UNIT 1

TOLERANCE STACK-UP

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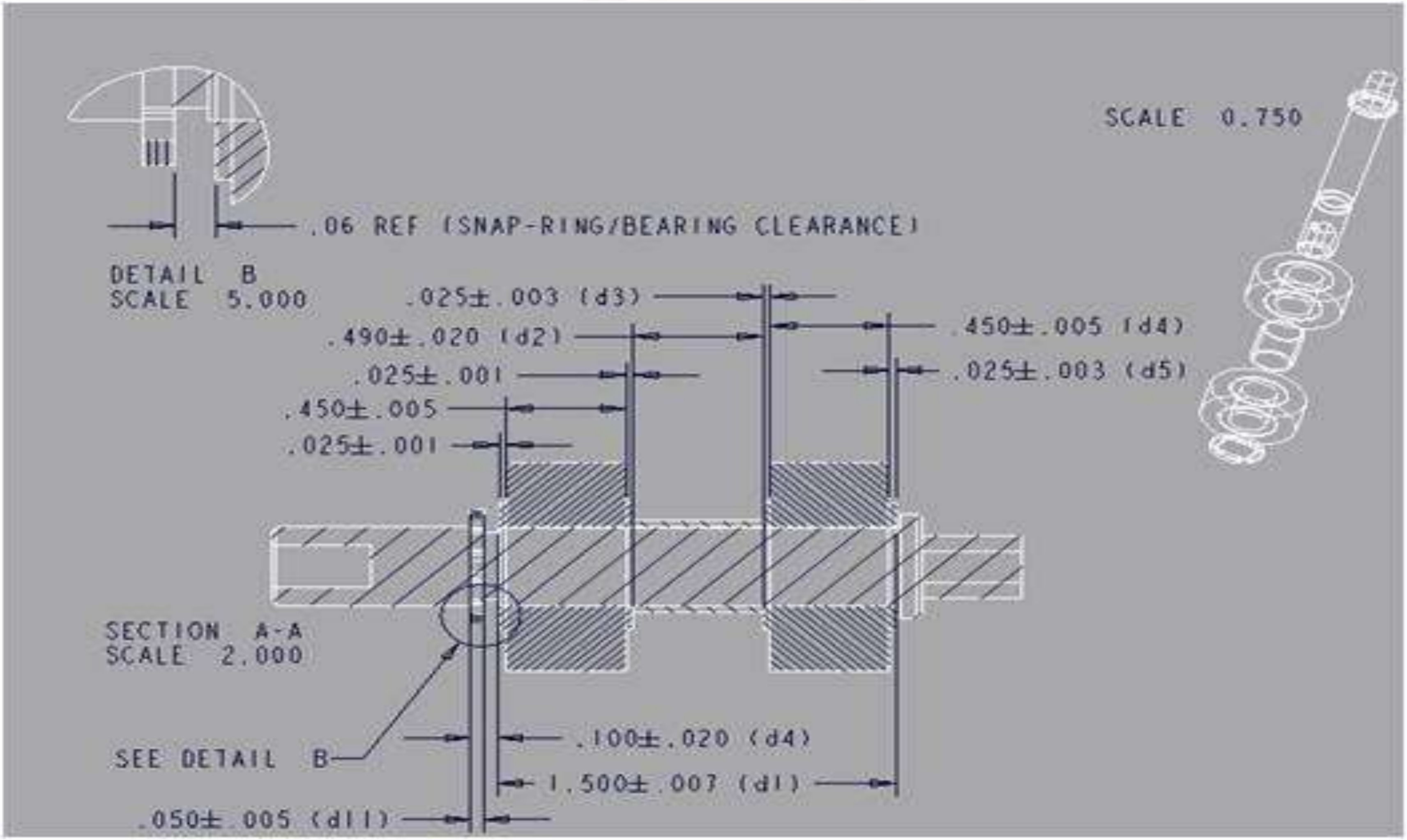
- Product manufacturers utilize an organized flow of information to translate customer requirements into product requirements.
- Tolerance Stack-Ups are vital to address mechanical fit and mechanical performance requirements. Mechanical fit is simply answering the question, “Do the parts that make up the assembly always go together?”
- Mechanical performance requirements would include the performance of mechanisms, like switches, latches, actuators, and the like. Other performance requirements could include optical alignments or motor efficiency. So what is a “stack-up”?
- Tolerance stack-up calculations represent the cumulative effect of part tolerance with respect to an assembly requirement. The idea of tolerances “stacking up” would refer to adding tolerances to find total part tolerance, then comparing that to the available gap or performance limits in order to see if the design will work properly. This simple comparison is also referred to as worst case analysis.

TOLERANCE STACK-UP…contd

❖This process for mechanical requirements is generalized in the flow diagram below.



TOLERANCE STACK-UP…contd

- ❖Worst case analysis is appropriate for certain requirements where failure would represent catastrophe for a company. It is also useful and appropriate for problems that involve a low number of parts. Low being defined as three or four parts.
- ❖Worst case analysis is most often done in a single direction, i.e. a 1D analysis.
- ❖A 1D Tolerance Stack-up is created by creating a cross section of a model and adding the tolerance values for each feature in a straight line. The variation in each contributes to the overall output/outcome.
- ❖If the analysis involves part dimensions that are not parallel to the assembly measurement being studied, the stack-up approach must be modified since 2D variation such as angles, or any variation that is not parallel with the 1D direction, does not affect the assembly measurement with a 1-to-1 ratio.

TOLERANCE STACK-UP…contd

❖Many companies utilize a statistical method for tolerance analysis. One approach involves a simple calculation using the RSS Method, Root-Sum-Squared. Instead of summing tolerances, as in worst-case analysis, statistical analysis sums dimension distributions.

❖It is important to understand that the inputs values for a worst-case analysis are design tolerances, but the inputs for a statistical analysis are process distribution moments (e.g., standard deviation).

❖Worst-case analysis (also called tolerance stack-up analysis) can be used to validate a design.

❖Statistical analysis (also called variation analysis) can be used to predict the actual variation of an assembly based on the variation of the part dimensions. This approach requires distributions to be normal with all parts at the same quality level, i.e. +/- 3σ.

TOLERANCE STACK-UP…contd

- In a Worst-Case Analysis, each dimension will have a minimum and maximum value that represents the range of acceptability for that dimension. Worst-Case answers the question, if I take the maximum range on each input, what is the maximum range for the measurement of interest or stackup? We are therefore dealing with the limits of acceptability and not probability.
- RSS (Root-Sum Squared) Statistical Analysis does not focus on the extreme values, but focuses on the distribution of the variation for each dimension. Each dimension will have a unique distribution of values based on the manufacturing process. Tool wear, operator differences, changes in material and environment all contribute to variation in the dimension value. Each dimension has its own distribution curve.

TOLERANCE STACK-UP…contd

Main Rules

1. Start at the bottom and work up, or start at the left and work to the right.
2. Always take the shortest route.
3. Stay on one part until all tolerances are exhausted.

Step 1 : Identify the requirement that is to be analyzed.

Step 2 : Identify all dimensions and tolerances that contribute to the gap.

Step 3 : Assign each dimension a positive or negative value:

Up is positive; Down is negative

Right is positive; Left is negative

Step 4 : Only one set of mating features creates the worst-case gap.

Step 5 : The analyst must deduce which geometric tolerance, location or orientation if either, contributes to the gap.

Step 6 : If your assumptions are wrong, your answer is wrong.

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