Jobshop Lean: How to Achieve Lean and Flexibility in Machine Shops

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A Machine Shop Is Not a Toyota Factory

High

QUANTITY
(Volume)

Low

Low

High

Assembly Lines or Transfer Lines

Flexible Flowshops

Manual Cells

Toyota is here

Most machine shops are here

Flexible Mfg.Cells

Jobshops

MIX
(Variety)
A Machine Shop Is Not a Toyota Factory

• **Jobshops ≠ Assembly Facilities**
  – High mix of products i.e. *many* different routings
  – Part families may not be known
  – Product mix segmentation must be done
  – Setup times, cycle times, lot sizes, etc. vary significantly
  – Wide variety of product designs and equipment types
  – Typical facility has a Process Layout (= batch-and-queue)

• **Different (and Difficult) Business Environment**
  – Demand is unstable
  – Lot sizes change
  – Customer loyalty and sanity are non-existent
  – Production schedules are driven by due dates *(not* Takt Time)*
  – Shifting capacity constraints
  – Due dates are different and subject to frequent changes
Flexibility: What Lean Fails to Provide

• Setup Flexibility
  – Individual resources can rapidly change over from making one part to another

• Process Flexibility
  – Resources (machines, people, tools, etc.) can process a variety of parts/products having different process specifications

• Routing Flexibility
  – System provides a variety of routes with different combinations of machines to make the same part

• Mix Flexibility
  – System can simultaneously process a large variety of parts (or part families) with different designs and routings involving different combinations of machines

• Volume Flexibility
  – System can accommodate high variability in the delivery quantities set by customers of the same, or different, parts/products
  – System can accommodate parts/products in different phases of their life cycle ex. ramp-up, production, end-of-life and prototype

• Facility Flexibility
  – System can be reconfigured quickly to accommodate mix and volume changes
  – System has many mobile resources that can be re-located on demand
These Lean tools have *limited (if any!)* use in a job shop!
How to Make a Machine Shop Lean and Flexible
“Playbook” of Practices for JobshopLean

• “4H” Leadership
  – Leads by example (Involved! Engaged!)
  – In-depth knowledge (A job shop ≠ An assembly line)
  – Uses TOC & Lean & Six Sigma & Software & Technology & … (Lean is far from sufficient!)
  – Value Stream Network Mapping

• Motivated Workforce
  – Waste elimination of day-to-day work is second nature (Self-critiquing)
  – Multi-skilled/Team-oriented

• Product Mix Segmentation
  – M³ (Mixed Mode Manufacturing) Facility (Runners/Repeaters/Strangers)

• Independent Cells
  – Manufacturing Focus through Part Families (Group Technology)
  – Flexibility through Multi-function Automation

• Partial Cells and Virtual Cells
  – IT-enabled communications
  – ERP with FCS and MES
  – Virtual Cells/Distributed Teams
  – Water Strider = Material Handler + Expeditor (= Cell Manager On Wheels!)
  – Real-time Order Tracking (RFID, ADC, 2-way Radio Communications, “Spycams” on constraint w/c’s, Cell phones that read bar codes and allow cussing, … and more)
  – etc.

• Process Standardization
  – Variety Reduction
  – Design For Manufacture
  – Value Analysis
  – Computer-Aided Process Planning

• Unconventional Thinking
  – Order bartering with competitors (“Goodness Of Fit”)
  – No shame in firefighting (Just do it efficiently!)
  – Risk management under uncertainty
eBook on JobshopLean


Book

JobshopLean: Adapting Lean for Small and Medium High-Mix Low-Volume Manufacturers

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Segment the Product Mix

The method of PQR$T Analysis needs **good** data.
Split the Shop into Two Shops: Shop #1 of 2

Implement manufacturing cells to produce orders for these products.
Split the Shop into Two Shops: Shop #2 of 2

Implement a “Quick Turnaround Shop” that has AM equipment, multi-tasking machines, highly-skilled employees, etc. to produce orders for these products.
Form Product Families

In each of these product families, do you think that the products could be produced by the same group of machines?

