed to electrostatic shock

Activity 4.4.1

1. Explain how both types of circuits use resistors, capacitors, and inductors in their design.
   a. Identify the functions of a ***resistor*** in the design of both electrical and electronic circuits.
   b. What function does a capacitor perform in both electrical and electronic circuits?
   c. State the role performed by an inductor in both circuits.
   d. State the source of electric power used by the passive components in a circuit to operate.
2. Describe what an electronic circuit is and how it differs from an electrical circuit.
   a. List five parts of an electronic circuit.
   b. Identify three elements in an electronic circuit that cannot be found in the electrical circuit.
   c. What is the function of the active components in an electronic circuit?
   d. In an electronic circuit, can the active components all alone perform any useful function?
3. How do the voltage and current levels differ between electrical and electronic circuits?
   a. Which type of electricity is used in conveying power to domestic, commercial and industrial installations?
   b. List three domestic devices that operate directly on alternating current. Which type of circuit operates directly on alternating current?
   c. List three devices that operate on power converted from alternating current.
   d. State the name of the electricity converted from alternating current.
   e. State the type of electricity mainly used in electronic circuits.
   f. Identify the type of circuits that operate on higher voltages and currents and lower voltages and currents.
4. Explain how the components used in electrical circuits differ from those used in electronic circuits.

i. List three circuit elements used in electrical circuits.

ii. State five circuit elements used in electronic circuits.

iii. Which type of circuit uses a larger number of components?

iv. List the components that can be found in both circuits.

v. State the general name for the components found in both circuits.

vi. State three functions of the components common to both circuits.

vii. Identify the components that are used by electronic circuits only.

viii. State the function of the components used exclusively by electronic circuits.

ix. What role is performed by the components used uniquely by electronic circuits?

Review Questions

1. Explain three key differences between electrical and electronic circuits in terms of components used and their application. Use Table 4.4.2 below to answer question 1.

   Table 4.4.2: Characteristics of Electrical and Electronic Circuit.

Characteristics	Electrical circuit	Electronic Circuit
Type of components		.
Complexity		
Application		

2. In terms of their application, differentiate between electrical and electronic circuits. Use Table 4.4.3 to answer question 2.

   Table 4.4.3: Differences Between Electrical and Electronic Circuits.

Type of Circuit	Application
Electrical	
Electronic	

3. a. Compare the complexity and power consumption of electrical and electronic circuits in terms of design and functionality.

   b. Describe three applications of electrical and electronic circuits and industries where electrical and electronics are used.

   c. Explain at least two safety consideration variations between electrical and electronic circuits due to their differences in voltage and current.

   Use Table 4.4.4 to answer question 3.

Table 4.4.4: Comparing complexity, applications, power consumption, industrial application and degree of safety of electrical and electronic Circuits.

Characteristics	Electrical circuit	Electronic circuit
Complexity in: i. Design ii. Functionality		
Power consumption		
Industrial applications i. ii. iii.		
Degree of safety i. Thermal hazard ii. Shock hazard		

Answers to Review Questions

1.

Characteristics	Electrical circuit	Electronic Circuit
Type of components	Passive components: resistors, capacitors and inductors	Passive components: Resistors, capacitors and inductors. Active components: Diodes, transistors, integrated circuits etc.
Complexity	Simpler and can be complex but direct	A higher degree of sophistication and complexity
Application	i. Power transmission and distribution to domestic commercial and industrial installations. ii. Electric motors, fans transformers,	Communication and entertainment, PA systems, home theatres, TV Electrocardiographs, X-ray machines, guided missiles Electronic battery chargers, mobile phones,

2.

Type of Circuit	Application
Electrical	Heat: electric hair drier, pressing iron, kettle Light: Electric bulbs Motion: Electric fan, motor
Electronic	Public Address systems, Consumer electronics: Home theatre, TV, mobile phone, digital camera etc.

3.

Characteristics	Electrical circuit	Electronic circuit
Complexity in: i. Design ii. Functionality	Discrete components Well-designed, serviceable	discrete components and integrated circuits well-designed, very complicated and highly serviceable.

