Design for Quality Essentials - A Sigmund Approach

* Predict @ Design Stage with G D & T
* Ensure Least Cost Tolerancing
* Identify & Correct Process Deviations
* Incorporate Intelligent Manufacturing
* Valuefacture

EGS India
Agenda

• Introduction to Design For Quality – DFQ
• Checklist for DFQ
• Dimensional Management Techniques
• Predicting Assembly Build
• Automating Inspection Process
• Summary
Introduction to DFQ

• What Tolerance to allocate?
• How will the tolerances affect function?
• Will there be any assembly issues?
• What will be the PPM estimates?
• Is it really necessary to tighten tolerances?
• Have I chosen the right tolerance?
• Am I responsible for increasing the product Cost?
DFQ: Definition of Paradigm

- Superior Functionality
- Best Fit
- Least Rejections
- Highest Customer Satisfaction
- Consistent Performance
Quality Issues

- Parts not aligning well for a perfect Fit
- Vibration & Noise due to moving parts
- Inconsistent Life & Performance under Controlled Testing
- Unpredictable Field Failures

*Have DFQ Objectives been translated into DFA Parameters? How do the drawings reflect DFA Objectives?*
Improper Fit
Vibration - Effects

- Machine Tool
- Rotating Systems
- Consumer Products
- Automotive
- Discomfort - Poor Performance - Premature Failure - Noise
Vibration & Noise
Field Failures
Six Sigma Approach

Define

Measure

Control

Improve

Analyze
Design for Six Sigma (DFSS)

• Objective is to Understand the Root Cause and Eliminate Defects
• Maximize Return on Investment
• Incorporate Processes for Continuous Improvement
• Enables Gap Analysis of entire Product Development System
• Addresses Voice of Customer (VOC)
5 Steps in DFSS

• **Plan**—enable the team to succeed with the project by mapping all vital steps

• **Identify**—hear the voice of the customer to select the best product concept

• **Design**—build a thorough knowledge base about the product and its processes

• **Optimize**—achieve a balance of quality, cost, and time to market

• **Validate**—demonstrate with data that the voice of the customer has been heard and that customer expectations have been satisfied
DFSS – Another Perspective

- **Define**—determine the project goals and the requirements of customers (external and internal)
- **Measure**—assess customer needs and specifications
- **Analyze**—examine process options to meet customer requirements
- **Design**—develop the process to meet the customer requirements
- **Verify**—check the design to ensure that it’s meeting customer requirements
SS Vs DFSS

- DMAIC is more focused on reacting, on detecting and resolving problems, while DFSS tends to be more proactive, a means of preventing problems.
- DMAIC is for products or services that the organization offers currently; DFSS is for the design of new products or services and processes.
- DMAIC is based on manufacturing or transactional processes and DFSS is focused on marketing, R&D, and design.
Checklist for DFQ

- Is the Drawing Correct?
- Is the Drawing Complete with Respect to Functional Tolerancing?
- Has Process Capability been incorporated while selecting Tolerances?
- Has Assembly Build Criteria been defined?
- Has Interference Analysis been performed?
- Have Critical Dimensions for Assembly Build been identified?
- Have tolerances been maximized for required Assembly Build?
- Have Tolerances been optimized for least cost?
- Is the PPM Estimate meeting our Business Profitability Objective?
- Is there a Dimensional Verification Plan?
Dimensional Management Techniques

• Develop G D & T / Plus-Minus Tolerancing Schematic using 3D CAD (Pro/Engineer, SolidWorks, SolidEdge)
• Perform Assembly Build Analysis using Sigmund integrated with 3D CAD
• Update 3D CAD Drawing with Optimized Tolerances
• Establish Critical-To-Quality (CTQ) Parameters/Dimensions for Inspection
G D & T Vs Plus/Minus Tolerancing

