

Representation of Solid Object using Orthographic Projection

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Abstract: *The design data of components in most of the industries are still in orthographic representations. Interpretation of orthographic projections requires skill whereas 3D models provide concise and unambiguous representation of part geometry. This necessitates the existing drawings to be converted into 3D models. A system that can automatically transform the orthographic projections of components into 3D models will greatly reduce the time required for transformation and will also be cost effective [1,3]. In this paper, an approach for automatic reconstruction of solid models from orthographic projections is presented this area.*

Keywords: Orthographic projection, engineering drawing, TVET, engineering education, future career

I. INTRODUCTION

The general structure of the system is shown in Fig 1. The orthographic projections of a typical component are shown in Fig 2. The data of all the entities in the drawing are first extracted from the DXF file and the entities belonging to each view are sorted as per views. A view separation methodology as explained by Shunmugam et al [2] is used to separate the entities belonging to each view by first determining the top left corner P of the top view. Then the entities are sorted based on their x and y coordinates of the start and end points with respect to the point P. Each entity is checked for intersection by any other entity. If intersection is found, then the selected entity is split at the point of intersection. In Fig.6(a), the topmost line in the top view is intersected by two lines L5 and L7. Hence the top most line is split into 3 lines L9, L8 and L10. After sorting, the entities belonging to each view are mapped to the corresponding orthogonal planes. i.e. the plan, elevation and side view entities are mapped into XY, XZ and YZ planes correspondingly. The maximum length (L), breadth (B) and height (H) of the solid are identified from the orthographic projections. Then the loop of entities that form the outer boundary of plan, elevation and side view are identified and extruded along their normal according to their model height, breadth and length respectively. These extruded solids intersect each other as shown in Fig 3 and the solid model so formed partly represents the initial 3-D model. In order to construct the final model, the pockets, slots and bosses if any are identified from the orthographic projections.

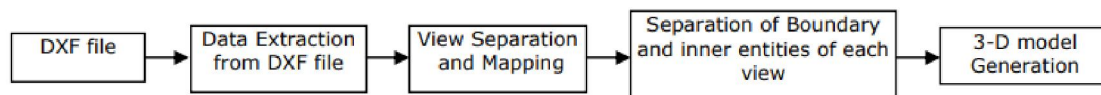


Fig.1: Structure of the system

II. ORTHOGRAPHIC PROJECTION

An orthographic projection enables us to represent a 3-D object in 2-D (see Figure 2-1). An orthographic projection is a system of drawings that represent different sides of an object. These drawings are formed by projecting the edges of the



object perpendicular to the desired planes of projection. Orthographic projections allow us to represent the shape of an object using 2 or more views. These views together with dimensions and notes are sufficient to manufacture the part.

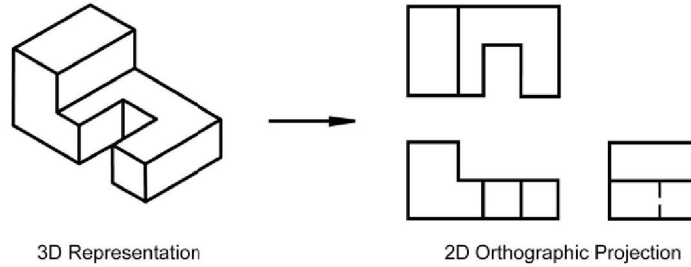


Fig. 2: Orthographic Projection

A. Six Principal View

The 6 principle views of an orthographic projection are shown in Figure 2-2. Each principle view is created by looking at the object in the directions indicated in Figure 2-2 and drawing what is seen as well as what is hidden from view