Power consumption	High, because i. Resistive elements disperse energy in the form of heat. ii. Inductors and capacitors absorb or store energy in the form of voltage and current.	Low power consumption Produce energy in the form of voltage and current.
Industrial applications i. Automation ii. Mobile phones iii. Transformer	Food processing plants, Power generating plants Power distribution sub-station	Mining companies Telecommunication, MTN Communication industry
Degree of safety i. Thermal hazard ii. Shock hazard	Very high Highly deadly or lethal	Low Less harmful

Extended Reading

Click on the link below to learn more about the circuit theory

- https://circuitglobe.com/category/electrical-terms/circuit-theory

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UNIT 5

METAL TECHNOLOGY

Welding Technology

INTRODUCTION

Arc welding is a type of welding process that uses an electric arc to melt and join metals. In arc welding an electric current is made to 'jump' a gap between an electrode and the metal being welded, **thereby,** producing a temperature in the region of 3600°c. The heat of the arc melts the electrode and droplets of metal are forced across the arc and onto the metal, forming a weld.

When metals are welded, the pieces to be joined are raised to a high temperature and fused. Electric arc welding is the process of using a coated rod called an electrode to carry an electric current. The electric arc welding process is used due to its versatility, portability, cost-effectiveness, safety and ease of operation. This unit will introduce you to the variety of basic arc welding tools/equipment and machines which are valued and used for electric arc welding operations. It will further offer you the opportunity to demonstrate the basic safety procedures involved in electric arc welding operations.

At the end of this section, you will be able to:

Describe the various tools and equipment for electric arc welding.

Key Ideas

- Electric arc welding is a process that uses an electric arc to generate heat, which melts and fuses metals together.
- The key idea behind this method is to create a sustained electric arc between an electrode and workpiece.
- Understanding this concept is crucial for effectively performing and evaluating electric arc welding.

TOOLS AND EQUIPMENT FOR ELECTRIC ARC WELDING

Electric Arc Welding

Electric arc welding is a process of using a coated rod called an electrode to carry an electric current, which forms an arc that creates sufficient heat between a gap at the end of the electrode and the work to melt both the electrode and the work, forming a weld joint when it has solidified.

Principles of Electric Arc Welding

The electric arc welding process is based on the effect of an electric current's flow. When an electric current flows through a cable, the resistance of the cable to the flow of electricity generates heat. The flow of electricity is called current and the greater the flow of current produces the greater the resistance, which generates intense heat.

The Key Components of Electric Arc Welding

The key components involved in electric arc welding include:

1. **Power Supply**: This provides the electric current necessary for welding. There are two types of currents used in arc welding:
    a. Direct current (DC): This provides a steady current, which is useful for welding thin materials.
    b. Alternative Current (AC): This alternates the direction of current and typically used for thicker materials.
2. **Electrode**: It **c**onducts the current and forms the arc with the workpiece. Electrodes can be consumable (e.g., in MIG or Stick welding) or non- consumable (e.g., in TIG welding).
3. **Workpiece (base metal):** These are the metal pieces that are being welded together.
4. **Electrode Holder:** It holds the electrode which conducts the welding current.
5. **Ground Clamp:** This completes the electrical circuit by connecting the workpiece to the welding machine.
6. **Shielding Gas or gas:** It protects the weld area from atmospheric contamination (used in processes like MIG and TIG welding).
7. **Welding Cables:** These cables **c**arry the electric current from the power source to the electrode holder and ground clamp.
8. **Welding Torch or gun:** It is used in some welding processes to direct the electrode and shielding gas.
9. **Arc**: The electric arc is the discharge that occurs between the electrode and the workpiece. The intense heat from arc melts the base metal and the electrode to form the weld.
10. **Cooling System:** It is used in some systems to prevent overheating of equipment.

11. **Protective Equipment:** This includes the welder's helmet, gloves, and protective clothing to safeguard the welder from intense light, heat, and sparks generated during the welding process.