Plus/Minus Tolerancing

Geometric Tolerancing
GD&T Drawings using 3D CAD
Answers to Quality Challenges

- CAD Part Geometry
- Tooling Geometry
- Assembly Sequence & Index Plan
- Dataset Tolerances, Datum and GD & T
- Inspection Dimensions
- PPM Estimation
- Performance

- Product Specification
- Process Capability
- Measurement Plan
- Tolerance Cost Drivers
- Key Characteristics

Varatech Sigmund

www.egs.co.in
Dimensional Management Plan

- Assembly Planning
- Process Selection
- Process Capability (Cp, Cpk)
- Design Fit Requirements

Design Parts & Assembly
- Allocate Part Tolerances
- Specify Assembly Build Requirements
- Perform Tolerance Stack Calculation

- Meet Build Criteria?
  - Yes: Cost of Precision Analysis
  - No: Tolerance Optimization

Cost of Precision Analysis
- Meets Cost Criteria?
  - Yes: Inspection Dimensional Management, SPC & PPM Report
  - No: Launch Production

- Tolerance Optimization
Tolerance Analysis Vs Tolerance Synthesis
Setting Build Objectives

• Eliminate Assembly Interference
• Ensure Uniform Gap between Gripper Jaws in Closed condition
• Control size of smallest and largest parts that can be held between the Jaws
Setting Build Objectives

- Ensure Assembly
- Minimize Back Lash
- Minimize Vibration
- Eliminate Noise & Wear Issues
Defining Node Tree of Dimensions & Tolerances

Door Handle Gap
Worst Case Analysis

<table>
<thead>
<tr>
<th>Gap</th>
<th>Roll Up</th>
<th>Roll Down</th>
</tr>
</thead>
<tbody>
<tr>
<td>PNominal</td>
<td>0.0000</td>
<td>0.0000</td>
</tr>
<tr>
<td>PRange</td>
<td>0.0100</td>
<td>1.0000</td>
</tr>
<tr>
<td>POffset</td>
<td>0.0000</td>
<td>0.0000</td>
</tr>
<tr>
<td>%Cont</td>
<td>100.00</td>
<td>100.00</td>
</tr>
<tr>
<td>Weight</td>
<td>---</td>
<td>1.0000</td>
</tr>
</tbody>
</table>

Analysis Method
- Roll Up: WC
- Roll Down: WC

Surface Profile
- Seal Profile
  - Seal1 Sub Assembly
    - #... D E F
      - PNominal: 0.0000, Roll Up: ---, Roll Down: ---
      - PRange: 0.7500, Roll Up: 0.6667, Roll Down: 0.6667
      - POffset: 0.0000, Roll Up: 0.0000, Roll Down: 0.0000
      - %Cont: 24.92, Roll Up: 33.33, Roll Down: 33.33
      - Weight: ---, Roll Up: 1.0000

- Float
  - Float Sub Assembly
    - #... A B C
      - PNominal: 0.0000, Roll Up: ---, Roll Down: ---
      - PRange: 1.3600, Roll Up: 0.6667, Roll Down: 0.6667
      - POffset: 0.0000, Roll Up: 0.0000, Roll Down: 0.0000
      - %Cont: 31.70, Roll Up: 23.33, Roll Down: 23.33
      - Weight: ---, Roll Up: 1.0000

- Surface Profile
  - SA Profile

Float
- Pin 2 Handle
  - #... A B C
    - PNominal: 0.0000, Roll Up: ---, Roll Down: ---
    - PRange: 0.4100, Roll Up: 0.1667, Roll Down: 0.1667
    - POffset: 0.0000, Roll Up: 0.0000, Roll Down: 0.0000
    - %Cont: 13.62, Roll Up: 8.33, Roll Down: 8.33
    - Weight: ---, Roll Up: 1.0000

