Machining

The Seven Requirements for Optimized Machining

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Today's demand for quality products at a lower cost requires all of us to look more closely at our manufacturing operations. Optimizing our manufacturing process is not just a good goal, it's a requirement for our futures. Optimized machining is not achieved by following a set of fixed parameters, but by following principles. These principles are termed "The Seven Requirements For Optimized Machining". All seven are required to achieve and maintain optimized machining conditions. They can also be used to evaluate current operations, and to review optimized operations to ensure continual success.

Each one of these requirements is necessary for the success of any optimized machining application.

1. QUALITY TOOLING

These are requirements for a quality tool:

- **Reasonable Price.** The most expensive is not necessarily the highest quality.
- **Product Consistency.** Optimized machining requires a consistent tool.
- **Product Service.** The best tool in the world is not worth anything if the manufacturer can't support you.
- **Specially Designed Tooling.** Special tooling designed to fit the application can yield a multiple increase in productivity levels and a lower cost per part.

2. PROPER MACHINE CONDITION

The success of any machining operation depends on proper machine maintenance and matching machine capabilities to the operation.

- **Maintain the machine to original operating specifications. Determine the machine's capabilities.**
  - Set up a maintenance program and maintain on a regular basis.
  - If it breaks, fix it the right way, the first time.
  - Better yet, fix it before it breaks.
- **Match the machine to operational requirements. Utilize the machine's best characteristics.**

    - Rigid machines should be used for the heavy machining operations.
    - Fast machines should be used for light matching of multiple operations.
    - Make sure machine has the physical capabilities for the job. (i.e. HP)

3. SIMPLICITY OF OPERATION

There is no substitute for simplicity. It only makes optimization easier.

- **Simplify your operation set up. Optimized machining includes setup time.**
    - Standardize setup or setup procedures.
    - Make sure setup meets operational requirements. (i.e. rigidity)
- **Use common sense and simplicity to organize the sequence of operations. Create better flow.**
    - Don't chase your tail around the shop.
    - Product consistency can be maintained better with simplified operations.
    - Break up multiple operations if necessary. This may also improve through-put.
- **Don't sacrifice any of the other requirements. You will lose more than you gain.**

4. RIGIDITY

Tool life, cycle times, and product through-put can't be optimized without rigidity.

- **Machine rigidity (evaluate capability)**
    - Make sure the machine has the proper rigidity for the operation.
    - Anti-backlash required on axis feeds for climb machining. (best tool life)
- **Part piece and setup rigidity (evaluate best configuration)**
    - Evaluate part configuration and machining orientation.
    - Design setup for maximum rigidity. Reduce the number of operations if necessary.
- **Tooling system rigidity (evaluate for maximum rigidity)**
    - Use the largest diameter and the shortest length of tool possible.
    - Use a tool holding system designed for rigidity and the shortest overhang allowed.

5. PROPER SPEED TO FEED RELATIONSHIP

Metal removal rates can't be optimized if the proper speed to feed relationship is not achieved.

Speed to Feed Relationships:

- **Relationship too far apart (poor tool life)**
    - Speed too high and feed too low causes high frictional heat and rapid edge wear.
    - Adjust by bringing speed down first; increasing feed may cause tool to break if speed is too high and out of proportion for application.
- **Relationship too close together (catastrophic failure)**
    - Feed too heavy for tool structure and causes tool to shatter, possibly damaging part piece and tool holding system.
    - Adjust by bringing feed down first, in case speed is also too high.
- **Determining proper relationship (work with application)**
    - Start with a moderate speed for given application. You can't work with relationship if speed is too high on first pass.
    - Start with medium feed and work up until machining conditions indicate relationship getting too close together (chattering), then back off 10% to 20% on feed. (this established optimum feed)

    - Increase speed and feed proportionately upward 10% to 20% at a time, until machining conditions indicate you have reached the upper limit for the application. (chattering, poor part finish, excessive vibrations)
    - Reduce speed and feed proportionately downward by 20%. (established optimized machining rates with safety factor)

6. PROPER CUTTING FLUID

- **Running dry**
    - Causes very poor tool life.
    - Don't ever run dry, unless you have to for safety's sake.
    - If you must run dry, keep speed on the low side (but not too low) and feed on the high side. This keeps frictional heat low and maintains heat in chip formation.
- **Water-based coolant**
    - For heat generating applications, water absorbs heat better than oil.
    - Use in applications where light chip loads are common (i.e. finishing end mills). Light feeds transfer more heat into the cutting tool.
    - Flood systems are much more efficient than mist. Mist systems must be positioned precisely to work properly.
- **Oil-based coolant**
    - For heavy feed applications, oil does not absorb heat very well.
    - Use in heavy feed applications, such as with roughing end mills, where high chip loads are common. Thicker chips absorb heat better but need more lubricant to produce.
    - Chilled high pressure systems work better than flood. Only do this if the machine is enclosed and has a mist extraction system.
- **Natural vegetable oil lubricant**
    - For heavy feed applications only, not a coolant.
    - Can be used as a replacement for oil based coolant applications. It typically has a lubricity level 3 times that of oil based coolant, and is biodegradable.
    - Mist system is all that is typically required, otherwise it very expensive.

7. OPERATOR TRAINING

Operator training is essential in achieving and maintaining optimized machine applications.

- **The operator must be a direct part of the optimization attempt for it to succeed. He or she is the one who has to maintain it from now on.**
    - Draw on the operator's experience. No one knows their machine better.
    - Take the operator's advice on machine capability and required machine maintenance requirements. This will help you a lot in the early stages.
    - If they own it, they will take care of it. They'll keep it going when you're not around.
- **The operator must know the differences between what they have been doing for years, and an optimized application, and how it reacts to changes. Machining conditions at elevated speeds and feeds react differently than those at lower speed and feed ranges.**
    - They must clearly know how the operation functions and reacts. (sound and feel)
    - They must also know how to adjust the application properly if something changes. Nothing is ever 100% absolutely the same.
- **You must also train them, and yourself, to work together to achieve this common goal.**
    - If you can't work together and trust each other, the operation will definitely fail, and everyone loses.
    - To err is human, grow from your mistakes.
    - A lack of proper training—or no training—is unprofitable and bad business.

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