Note: *These components work together to create the condition necessary for electric arc welding.*

Table 4.5.1: Showing Details of Names, Descriptions, Uses, Safety and Pictures of Tools, Equipment and Machines Used for Electric Arc Welding

S/N	NAME OF TOOL/ EQUIPMENT/ MACHINE	DESCRIPTION OF TOOL/EQUIPMENT/ MACHINE	USES OF TOOL/ EQUIPMENT/ MACHINE	SAFETY TO BE OBSERVED WHEN USING THE TOOL/EQUIPMENT/ MACHINE	PICTURE OF TOOL/ EQUIPMENT/MACHINE
1	**Generator Welding machine**	A welder generator creates power without reliance on mains electricity. Simply fill up the fuel tank, just as you would for a regular generator and the welder generator will power your welding equipment wherever you need it.	It can be used as a standalone generator.	1. Always make sure you have a good ground connection between the workpiece, welding machine and the generator. 2. There must be proper ventilation when welding. 3. Use protective gears.	
2	**Transformer welding machine**	The transformer housed in a welding machine is used to convert the high voltage input or primary power from the wall plug and this is usually from 208 to 600volts, with a low alternating current (AC) from 15 to 55amps. The transformer performs the task described by stepping down from the high voltage.	Welding transformers are used in changing alternating current from the power line into a low voltage.	1. If the welding operation must be done on steel or other conductive material, use an insulating material under the operator. 2. Wear rubber gloves under the welding gloves. 3. Turn off the welding transformer when **not** in use	
3	**Transformer-rectifier welding machine**	Welding rectifiers are essentially transformers with an electrical device as a rectifier which changes AC to DC. Rectifiers basically consist of silicon diodes which ensure the flow of current in one direction giving DC output.	It ensures the flow of current in one direction giving DC output.	1. Inspect welding cables and connections regularly for damage. 2. Ensure the welding machine is correctly grounded to prevent electrical shocks. 3. Always make sure that the fan is working.	

4	**Electrode holde**r	An electrode holder is an equipment that holds an electrode in position, that is secure, and safe during welding.	1. The primary function of the electrode holder is to support the electrode, guaranteeing a good electrical contact for current passage. 2. It should also guarantee sufficient electrical insulation for the welding operator.	1. The electrode holders should be in good condition with **no** cracks or missing insulation. 2. Never change electrodes with bare hands or wet gloves. 3. **Do not** put an electrode holder's uninsulated jaws on the working table when the machine is switched on. This can cause a flash, which may affect your eyes, and also cause a short-circuit, which can damage the machine.	
5	**Ground clam**p	If there is no grounding, leakage will occur and the leakage current will conduct electricity through the human body which will cause personal injury.	A ground clamp is a device used to provide a secure electrical connection between a ground wire and a ground point such as a pipe or ground rod.	1. Wear safety googles. 2. Avoid over tightening.	
6	**Chipping hamme**r	The chipping hammer is used for the removal of slag after arc welding. The hammer is of robust construction and well balanced. When working on stainless steel or aluminium, a chipping hammer made of stainless steel must always be used.	It is used for removal of slag after arc welding.	1. Use hearing protection. 2. Properly position your body while moving and using the equipment. 3. Allow the tool to do the work by using a grip light enough to maintain control.	
7	**Wire brus**h	A wire brush is an abrasive tool that has stiff filaments made from a variety of rigid materials designed to clean and prepare metal surfaces.	1. Cleaning rust and removing paints. 2. Preparing a surface for painting.	1. Wear appropriate PPEs 2. Observe all speed restrictions indicated on the brushes.	

8	**Welding helmet**	A welding helmet is a type of personal protective equipment used in performing certain types of welding to protect the eyes, face and neck from flash burns, sparks, infrared and ultraviolet light and intense heat	It is used to protect the eyes, face and neck from flash burn, sparks, infrared and ultraviolet light and intense heat	1. Use a helmet for welding or cutting applications only. 2. **Do not** use the helmet while working with or around corrosive or explosive liquids.	
9	**Welding hand shiel**d	A hand shield is a type of welding mask that is designed to be hand-held by the observer for a short duration.	Hand shields protect the eyes and skin from damage caused by heat and light emitted by the welding process.	Ensure that the hand shield meet safety standards i.e. both the shell and the hand shield must be heat resistant and build to withstand impact, scratches and potential welding splatter.	
10	**Leather gloves**	A leather glove is a glove covering hand with separate sections for fingers and thumb, sometimes extending over the wrist or parts of the arm.	The leather glove protects the hand from scuffs and scrapes and also protect against sparks and other metalworking hazards.	When handling chemicals, exposure must be kept to a minimum.	
11	**Welding electrode**	A welding electrode is a piece of wire or rod which can be of metal or alloy and has a flux with or without flux and carries an electric current to obtain sufficient heat for welding.	It is used to sustain the welding arc and to provide the filler metal required for the joint to be welded.	1. **Do not** dip energized (hot) electrode holders in water. 2. Avoid direct contact with the live parts of the welding equipment and the workpiece.	
12	**Leather Apro**n	A garment made from leather usually tied around the waist worn to protect the underclothing and the body from sparks from the welding process.	It is used to protect the workers and their clothing from sparks and high temperature burns from the welding process.	Before use, the leather apron should be inspected for cracks, abrasions or other damage.	
13	**Welding screen or boot**h	Welding screens add an additional layer of protection in the welding workspace, ensuring that workers operating in close vicinity of the welding area are not exposed to harmful UV lights or the risk of flash burns.	Welding screens are designed to absorb or reflect UV rays providing effective protection.	While a screen can help protect bystanders and individuals in the vicinity from hazards such as radiation, individuals directly involved in the welding process should always wear PPEs.	