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### Machines shared by the two cells that could result in machine duplication or exception operations

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**FINAL MATRIX**

[Diagram showing the Final Matrix with highlighted cells for machines shared by Cell #1 and Cell #2, indicating potential conflicts or exceptions.]
Form a Cell to Produce Each Product Family

FOCUS: The cell’s team can complete and ship any order for any part (or product) in its part (or product) family in any quantity to any customer to reach by an agreed-upon delivery date.

FLEXIBILITY: The cell can produce any part (or product) in its part (or product) family.

CONTINUOUS IMPROVEMENT CULTURE: The cell’s team has full authority to do projects to achieve performance metrics (SQDPC) set by management.

ACCOUNTABILITY: The cell’s team is responsible for achieving performance metrics (SQDPC) set by management.

OWNERSHIP AND AUTONOMY: The cell’s team has full authority to establish cross-training programs, have a say in who gets recruited to work in their cell, partner with other cells to share resources as-and-when-needed, communicate directly with customers and suppliers, determine who does overtime on which days, etc.
Example of a Machining Cell

Order Flow Times reduced from 16 days to ≤ 5 days

Standard Lead Time quoted to customers was reduced from 20+ days to 10 days

Annual labor hours spent on material handling to/from the cell was reduced by 51 hours

The U-shape of the cell has machines on the periphery and the tables for cleaning, inspection, etc. in the center --- Flow of material in the cell is counter-clockwise and streamlined

The cell’s area was reduced from 2816 sq. ft. to 1410 sq. ft. --- The compact shape of the cell prevents clutter from accumulating on the floor

The distance travelled by any order processed in the cell was reduced from 618 ft. to 368 ft. --- Each operator can tend to at least two machines without any walking

The LOSE (Line Of Sight Efficiency) improved from 0.286 to 0.714 --- A cell employee can see progress of work on any order and quickly communicate with other employees
Change the Shop Layout to a Cellular Layout

The shop layout IS NOT aligned with actual product flow

The shop layout IS aligned with actual product flow

Process (Functional) Layout

Group (Cellular) Layout

Similar resources placed together

Resources to produce similar products placed together
Change the Shop Layout to a Cellular Layout

1. Pick a Part Family
2. Form Part Families using PFAST
3. Develop the VNM for this Part Family
4. Enhance the VNM with Flow Process Charts and Spaghetti Diagrams to identify the Seven Types of Waste
5. Identify the Bottleneck Process in the VNM
6. Exploit/Elevate the Bottleneck
7. Performance Evaluation of the VNM to compute their Impact on Throughput, WIP, and Operating Expenses
8. Has the entire VNM for this part family been optimized?
   - YES: Have all part families been investigated?
     - NO: STOP
     - YES: Subordinate the Value Network to the Beat of the Bottleneck using DBR/FCS Scheduling
   - NO: Subordinate the Value Network to the Beat of the Bottleneck using DBR/FCS Scheduling
Reduce Number of Machines in Each Cell
Give a Feasible Daily Schedule to Each Cell
Monitor the Bottleneck Machine in Each Cell

1. Data on Orders/Operations comes from SAP.
2. APSFeed3 augments data with rules to prioritize production of orders, data conversion, and some machine rules added to the SAP data.
3. Preactor uses data from APSFeed3 and scheduling rules to assign and sequence operations to resources.
4. Preactor then publishes schedule to the MES system, FactoryViewer.
5. As operations are executed, data is collected via shop floor terminals and fed back both to Preactor and SAP for updating and perpetuating the scheduling process.

