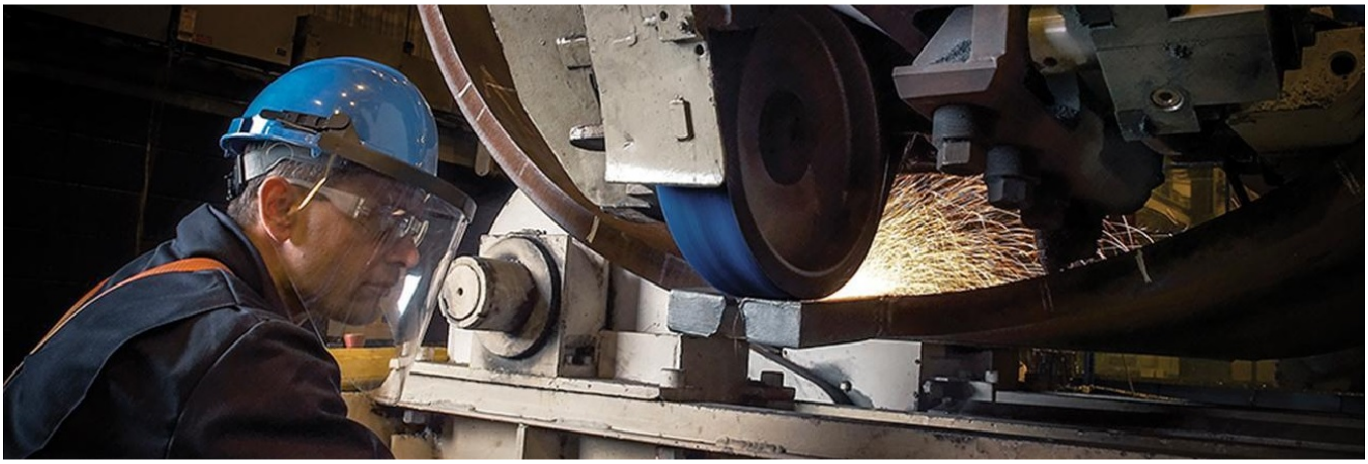

Machining

Removing Roadblocks to Optimizing Newly Installed Grinding Processes

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Generally new high volume lines producing complex parts that include grinding processes, such as automotive engine or aero engine blade and vane, proceed through various stages from machine procurement to actual production as outlined in Figure #1. If these lines include a process considered "*high risk*" it will be scheduled with "development time" as part of the grinder capability evaluation and purchase (steps 4 and 5) by testing and refinement. This is an effective strategy and substantially reduces problems associated with program launch but can be time consuming and expensive; very often workpiece samples may not even be available or are prototypes subject to further design change. In such cases or for component designs that are different, *but* ***not*** *radically different* from existing designs, "optimization time" is rarely scheduled prior to the actual machine qualification.