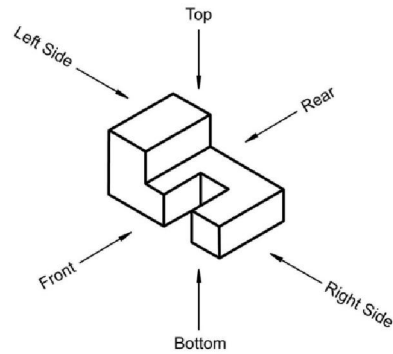


Fig.3: The Six Principal View

B. The Glass box Method

To obtain an orthographic projection, an object is placed in an imaginary glass box as shown in Figure 2-3. The sides of the glass box represent the six principle planes. Images of the object are projected onto the sides of the box to create the six principle views. The box is then unfolded to lie flat, showing all views in a 2-D plane. Figure 2-4 shows the glass box being unfolded to create the orthographic projection of object

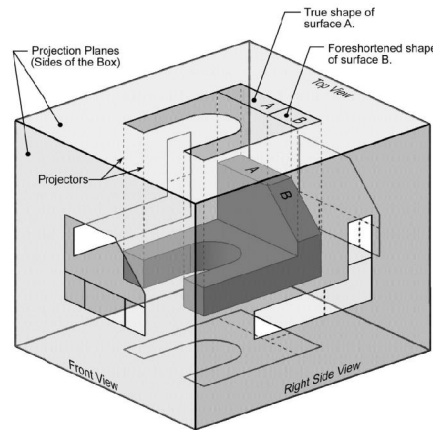


Fig.4: Object in Glass box



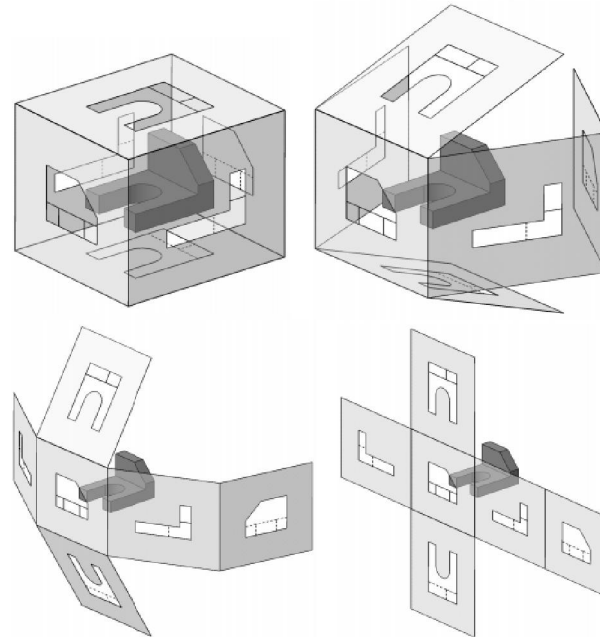


Fig.4: Glass box being unfolded.

C. The Front View

The front view shows the most features or characteristics of the object. It usually contains the least number of hidden lines. The exception to this rule is when the object has a predefined or generally accepted front view. All other views are based on the orientation chosen for the front view. The top, front, and bottom views are all aligned vertically and share the same width dimension. The left side, front, right side, and rear views are all aligned horizontally and share the same height dimension (see the figure shown in Exercise 2-1)

D. Line Types Used In An Orthographic Projection

Line type and line weight provide valuable information to the print reader. For example, the type and weight of a line can answer the following questions: Is the feature visible or hidden from view? Is the line part of the object or part of a dimension? Is the line indicating symmetry? There are four commonly used line types: continuous, hidden, center and phantom. The standard recommends using, no less than, two line widths. Important lines should be twice as thick as the less important thin lines. Common thicknesses are 0.6 mm for important lines and 0.3 mm for the less important lines. However, to further distinguish line importance, it is recommended to use four different thicknesses or weights: thin, medium, thick, and very thick. The actual line thickness should be chosen such that there is a visible difference between the line weights; however, they should not be too thick or thin making it difficult to read the print. The thickness of the lines should be adjusted according to the size and complexity of the part. The following is a list of common line types and widths used in an orthographic projection.

