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COLLEGE OF ENGINEERING AND TECHNOLOGY

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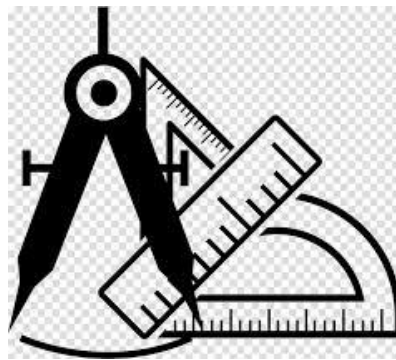
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DEPARTMENT OF MECHANICAL ENGINEERING

24ME403 - METROLOGY & MEASUREMENTS

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24ME403 - METROLOGY & MEASUREMENTS

UNIT III: TOLERANCE ANALYSIS

CO3: To apply the tolerance symbols & tolerance analysis for Industrial Applications

TOLERANCE CHART

Tolerance charting (also called as ‘tolerance chain analysis’) is a graphical and analytical method used to systematically analyze the accumulation of tolerances in a machined component during manufacturing. It helps ensure that the final dimensions of a part fall within the design specifications after all machining operations are completed.

Purpose of Tolerance charting:

The main purposes of tolerance charting are:

- **To verify feasibility:** To check whether the specified blueprint tolerances can be achieved with the proposed sequence of machining operations.
- **To determine working dimensions:** To establish the working dimensions and tolerances for each machining step that will ensure the final part meets design requirements.
- **To identify tolerance stack-up:** To analyze how individual machining tolerances accumulate and affect critical final dimensions.
- **To optimize process sequence:** To help in selecting the best sequence of operations to minimize tolerance accumulation.
- **To reduce scrap and rework:** By ensuring that all intermediate operations are correctly toleranced, the likelihood of producing out-of-tolerance parts is minimized.

Methodology of Tolerance Charting:

Step 1: Draw the component blueprint

- Draw the finished component with all required dimensions and tolerances as specified by the designer.

Step 2: Establish the operational sequence

- List all machining operations in the order they will be performed (e.g., rough turning, finish turning, grinding, milling, etc.).
- Determine the locating and datum surfaces for each operation.

Step 3: Draw the Tolerance Chart

- Create a horizontal time axis representing the sequence of operations from left (raw material) to right (finished component).
- Draw vertical lines representing each machined surface at each operation stage.
- Connect the surfaces with lines showing how dimensions are transferred from one operation to the next.

Step 4: Identify tolerance chains

- For each final blueprint dimension, trace back through the chart to identify all intermediate working dimensions that contribute to it.
- These form a "tolerance chain" or "dimensional chain."

Step 5: Assign working tolerances

- Assign practical tolerances to each intermediate machining operation based on the capability of the machine tools and processes used.
- These are typically tighter for finishing operations and wider for roughing operations.

Step 6: Perform stack-up analysis

- For each final dimension, add up all the intermediate tolerances in its chain (worst-case method) or use statistical methods (RSS) to calculate the total accumulated tolerance.
- Compare the calculated accumulated tolerance with the blueprint tolerance.

Step 7: Adjust if necessary

- If the accumulated tolerance exceeds the blueprint allowance, adjustments are needed.
Options include:
 - Tightening tolerances on specific operations.
 - Changing the sequence of operations.
 - Using more precise machines for critical operations.
 - Adding additional finishing operations.

Example illustration:

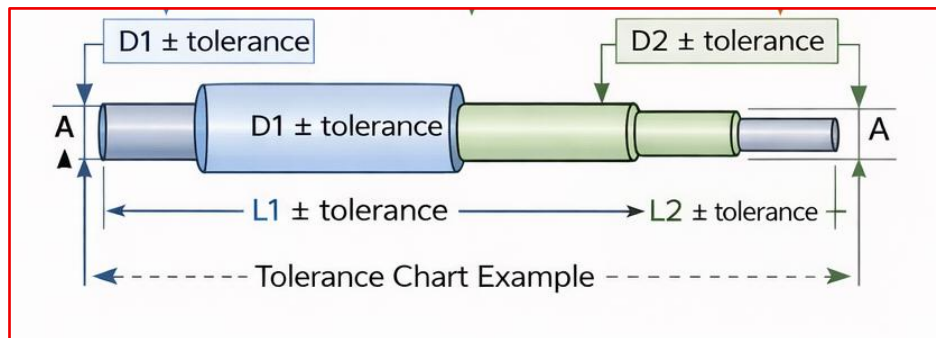
Consider a simple stepped shaft requiring two final dimensions: D1 and D2. The tolerance chart would show:

Operation 1: Face end A and turn diameter to length L1.

Operation 2: Turn diameter to length L2 (using end A as datum).

Operation 3: Finish grind both diameters.

The chart helps verify that the tolerances on L1 and L2 from operations 1 and 2, combined with the grinding allowance, will still produce the final dimensions within blueprint limits.



Limitations of tolerance charting:

- Can be time-consuming for complex parts with many operations.
- Requires experienced personnel to set up the chart correctly.
- Worst-case analysis may lead to unnecessarily tight tolerances.
- Does not account for dynamic variables like tool wear, temperature effects, or fixture errors.