Position
- Pin Position
  - #... A B C
    - PNominal: 0.0000, Roll Up: ---, Roll Down: ---
    - PRange: 0.0000, Roll Up: 0.0000, Roll Down: 0.0000
    - POffset: 0.0000, Roll Up: 0.0000, Roll Down: 0.0000
    - %Cont: 0.00, Roll Up: 0.00, Roll Down: 0.00
    - Weight: ---, Roll Up: 1.0000

Surface Profile
- Housing Profile
  - #... A B C
    - PNominal: 0.0000, Roll Up: ---, Roll Down: ---
    - PRange: 0.7500, Roll Up: 0.1667, Roll Down: 0.1667
    - POffset: 0.0000, Roll Up: 0.0000, Roll Down: 0.0000
    - %Cont: 24.92, Roll Up: 8.33, Roll Down: 8.33
    - Weight: ---, Roll Up: 1.0000

- Hand Profile
  - #... A B C
    - PNominal: 0.0000, Roll Up: ---, Roll Down: ---
    - PRange: 0.0000, Roll Up: 0.0000, Roll Down: 0.0000
    - POffset: 0.0000, Roll Up: 0.0000, Roll Down: 0.0000
    - %Cont: 0.00, Roll Up: 0.00, Roll Down: 0.00
    - Weight: ---, Roll Up: 1.0000
PPM Estimates

RollUp/RollDown Statistics Report
Door Handle Gap
Worst Case Analysis

Specification Limits: LSL=1.0000, Nominal=0.0000, USL=1.0000
Control Limits: LCL=1.5050, Mean=0.0000, UCL=1.5050, Mean Shift=0.0000
Defects: %Out of Spec.=4.6224, ppm Out of Spec.=46224
Capability: Cp=0.6645, Cpk=0.6645
Identifying Contributors

Sensitivity Report for Roll Up Door Handle Gap Worst Case Analysis

Analysis Method: WC

- 24.92% Handle Profile
- 24.92% Bezel Profile
- 16.61% Housing Profile
- 13.62% Pin 2 Handle
- 13.29% Bezel 2 Sub Assembly
- 6.64% Pin Position
## Incorporating Process Capability

### PCRSS Set Data: Worst Case-Gap Study

<table>
<thead>
<tr>
<th>Tolerance Name</th>
<th>% RSS</th>
<th>Cc Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>DetailItem1@Annotations@Bezel-1</td>
<td>32.270</td>
<td>0.25</td>
</tr>
<tr>
<td>DetailItem2@Annotations@Handle_Lever-1</td>
<td>32.270</td>
<td>0.25</td>
</tr>
<tr>
<td>DetailItem1@Annotations@Handle_Housing</td>
<td>14.342</td>
<td>0.25</td>
</tr>
<tr>
<td>Pin2Handle</td>
<td>9.644</td>
<td>0.25</td>
</tr>
<tr>
<td>Bezel2Subassembly</td>
<td>9.179</td>
<td>0.25</td>
</tr>
<tr>
<td>DetailItem2@Annotations@Handle_Housing</td>
<td>2.295</td>
<td>0.25</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Accept**
- **Cancel**
Updating 3D CAD Drawings
Summary of Benefits

- **Correctness & Completeness** of Drawings assured
- Assembly Issues are eliminated
- Maximize Tolerancing for Least Cost
- Identification of Critical Dimensions affecting Assembly Build & Performance
- Estimate Rejections *a priori*
- Establish Dimensional Inspection FREE OF ERRORS
- Eliminates customer rejection of parts/ assemblies
- Ensures Consistent Quality
- Reduces/ Eliminates Human errors in subjective interpretation of drawings that result in re-work, time delays and escalates product cost
Customers benefited by Sigmund
Importance of DFQ approach

- First Time Right is a necessity
- Clear Insight into Dynamic Tolerance Interaction
- Consistency in Quality – Requirement to meet World Class Quality Standards
- Establish lead and provide differentiation among Global Suppliers in competitive environment
Thank You

Interested in Design for Quality?
Contact: info@egs.co.in
Web: www.egsindia.com  www.egs.co.in