If you have questions about this system, please contact: Paul Mittendorff (Director - Manufacturing Systems) @ Hoerbiger Corporation of America, Inc., P: 954-974-5700 x 2170 E: paul.mittendorff@hoerbiger.com
Use Water Spider(s) Instead Of/With an MES

Train water spider(s) to execute the daily schedule! No software can provide better situational awareness about order status than a smart and motivated employee!
Water Spider’s Work in an Assembly Factory

Water Spider’s Work in a CNC Machine Shop

1. Get the current status of the job from the scheduler.
2. Go to the board.
3. Make a note of all late jobs on the board.
4. Track the job backwards on the board.
5. Identify the current location of the job in the workshop (WC).
6. If the job is delayed in the WC, get the expected date of completion from the WC.
7. Transfer the job from the outbound saw horses to the cart.
8. Move the job to the next WC.
9. Identify the current location of the job in the WC.
10. If the job is delayed for approval, get the approval from the front office.
11. After the simulation is over, jobs wait for approval from sales on the saw horses.

Jobs that are late are marked in red colour.
Can You Manage Every Cell with Your ERP?

- Revise the schedule daily
- Direct the Water Strider to pick up or drop off each order
- Track Scrap and Uptime at the Bottleneck
- Generate end-of-shift performance reports
- Schedule deliveries of raw materials from their suppliers
Right-size Processes to Absorb into Cells

SOURCE: http://blog.cnccookbook.com/2016/08/02/specialized-work-stations-keep-shop-organized/
Can/Should Inspection be Right-sized?

- Is any of these Inspectors working in a cell?
- Can Inspection be done on a mobile truck that “drives around” the shop?
- Can there be two (or more) Inspection departments ex. one located in the center of the shop and the other next to Shipping?
- What if Inspection is the Bottleneck?
“Raze” and Standardize Product Routings

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Exception Operations

Machine Duplication

Product Family #1

Product Family #2
Rationalize your Product Mix (PQ$ Analysis)

Pursue new business in the RUNNERS and REPEATERS segment to make products that “fit” into existing part families for which cells have already been implemented.

Decide whether you really should produce some (or all?) of the products in the STRANGERS (“Cats and Dogs”) segment.
Support an In-House CI Team

- **Focus:** Train and develop key employees who will be empowered to make improvements in the shop
- **Members:** Owner (Champion), Plant Manager (Leader), **Industrial Engineer**, Department Supervisors, Others as necessary
- **Weekly Activity Schedule:**
  - One team meeting per week for ½ day
  - *Instruction (if needed):* A problem-solving tool is taught, possibly using a relevant video
  - *Progress Reporting:* Each member reports on their role in the project
  - *Hands-on Work:* Team goes to work in a particular area on the shop floor
Support an In-House CI Team

• Instructional Resources:
  • Online videos from YouTube
    • Free YouTube videos: [Video 1], [Video 2], [Video 3], [Video 4], [Video 5], [Video 6]
    • “These Will Cost You!” videos: Gemba Academy, SME, GBMP, Enna, etc.
  • Interactive simulations, workshops, etc.
  • Case Studies:
    • Google key words like “Lean machine shops”, “5S in machine shops”, etc. to get informative articles
Hire a Full-Time IE: Project Work on Lean

Example #1: Eliminate repetitive counting & weighing

Example #2: Use 5S to reduce time for building a box

Example #3: Use 5S to reduce setup time for milling

Example #4: Eliminate unnecessary administrative steps for reporting scrap

Bryan Wang did this work during a summer internship funded by the Forging Defense and Manufacturing Consortium (now PRO-FAST)
With the intern from OSU as their Facilitator, a group of 10 employees from Bula Forge & Machine, Inc., including the President, Vice-President, Shop Managers, Sales Manager, and department heads of Scheduling, Human Resources, Purchasing, and Engineering, met for 1 hour per week for the first 8 weeks, and added 3 hours in the following 4 weeks.