Safety Note: *When welding, special goggles, or masks (with 'coloured' glass) must be worn to protect the eyes from the glare from the flame or arc. A leather apron and gloves should also be worn to protect the worker from molten metal and flying sparks.*

The electric arc welding process involves using a coated rod called an electrode to carry an electric current. This forms an arc that creates sufficient heat between a gap at the end of the electrode and the workpiece to melt both the electrode and the work, forming a weld joint when it has solidified.

When discussing the tools and equipment for electric arc welding, the following key points are:

1. **Access to Proper Tools**: The success and safety of electric arc welding depends heavily on the proper selection and use of tools and equipment and the essential tools include welding machines, electrodes, protective gear, and accessories like clamps and chipping hammers. The quality and suitability of these tools directly affects the weld quality and the safety of the welder.
2. **Safety Considerations**: Safety equipment such as helmets with appropriate shade levels, gloves, and protective clothing are crucial to preventing injuries from arc radiation, spatter, and electric shock. Ensuring that all equipment is in good working condition and used correctly is essential to minimising risks.
3. **Compatibility and Maintenance**: The compatibility of tools and equipment with the specific type of welding task is important. Regular maintenance and inspection of tools, especially welding machines and cables, ensure they operate efficiently and reduce the likelihood of malfunctions.
4. **Advancements In Technology**: Technological advancement has improved the efficiency and safety of arc welding tools and equipment, modern welding machines with features like inverter technology and digital controls offer better performance, energy efficiency, and ease of use.
5. **Training and Skill**: The effectiveness of tools and equipment in electric arc welding also depends on the skill and training of the operator. Proper training ensures that welders can maximise the potential of their tools while adhering to safety protocols.
6. **Environmental Considerations**: The choice of equipment can also impact on the work environment. For instance, using equipment with fume extraction capabilities or proper ventilation systems can significantly reduce exposure to harmful fumes.

In conclusion, the tools and equipment used in electric arc welding are critical to achieving high-quality welds, ensuring safety, and maintaining efficiency. The selection, maintenance, and proper use of these tools, combined with operator skill, determine the overall success of welding operations.

Activity 4.5.1

1. Your Applied Technology facilitator has assigned you in groups to design and make a coal pot using the electric arc welding operation to reduce cooking challenges currently faced in the school kitchen:
   a. Using freehand sketches, show three (3) possible solutions of the coal pot with annotated notes and select one.
   b. Research the types of metal you will find suitable for making the coal pot.
   c. Identify the type of electric arc welding tools/equipment/machines you will need for making coal pots.
   d. Identify safety precautions you would need to observe when making the coal pot.
   e. Identify the PPEs you will need to protect you from accidents when making the coal pot.