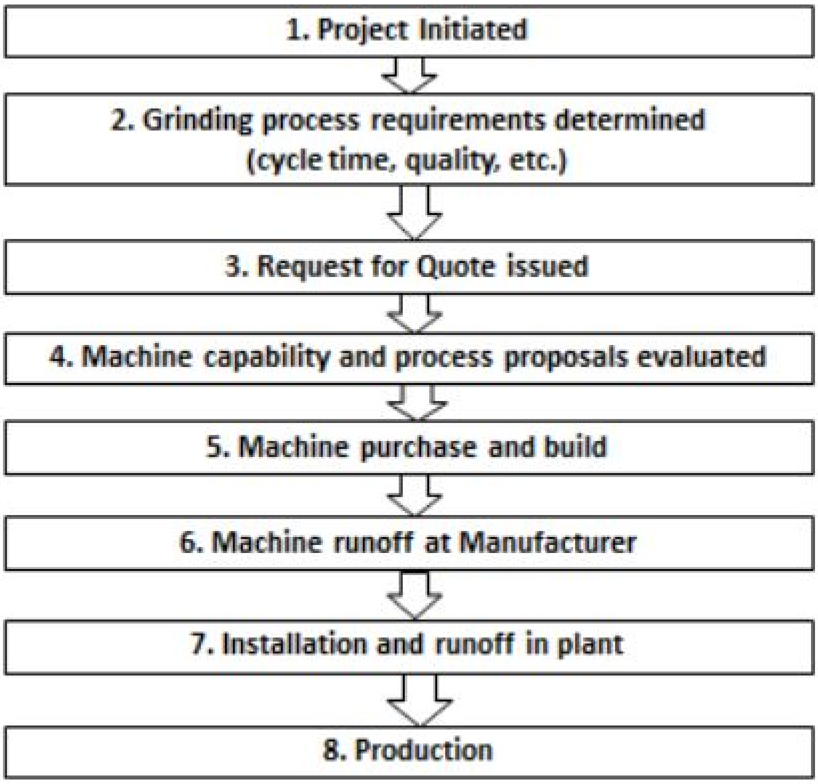

Figure #1 Typical production grinding process implementation

When machines are qualified and installed with "*non-radical*" processes, focus is on part quality and cycle time. Wheel specifications may well be selected to ensure the highest quality amid uncertainties of the new part design and their impact on holding part tolerances to often more stringent CpK specifications than required for production. Additionally, due to cost or availability, often only 50 or 100 parts are provided for qualification making the establishment of a long term stable process questionable. There is typically not a lot of time, or components, to optimize the tooling or abrasive cost per part. After installation, in a lot of cases, an "if it ain't broke, don't fix it" attitude takes over and processes get locked in. Optimization is seldom attempted.

It is therefore very important that the "extra step" of optimization be considered as a final "audit" of the process.   Most of the time this step could be simply a process "tune-up" so that requalification of the entire process is not needed, but occasionally large enough opportunities may be uncovered, that would warrant major changes to the cycle and/or wheel specification. Cost/benefit analysis would be performed to determine if a more substantial process change should be done.

There are several reasons why lack of "optimization time" can cause sub-optimal processes:

- Cycles can function acceptably in the machine but not be 'wheel friendly'. i.e. wheel life may be less than optimal
- Wheel technology evolves. Estimates made on existing technology may not be optimal for new technology
- Subtle variations in part configuration, machine design and quality requirements make process optimization very difficult outside the production line. This is because the production line provides lots of parts and an environment with real variations and metrology. These two qualities provide a test for "robustness" of the "optimized" process.

Examples:

The Grinding cycle pictured in Figure #2 was shipped from the OEM installed in a plant and is currently in production. This cycle works fine and produces acceptable parts, but it is not “wheel friendly”.

Wheel “unfriendliness” of this cycle is due to the large spike(power/force) at the beginning of the cycle. Wheel wear is proportional to the square of the grinding force, high forces will cause the wheel to wear quickly. In this case reducing Fast Feed and increasing Medium feed would extend wheel life while maintaining cycle time and part quality.