1. Visible lines: Visible lines represent visible edges and boundaries. The line type is continuous and the line weight is thick (0.5 - 0.6 mm).
2. Hidden lines: Hidden lines represent edges and boundaries that cannot be seen. The line type is dashed and the line weight is medium thick (0.35 - 0.45 mm).



3. Center lines: Center lines represent axes of symmetry and are important for interpreting cylindrical shapes. Crossed center lines should be drawn at the centers of circles. They are also used to indicate circle of centers and paths of motion. The line type is long dash – short dash and the line weight is thin (0.3 mm).

4. Phantom lines: Phantom lines are used to indicate imaginary features. For example, they are used to indicate the alternate positions of moving parts, and adjacent positions of related parts. The line type is long dash – short dash – short dash and the line weight is usually thin (0.3 mm).

5. Dimension and Extension lines: Dimension and extension lines are used to show the size of an object. In general, a dimension line is placed between two extension lines and is terminated by arrowheads, which indicates the direction and extent of the dimension. The line type is continuous and the line weight is thin (0.3 mm).

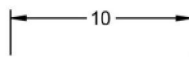





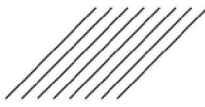

6. Cutting plane lines: Cutting plane lines are used to show where an imaginary cut has been made through the object in order to view interior features. The line type is phantom and the line weight is very thick (0.6 to 0.8 mm). Arrows are placed at both ends of the cutting plane line to indicate the direction of sight.

7. Section lines: Section lines are used to show areas that have been cut by the cutting plane. Section lines are grouped in parallel line patterns and usually drawn at a 45° angle. The line type is usually continuous and the line weight is thin (0.3 mm).

8. Break lines: Break lines are used to show imaginary breaks in objects. A break line is usually made up of a series of connecting arcs. The line type is continuous and the line weight is usually thick (0.5 – 0.6 mm).

Instructor Led Exercise 2-2: Line types

Using the line type definitions, match each line type name with the appropriate line type.

• Visible Line	
• Hidden Line	
• Center Line	
• Phantom Line	
• Dimension and Extension Lines	
• Cutting Plane Line	
• Section Lines	
• Break Line	

III. CREATING AN ORTHOGRAPHIC PROJECTION

The steps presented in this section are meant to help you create a technically correct orthographic projection using the 3rd angle projection standard. To understand and visually see how views are created using the 3rd angle projection



standard, put your right hand on a table palm up. You are looking at the front view of your hand. Now rotate your hand so that your thumb points up and your little finger is touching the table. This is the right side view of your hand. Put your hand back in the front view position. Now rotate your hand so that your finger tips are pointing up and your wrist is touching the table. This is the top view of your hand. The following steps will take you through the creation of an orthographic projection. Once you become experienced and proficient at creating orthographic projections, you will develop short cuts and may not need to follow the steps exactly as written. These steps are visually illustrated in Figure 2-17

1. Choose a front view. This is the view that shows the most about the object.
2. Decide how many views are needed to completely describe the object. If you are unable to determine which views will be needed, draw the standard views (front, top and right side).
3. Draw the visible features of the front view.
4. Draw projectors off of the front view horizontally and vertically in order to create the boundaries for the top and right side views.
5. Draw the top view. Use the vertical projectors to fill in the visible and hidden features.
6. Project from the top view back to the front view. Use the vertical projectors to fill in any missing visible or hidden features in the front view.
7. Draw a 45° projector off of the upper right corner of the box that encloses the front view.
8. From the top view, draw projectors over to the 45° line and down in order to create the boundaries of the right side view.
9. Draw the right side view.
10. Project back to the top and front view from the right side view as needed.
11. Draw center lines where necessary.

