Cylinder Production

Manufacturing Process

- Brass is smelted and extruded to form long, round or shaped bars
- Requires knowledge of metallurgy and geometry to create a metal with the attributes you want:
  - hardness
  - machinability
  - formability
  - Corrosion resistance

Manufacturing Process

Bars are machined into the parts using computer controlled lathes or machining centers

Swiss Screw Machine Video

- Requires knowledge of metallurgy, machining and geometry to:
  - interpret the design
  - write the programs for the cutting of the metal
  - calculating the speed and feed rate of the tools
Manufacturing Process

Components are assembled and pins inserted

Manufacturing Process

Considerations when developing the process

- Cycle time vs "akt" time
  - The difference between the actual time it takes to make a part vs how many you need to make in a certain timeframe to meet your customers' demands
- Waste production in the process
- Is it recyclable (brass chips are 100% recyclable)
- Cutting fluid - is it a hazardous waste when it's reached the end of its useful life
- Equipment maintenance and tooling costs
- New equipment requirements
- Skill required to operate and maintain equipment
- Capability of machine vs design requirements

Manufacturing Process

Material Selection

- Brass makes up 99% by weight of the cylinder and key
  - Very easy to machine vs other metals like steel
    - Keeps tooling cost low and saves wear and tear of the machines
  - Very corrosion resistant
  - Does not rust
  - No protective surface that can wear off (like stainless steel)
  - Long wear resistance when mating parts are also brass
GD&T

**Geometrical Dimensioning and Tolerancing**

- Everything must have a dimension and tolerance.
- Tolerance defines the allowable variation of individual features.

**Hole Diameter**
**Tolerance:** 1.02" to 1.03"

**Plug Diameter**
**Tolerance:** 1.00" to 1.01"

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**GD&T**

If using MMC Clearance Fit:

[Diagram of MMC Clearance Fit]

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**GD&T**

**ACIS TO REMEMBER SYMBOLS, RULES, AND GUIDELINES**

[Table and diagram of ACIS symbols and rules]

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Process Not in Statistical Control

Future Prediction

• Special causes present
• Distributions are unpredictable

STATISTICAL ANALYSIS

• Compare the difference between the process center and each specification limit to one-half the natural tolerance of the process

• $C_{pu}$ is the difference between the process center and upper specification limit
• $C_{pl}$ is the difference between the process center and lower specification limit

$C_{pu} = \min(C_{pl}, C_{pu})$

STATISTICAL ANALYSIS

Process Capability Calculations - Example

• Specification Limits: $LSL = 8$, $USL = 20$

• Process Information: $\bar{x} = 16$, $\sigma = \bar{R}/d_2 = 2$

$C_{pu} = \frac{(USL - \bar{x})}{\sigma} = \frac{(20 - 16)}{2} = 2$

$C_{pl} = \frac{(\bar{x} - LSL)}{\sigma} = \frac{(16 - 8)}{2} = 4$

$C_{pu} = \min(C_{pu}, C_{pl}) = \min(2, 4) = 2$

$C_{pu}$ of 1.33 is the minimal target
PROGRAMMING

• Review part print for manufacturability
• Determine tools needed
• Based on part material, calculate speed (RPM) used for turning and drilling
• Formula for calculating RPM: 3.82 x SFM/stock dia
  • SFM is a tabulated standard that is found in Mfg.
    handbooks and dependant on material qualities

<table>
<thead>
<tr>
<th>Material</th>
<th>SFM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brass</td>
<td>600</td>
</tr>
<tr>
<td>303 Stainless Steel</td>
<td>300</td>
</tr>
<tr>
<td>316 Stainless Steel</td>
<td>90</td>
</tr>
<tr>
<td>4140 Steel</td>
<td>120</td>
</tr>
</tbody>
</table>

• Example: Brass part made from 1.5" diameter bar with 0.5" drilled hole
  • 3.82 x 600 / 1.5 = 1128 RPM for turning
  • 3.82 x 600 / 0.5 = 4584 RPM for drilling

PROGRAMMING

Staffing

Types of Positions
- Top Level (Bachelors or Masters Degree)
  - Manufacturing Engineer
  - Quality Engineer
  - Design Engineer
  - Production Support
- Mid-Level (Associates Degree or specialized training)
  - CNC Programmers
  - CAD Designers
  - Engineering Technicians
  - Buyer/Planners
  - Customer Technical Support
- Entry Level (High School Diploma)
  - Machinists
  - Automation Technicians
  - CNC Operators and Machinists

Salary Scale

- 60-90K
- 50-60K

Electromechanical
Skills we look for in a new hire

Ability to understand complex systems and information

- PROBLEM SOLVING SKILLS

The level of complexity is dependent on the position:
- Engineers (quality, inf, and design) need to understand a very high level of complexity.
  - How parts interact with each other in a lock
  - How machines function (hydraulics, electronics, motors and robotics)
  - How materials react (corrosion, wear, conductivity, strength)
- High level Machine operators or one of the trades (Electricians, technicians, Mechanics, Tool and Die Makers)
  - Need to be close to the level of an Engineer for problem solving
  - Do not need the Calculus or high level math skills

Sample Questions
- Logic Testing
- 68 Questions
- No actual math
- A math test is under review