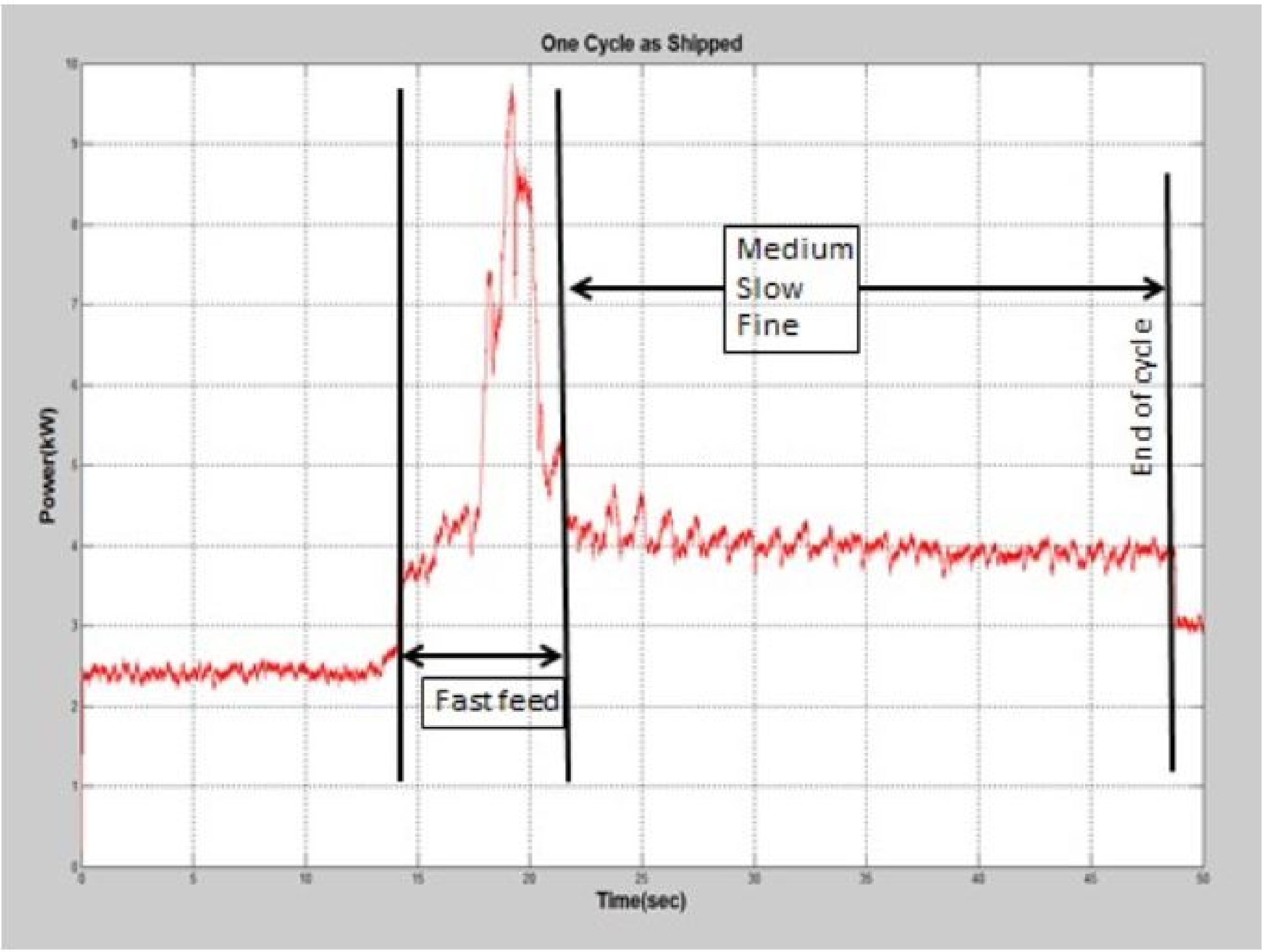

Figure #2 Non-optimized cycle

A Cycle in the Process of Optimization

In a recent unusual case the manufacturer agreed to do “in situ” optimization of the grinding process. Initially the grinding cycle was changed to make it more “wheel friendly” as discussed above. In this case the friendlier cycle was also ~5 sec shorter than the initial cycle.