Following the aforementioned steps will insure that the orthographic projection is done correctly. That is, it will insure that:

- The front and top views are vertically aligned.
- The front and right side views are horizontally aligned.
- Every point or feature in one view is aligned on a projector in any adjacent view (front and top, or front and right side).
- The distance between any two points of the same feature in the related views (top and right side) are equal

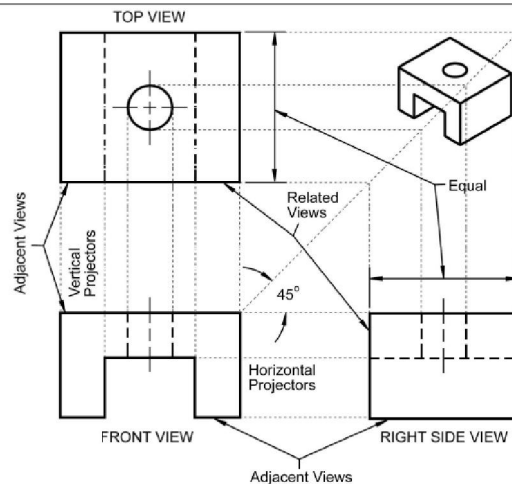


Fig.5: Creating an orthographic Projection



A. Projection Symbol:

In the United States, we use 3rd angle projection to create an orthographic projection. This is the method of creating orthographic projections that is described in this chapter. In some parts of Europe and elsewhere 1st angle projection is used. To inform the print reader what projection method was used, the projection symbol should be placed in the bottom right hand corner of the drawing. If the drawing uses metric units, the text “SI” is placed in front of the projection symbol. The projection symbols are shown in Figure 6. Figure 7 shows the projection symbol’s proportions.

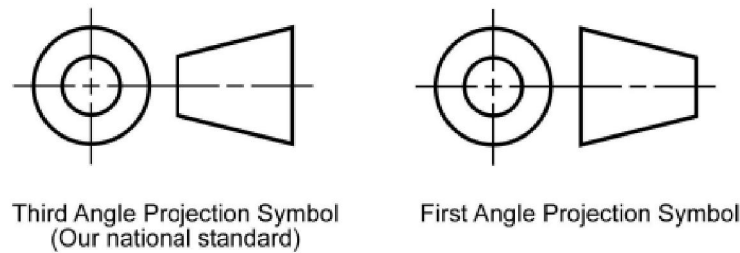


Fig.6: First and third angle projection symbols

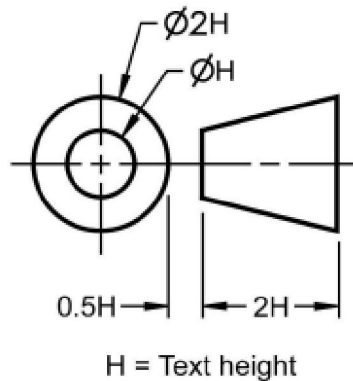


Fig.7: Projection symbol proportions.

IV. CONCLUSION

This study underscores the enduring value of hand engineering drawing on the orthographic projection in vocational education, particularly its role in preparing students for successful careers in the industrial sectors. We found three themes derived from experts who had already experienced the benefits of hand engineering drawing in their careers and practices. By fostering a deep understanding of fundamental technical skills, career readiness, and skills application, as well as developing cognitive and analytical abilities, vocational education programs can significantly contribute to the readiness and success of future careers. This alignment between educational outcomes and industry requirements is crucial for building a competent, efficient, and innovative workforce. Thus, working collaboratively with someone with experience in the field could help engineering schools’ curricula get updated with current demands and needs. Integrating traditional hand drawing skills with modern digital tools prepares students to meet the evolving demands of the industrial sector, promoting adaptability and proficiency in both manual and digital realms. Our study has limitations; it involves a few participants from two industry specializations and only focuses on the Indonesian TVET system. Further research can explore their perspectives and ideas regarding engineering curricula with more experts and industry specializations, and even comparing TVET system from different regions or countries.



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