• Readings of these books followed by discussion: *The Goal*, *Lean Thinking*, *The Toyota Way*
• Some additional readings ex. chapters from *Learning to See* and *Toyota Talent*

Bryan Wang did this work during a summer internship funded by the Forging Defense and Manufacturing Consortium (now PRO-FAST)
<table>
<thead>
<tr>
<th></th>
<th>Activities</th>
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<tbody>
<tr>
<td>1</td>
<td>Study assigned readings at home</td>
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<tr>
<td>2</td>
<td>Lectures on Lean concepts &amp; tools by the intern (using real examples from Bula)</td>
</tr>
<tr>
<td>3</td>
<td>Discussions on how to use Lean concepts &amp; tools at Bula</td>
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<tr>
<td>4</td>
<td>Identify target parts/operations/areas that could be done as group (or individual) projects</td>
</tr>
<tr>
<td>5</td>
<td>Implement the projects</td>
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<td>6</td>
<td>Present results during group meetings</td>
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<tr>
<td>7</td>
<td>Discuss follow-up actions for each project</td>
</tr>
</tbody>
</table>

Bryan Wang did this work during a summer internship funded by the Forging Defense and Manufacturing Consortium (now PRO-FAST)
Does Your Top Floor have “4H” Leaders?

- **HEAD**
  - Are they active learners of Lean ex. could they co-teach 1-2 training modules in the company’s training program?
  - Do they support a wall paper in the lunch room featuring (1) stellar improvement projects done by employees, (2) significant issues/concerns for which they solicit improvement ideas from the entire workforce, etc.?
  - Do they offer improvement ideas to the CI team?
- **HEART**
  - Have they made *Respect for Employees* core to the company’s HR policies and programs?
  - Are specific employees appreciated for their stellar performance, possibly with “more meaningful” rewards?
- **HANDS**
  - Are they out on the floor doing the simple things that will lift employees’ spirits such as shaking hands, patting backs, greeting employees that walk by, etc.?
  - Are they active participants in at least a few kaizens?
- **HOOVES**
  - This is not to say that every executive is an ass or a horse!
  - Do they “stand on an X” on the shop floor at least once in the week? Do they note their observations and share them with the CI team? Do they lead a RCA session? Do they ask for a Corrective Action Plan to address the root cause(s)?
  - Do they participate in a Morning Huddle of at least one department every day?
Does Your Top Floor have “4H” Leaders?

- **HEAD**
  - Repeat a Read-Do-Learn process to master practices that help to improve leadership skills and ability to engage with employees. Some of these practices are *Gemba Walks, Training Within Industry, Problem Solving, Management Kata aka Lean Daily Management*, etc.
  - Examples of good free info available online: Gemba Walks (Click [here](#) and [here](#)) & Training Within Industry (Click [here](#))

- **HEART**
  - In the lobby of the company, mount a display board that is signed by each and every employee of the company. Replace it every year by having new employees sign on the spots where employees are no longer because they quit the company “under unhappy circumstances”.

- **HANDS**
  - At the annual picnic, be sure to recognize and reward exemplary employees with awards such as Best Ideas for Product and Process Innovation, Best Ideas for Cost Reduction, Best Ideas for Safety and Ergonomics, Best Community Service Projects, etc.

- **HOOVES**
  - At least once a week, go and visit any one cell or department to surprise (or shock!) the employees while they are at work. Have brief chats with each of them! Ask them about their work! Maybe ask the team to describe one of their ongoing improvement projects?
CASE STUDY: Implementing JobshopLean at Wear Technology
Lean Manufacturing Begins With Layout, Commitment

Sustainably streamlining production of a varied mix of low-volume work depends not only on a strategy tailored for job shops, but also on human drive and enthusiasm.

Article Post: 7/3/2017
MATT DANFORD
Senior Editor, Modern Machine Shop
Our Goal: Improve Material Flow in the Shop
Projects to Improve Material Flow in the Shop

- Move Pre-Inspect into the warehouse
- Re-layout the Shipping department

Move the YELLOW STRAIGHTENER and SIM station into a cell located near the WEINGARTNER

Incorporate the new Mori Seiki MillTurn into the factory flow:
1. Will it combine consecutive steps in existing routings?
2. Will it eliminate operations in existing routings?