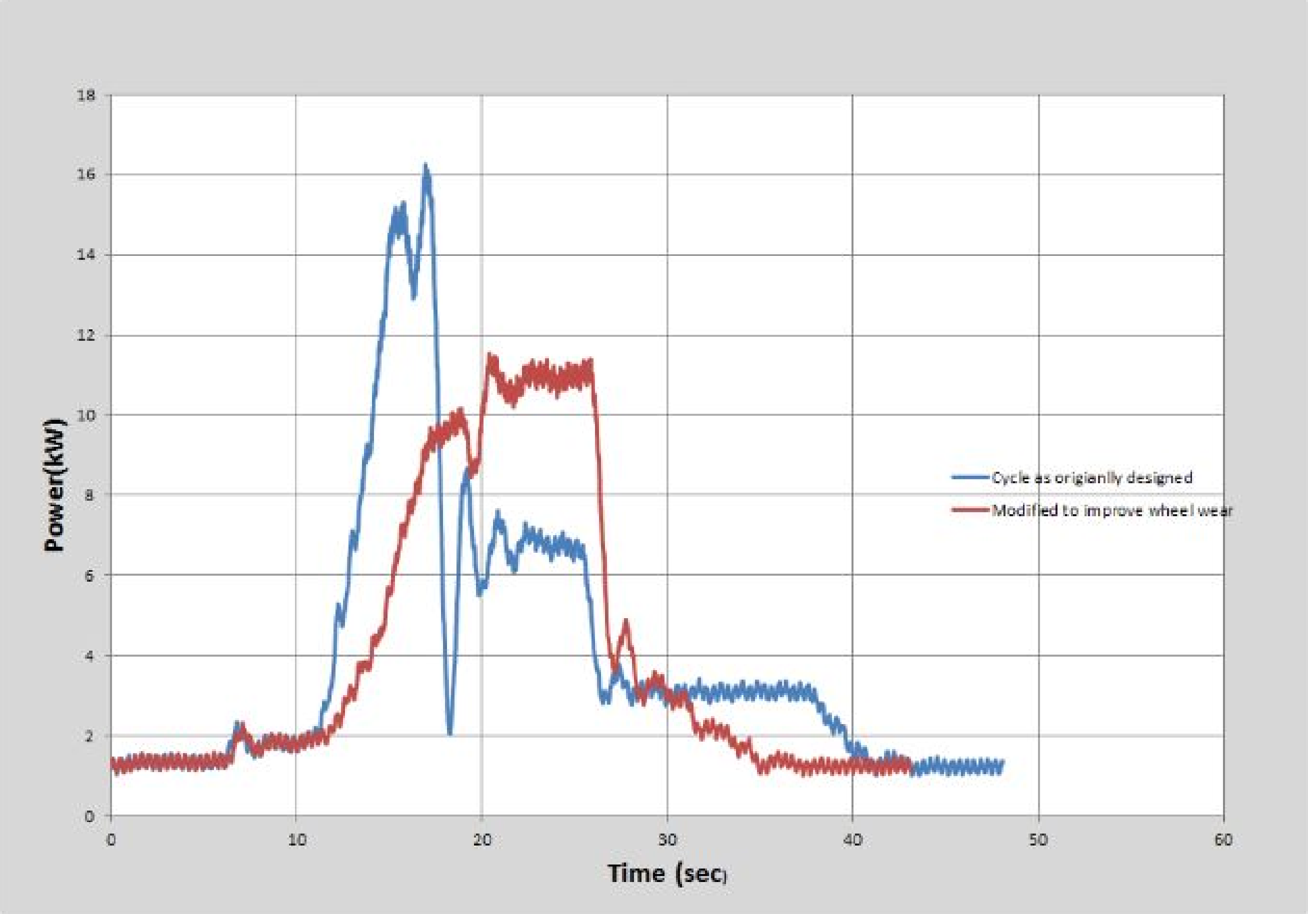

Figure #3 Cycle modified to improve wheel wear and shorten cycle

After the modified cycle had been run for several weeks to validate continued part quality, the parts per dress was increased from 8 to 20 and the depth of dress was reduced from 0.03 mm to 0.02mm. This process has now been running about 6 weeks without significant change in part quality. Summary of the cost savings per annum is shown below.

Summary	As Shipped	Optimized	Benefit	
Wheel cost/annum	$36,666.19	$8,444.32	$23,221.88	wheel $
Machining cost/annum	$184,875.00	$171,150.00	$13,725.00	machine $
Wheel change cost/annum	$1,022.73	$272.73	$750.00	change $
Dresser change cost/annum	$120.00	$120.00	$0.00	dressing $
Dresser cost/annum	$1,423.00	$1,423.00	$0.00	dresser $
Cost of scrap	$0.00	$0.00	$0.00	scrap $
Components/wheel (max.)	42,240	158,400	116,160	parts/wheel
Total Costs	$219,107.00	$181,410	$37,697	Total Costs
Costs/Component	$1.217	$1.008	$0.21	$/component

Strategy for Optimization

The solution, as illustrated in the second example, is to schedule time and parts in the early stages of production (between steps 7 and 8 in Figure #1) to work on process optimization with the machine builder and the tooling/abrasives Application Engineering team. At the very least power monitoring equipment should be used during this phase to assist in cycle evaluation and development. With this additional step the process can be monitored for stability on longer part runs which can bring problems to light and/or present opportunities for improvements.

The potential payoff from this step is large, since improvements/cost saving made at this stage will be in place through the entire project life cycle.

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