   Prepare a mock-up of the coal pot using suitable compliant material(s).
      a. State the reasons why you will use compliant material(s) for making the mock-up.
      b. State the reasons why you would make a mock-up before making the real coal pot.
      c. Display your mock-up for appraisal in the classroom/workshop.
      d. Use the appraisal report to make modifications to your mock-up.
2. Electric arc welding tools, equipment and machines are sometimes difficult to set up and operate because these sets of equipment and machines need an electricity supply for their operations.
   a. Using your ICT tools, find out the following:
      i. Importance of using the Electric Arc Welding operations for making artefacts.
      ii. ii. The difference between a generator welding machine and a transformer welding machine.
      iii. General safety precautions to be observed when using the electric arc welding equipment.
3. Practice, they say makes perfect. One way of demonstrating the understanding of tools, equipment and machines used for electric arc welding is by sketching these tools and equipment. It is important to continuously practice sketching tools and equipment to enhance your skills and competencies in the subject area.
   a. Make freehand pictorial sketches of the following electric arc welding tools, equipment and machines:
      i. Transformer welding machine
      ii. ii. Electrode holder

iii. Ground clamp

iv. Chipping hammer

v. Wire brush

vi. Welding hand shield

b. Briefly state the use(s) of each of the tools/equipment/machines sketched (in 'a') above.

c. Create a table and briefly state two safety precautions to be observed for each of the tools, equipment and machines sketched (in ai-vi) above.

d. Show the sketches you made (in '3a') to your Applied Technology teacher for feedback.

e. Use the feedback from your Applied Technology teacher to improve upon your sketches.

f. Display your final sketches in class for appraisal by your classmates.

4. To better understand electric arc welding it is best to visit nearby electric arc welding workshops in groups. A visit will help you identify some tools, equipment and machines that would not be available in your school workshop. You can further use the opportunity to observe how the electric arc welding tools, equipment and machines are used for making products.

Note:

- *Your Applied Technology teacher will lead you in the process of organising the industrial visit.*
- *On the visits, make sure you observe all the health and safety guidelines and instructions at all times to maximise your own and others' safety.*

a. Briefly discuss in groups, the following stages involved in organising the industrial visit:

i. Preparations before the visit

ii. ii. what to do during the visit

iii. what to do after the visit

b. i. List any six (6) electric arc welding tools/equipment/machines you identified at the workshop you visited.

ii. observe how the electric arc welding tools/equipment/machines are used as demonstrated by the master craftsperson.

iii. Observe how safety was demonstrated at the workshop you visited.

c. i. Prepare a visit report in groups and discuss in class for feedback.

ii. Refine your visit report based on feedback from your class.

iii. Take pictures or make sketches of tools/equipment/machines and products you found at the electric arc welding workshop you visited.

iv. Prepare a photo or sketch album and display it in the classroom appraisal.

v. Use the feedback from the appraisal to make modifications to your album.

Review Questions

The following questions will help you learn more about the areas covered in this unit.

1. The electric arc welding tools, equipment and machines are relatively portable but cannot be carried about and used easily.

a. i. Briefly describe the reason why electric arc welding tools, equipment and machines cannot be easily carried about and used everywhere.

ii. Describe **four (4)** safety precautions to be observed when using the electric arc welding tools, equipment and machines.

b. State **one (1)** use of each of the following electric arc welding equipment:

i. Generator welding machine

ii. Ground clamp

iii. Welding helmet

iv. Welding hand shield

2. The forms and models of the Transformer welding machine and Transformer-rectifier welding machine seem similar but differ in their operations. Knowing their differences helps you to identify the most suitable machine for carrying out the right electric arc welding operation.

a. Distinguish between the Transformer welding machine and the Transformer rectifier welding machine.

b. State one safety precaution each to be observed when using the Transformer welding machine and the transformer-rectifier welding machine.

3. A welding electrode is a piece of wire or rod which can be of metal or alloy has a flux with or without flux and carries an electric current to obtain sufficient heat for welding.

a. Briefly explain the purpose of sometimes coating the surface of the arc welding electrode with flux.

b. State the main use of the arc welding electrode.

c. State the safety to be observed when using the welding electrodes.

d. Distinguish between the welding helmet and the welding hand shield.

e. State two safety precautions to be observed when using the arc welding helmet.

f. Identify two (2) uses of the Wire brush used in electric arc welding.