Create and operationalize the new position of Water Strider immediately

Introduce a sufficient number of additional material handling carts on the floor:
- Each cart carries only one set of (twin) screws
- Each cart is right-sized to carry small or large screws

Re-layout the Machine Shop:
- Locate the Daewoo near Boxing
- Eliminate the Tarnow Lathe?
- Eliminate the Webb Lathe?
- Re-locate the Sharp Mill?
- Move the N TOS Lathe next to the W TOS and E TOS Lathes?
Projects to Improve Material Flow in the Shop

- Re-locate all THREAD MILLS into the area where the MACHINE SHOP is currently located
- Move the EITEL press between the COBURGS and the GRINDING department
- Operationalize the Single Order Tracking Board
- Transform the gemba walk meetings of the Team Leaders into problem-solving sessions and idea-sharing opportunities
- Penalize any department that sends defective screws to another department
- Improve maintenance of machines to reduce lost capacity on the CNC’s
- Prevent Sales and Customer Service from overloading the shop to meet end-of-month quotas (= Push Scheduling)

Install a gemba board in the FINAL INSPECT and SHIPPING departments to display how many orders failed to ship on-time, including reason/s
Projects to Improve Material Flow in the Shop

- Build another STRAIGHTENER #3 and locate it near FINAL INSPECT
- Divide the shop into two focused factories – NEW & REBUILD
- Implement an MES (Manufacturing Execution System) integrated with an FCS (Finite Capacity Scheduler)
- Fill essential positions:
  - QC
  - Maintenance
  - Industrial Engineer (CI)
  - Production Controller
- Establish standard times for different types of screws using:
  - On-floor Time Studies with IE software like TimerPro
  - CNC machining time estimation software like MEPro
- Improve employee morale (and accountability too!)
- Increase the participation of officers in the gemba walks and kaizen events
Let’s Talk Strategy

Pursuing Continuous Improvement with Cellular Manufacturing
## Form Product Families: Initial Matrix

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### INITIAL MATRIX
Form Product Families: Final Matrix

**FINAL MATRIX**

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</table>

Machines shared by the two cells that could result in machine duplication or exception operations.
**Prevent any Part From Ever Exiting Its Cell - I**

Strategies to reduce, better yet eliminate, intercell flows of parts that utilize available capacity on common machine types distributed in multiple cells

1. **Group schedule part families to exploit common setups, tooling and process settings**
2. **Reduce tool-changing times** ex. machining and turning centers have pre-set tooling. ATC’s, combination tools, large tool magazines, toolwear sensing with replaceable inserts, etc.
3. **Reduce the # of tools by application of Variety Reduction Techniques and Group Technology ex. standardize part dimensions, tolerances, fillet radii, chamfer angles, thread types, hole radii, etc**
4. **Reduce the # of fixtures, develop quick-change flexible fixtures to handle families of parts, “Lean Tooling” (5S the fixture racks, use SMED to speed up fixture changes, etc)**
5. **Use Renishaw probes to do in-process parts gauging instead of stopping the machine to repeatedly loading/unloading the part to inspect it**
6. **Evaluate the production lot sizes and reduce them if they include safety stock (“buffers”)**
7. **Perform all necessary inspections within the cell**
8. **Eliminate “cats and dogs” type of less-critical parts which are not ordered frequently**
9. **Reengineer setups and process parameters to reduce setup times and cycle times using Six Sigma methods esp. DOE**
10. **Eliminate operator fatigue by automating (or mechanizing) handling, loading/unloading, etc.**
11. **Cross-train operators to allow them to inspect and monitor each other’s work**
12. **Maintain SPC charts at key machines**
13. **Redo scrap and rework**
14. **Dedicate existing machines to certain parts**
15. **Purchase new machines that cycle faster for some parts**
16. **Outsource**
17. **Redesign the parts to eliminate the feature(s) requiring the external operation**
18. **Reroute some parts to alternative machines in the cell**
19. **Purchase a multi-function machine that combines two or more of the existing machines; PLUS, it automates other non-value-added tasks**
20. **Optimize process parameters using Six Sigma methods**
21. **Eliminate exception operations that are forcing parts to leave their host cell to visit machines external to that cell**
22. **Elevate the constraint (ADD CAPACITY)**
   - **Virtual Cells with material handlers to “group/connect” the machines in the cell for each part family**
   - **Hybrid Flowshop**
   - **Cascading Flowlines**
   - **Modular Layout (Partial Cells)**
23. **Use automated handling**
24. **Ever Redesign other parts to eliminate features requiring the external operation**
25. **Using automated or semi-automated systems for material handling**
26. **Overlap shift changes to eliminate tear-down and startup delays**
27. **“Exploit the constraint” (MAKE BETTER USE OF AVAILABLE CAPACITY)**
28. **Group schedule part families to exploit common setups, tooling and process settings**
29. **Reduce (if any) absenteeism and "b-s-ing time"**
30. **Reduce transfer batches ("one-piece flow") to minimize machine idle time due to inter-machine transfer delays**
31. **Reduce downtime using TPM strategies**
32. **Reengineer setups and process parameters to reduce setup times and cycle times using Six Sigma methods esp. DOE**
33. **Eliminate operator fatigue by automating (or mechanizing) handling, loading/unloading, etc.**
34. **Cross-train operators to allow them to inspect and monitor each other’s work**
(Suri) Use smaller-scale implementation of process technology (Right-size and Down-size)
(H&W) Miniaturize and decentralize the process to duplicate it (possibly absorb into) across multiple cells; seek smaller and cheaper machines suited to certain families of parts (each family is specific to any one cell)
Ex: Dishwasher vs. (Large) Wash Tank, Table-mounted Saw vs. (Large) Band Saw, Electrical induction-hardening furnace vs. (Large) Gas-fired furnace (for Heat Treatment), (small & off-line) Paint Booth vs. (Monolithic & Conveyerized) Paint Line

(Irani) Design a Modular Layout with “partial cells” that group machines (a) prior to the MONUMENT process and (b) after the MONUMENT process

(LM) Split the routings into two (partial) cells by grouping the machines before and after the operations on the MONUMENT process

(Suri) If most of the machines needed cannot be dedicated and co-located in a cell, create a time-sliced virtual cell?

(H&W, Irani) Outsource the process (ex. purchase pre-painted parts to eliminate the centralized painting department) and establish a “milkrun” schedule for parts delivery

Electronic Kanban
Heijunka (Level Loading)
Schedule visibility via internet

(Suri) Use time-based routings instead of cost-based routings to determine equipment choices at the Process Planning + Cost Estimating step in the ‘front’ once

(Suri) Use time-based routings instead of cost-based routings to determine equipment choices at the Process Planning + Cost Estimating step in the ‘front’ once

(H&W, Irani) Create dynamic and reconfigurable cells, or partial cells (LAYOUT MODULES) by placing the other machines required in a mobile cell on wheels and moving them so as to co-locate them at/near the Monument. When the orders for the part family “dry up”, this “phantom cell” is dismantled, and the equipment is re-allocated into new mobile cells, suited for new part families identified (by PFAST) in the current product mix

(H&W, Irani) Execute the P-Q-R-$ Analysis module in PFAST; say we are able to segment the product mix being run through the Monument into Runners/Repeaters/Strangers and know which part families they belong to: dedicate some machines in the department to the High Volume (and/or) High Revenue parts but, for the REMAINDER CELL of machines in the department which must run the rest of the parts, deploy SMED, group tooling, etc. quick response strategies

(H&W, Irani) Operate the Monument as a Service Center

(H&W) Launch an aggressive Setup Reduction program (SMED)

Exploit/Elevate the (Capacity) constraint!