4. Freehand sketching of tools and equipment promotes the acquisition of skills and competencies. It is necessary that you practice freehand sketching of tools, equipment and machines reg.

a. Using a sketch pad, make freehand pictorial sketches of the following tools/ equipment/machines used in electric arc welding:
   i. Welding machine
   ii. Ground clamp
   iii. Chipping hammer
   iv. Welding helmet
   v. Welding hand shield

b. In a table form, state **three (3)** uses and **three (3)** safety precautions to be observed for each of the following arc welding equipment:
   i. Welding screen or booth
   ii. Leather Apron
   iii. Transformer welding machine

Answers to Review Questions

1.

a.

i. Because they can only be operated where there is a source of power (electricity).

ii.

- Wear special goggles, or masks (with 'coloured' glass) to protect the eyes from the glare from the flame or arc.
- Wear a leather apron and gloves to protect you from molten metal and flying sparks.
- Always make sure you have a good ground connection between the workpiece, welding machine and the generator.
- There must be proper ventilation when welding.

b.

i. **Generator welding machine**: It can be used as a standalone generator.

ii. **Ground clamp**: A ground clamp is a device used to provide a secure electrical connection between a ground wire and a6 ground point such as a pipe or ground rod.

iii. **Welding helmet**: It is used to protect the eyes, face and neck from flash burns, sparks, infrared and ultraviolet light and intense heat.

iv. **Welding hand shield:** Hand shields protect the eyes and skin from damage caused by heat and light emitted by the welding process.

2.

a. The primary difference lies in their construction and the type of current they produce for welding. In summary, while both types use a transformer, the key difference is that the transformer-rectifier welding machine has an added rectifier to convert AC to DC, making it more versatile and providing a more stable welding arc.

b.

- **Transformer welding machine safety:** Wear PPE, Electrical safety, work area safety, machine setup and operation, handling materials, emergency preparedness
- **Transformer-rectifier welding machine safety:** Wear PPE, Electrical safety, work area safety, machine setup and operation, handling materials, and emergency preparedness.

3.

a.

- To stabilise the arc
- To protect the weld pool
- For slag formation
- Adds alloying elements
- Controls the cooling rate
- Improves weld appearance.

b. To conduct electric current in the welding area, create an electric arc between the electrode and the workpiece.

c.

- Wear PPEs.
- Ensure proper ventilation
- Avoid electrical hazards.
- Protect against burns.
- Avoid exposure to AU and IR Radiation
- Inspect equipment regularly
- Maintain a safe Environment
- Handle Electrodes Safely
- Follow the Manufacturer's Instruction
- Be aware of Surroundings

d. A welding helmet is more suitable for extended welding tasks where hands-free operation is needed, while a welding hand shield is more suited for quick, small-scale jobs or as a secondary protective tool.

e.

- Proper fits
- Inspect for damage
- Maintain cleanliness
- Proper positioning
- Adequate ventilation.
- Electrical safety

f.

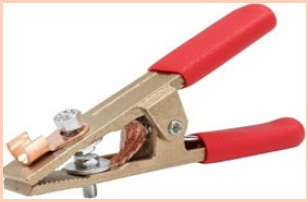
- For surface preparation
- Weld cleaning
- Maintenance

- Debris removal

4. a.

i. Welding machine

ii. Ground clamp



iii. Chipping hammer

iv. Welding helmet

v. Welding hand shield

b.

Arc welding equipment	Three uses	Three safety precautions to be observed
i. Welding screen or booth	1. For protection from UV and Infrared radiation 2. For containment of sparks and spatter 3. For enhanced visibility and focus	1. Wear appropriate personal protective equipment (PPEs) 2. Ensure proper ventilation 3. Avoid electrical hazards
ii. Leather Apron	1. For protection from heat and sparks 2. For insulation 3. For comfort and flexibility	1. Ensure the apron fits well and covers the body completely 2. Inspect apron for damage 3. Make sure the apron is securely fastened to prevent it from shifting
ii. Transformer welding machine	1. For manual metal arc welding (MMAW) 2. For metal inert gas welding (MIG) 3. For shielded metal arc welding (SMAW)	1. Always wear PPE 2. Ensure work area is ventilated to avoid inhaling hazardous gases and fumes 3. Inspect welding machine and cables for safety.

Extended Reading

Click on the links below for more information on welding technology

- https://www.weldinghandbook.com/gas-welding-hose-guide/
- https://www.steelsupplylp.com/blog/types-of-welding-rods
- https://www.instructables.com/Setting-up-the-oxy-acetylene-equipment-at-TechShop/

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