Group schedule to exploit common setups

Create a var vs. Features vs. Tools tri-modal matrix analysis using PFAST could connect the production plan and WP-in. One at the Monument and shopfloor status/location of all active orders

In-process gauging & control

Vision Sensors

Six Sigma

Die Design

© Shahrksh A. Irani, Christine Djunaedi and Lily Susanto

Prevent any Part From Ever Exiting Its Cell - II
Let’s Talk Strategy

Pursuing Continuous Improvement with Group Technology
Create a GT Database for Entire Product Mix

<table>
<thead>
<tr>
<th>Digit 1</th>
<th>Digit 2</th>
<th>Digit 3</th>
<th>Digit 4</th>
<th>Digit 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part Class</td>
<td>External shape, external shape elements</td>
<td>Internal shape, internal shape elements</td>
<td>Plane surface machining</td>
<td>Auxiliary holes and gear teeth</td>
</tr>
<tr>
<td>L/D ≤ 0.5</td>
<td>Smooth, no shape elements</td>
<td>No hole, no breakthrough</td>
<td>No surface machining</td>
<td>No auxiliary hole</td>
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<td>Surface plane and/or curved in one direction, external</td>
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<tr>
<td>L/D ≥ 3</td>
<td>Thread or functional groove</td>
<td>No shape elements</td>
<td>Thread</td>
<td>Axial on pitch circle diameter</td>
</tr>
<tr>
<td>With deviation L/D ≤ 2</td>
<td>Stepped to both ends</td>
<td>No hole, no breakthrough</td>
<td>Thread</td>
<td>Radial, not on pitch circle diameter</td>
</tr>
<tr>
<td></td>
<td>Functional groove</td>
<td>Smooth, or stepped to one end</td>
<td>External plane surface related by graduation around the circle</td>
<td>Axial and/or radial and/or other directions</td>
</tr>
<tr>
<td></td>
<td>Functional groove</td>
<td>No shape elements</td>
<td>External groove and/or slot</td>
<td>Axial and/or radial on PCD and/or other directions</td>
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<tr>
<td></td>
<td></td>
<td>Stepped to both ends</td>
<td>External spline</td>
<td></td>
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</table>

Position of digit | Characteristic digit represents
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First | Length to diameter less than or equal to 0.5
Second | External shape smooth with no shape elements
Third | Internal shape smooth with no shape elements
Fourth | Plane, external surface machining
Fifth | Contains no auxiliary holes
Example of a GT Application

Reduce proliferation of similar parts!
Within each part family, establish guidelines/rules to standardize planning and decision-making to produce any part in the family:
• CAD drawing templates
• CNC program templates
• Setup videos
• “Capable To Produce” tolerances, surface finishes, design features, special shape features, materials selection, feeds and speeds, etc.
Other Applications of the GT Database

- Speed up retrieval and improve organization of CAD drawings, CNC programs, etc.
- Generate rules to standardize design and manufacturing decisions
- Develop pre-set templates for job quotation, process planning, machine setup, cutting time estimation, etc.
- Provide a visual data-driven approach to plan company growth and business expansion into new markets
- Use knowledge of part families to prevent growth in unnecessary variety of tools, fixtures, material sizes, etc.
- Provide machine operators guidelines to determine job sequences on their machines to minimize setup changeover times
- Match the capabilities of robots, flexible automation, etc. using the design and manufacturing parameters of specific part families
- Populate ERP databases with standard data generated using sample data collected for each part family
- Develop cross-training programs for the supervisor and employees in each cell based on the complexity levels of the parts it must produce
- Establish norms and guidelines for tolerances, dimensions, surface finishes, process parameters, etc. used in different departments
THANK YOU!