Topics covered in *The Grinding Doc*'s three-day *High Intensity Grinding Course*

Day 1: Morning – introduction • how to get the most out of the course • how to use *The Book of Grinding* • Dr. Badger's background • introduction of attendees, type of grinding they're doing, issues they're facing • abrasive types, hardness • grit/workpiece chemical reactions • chip-formation in grinding • cutting, rubbing & plowing contact mechanisms • wheel wear types, how they affect cutting, rubbing & plowing • fundamental calculation: calculating surface speed from RPM & diameter, calculating RPM from surface speed & diameter, using *The Grinder's Toolbox* • milling-cutter analogy for chip thickness: how changing wheel speed, feedrates & depths of cut affect wheel wear & burn risk • wheel grade or "hardness" • relationship between normal & tangential force & grinding power • heat generation & power • wear flats • reading a conventional-wheel specification • angular/blocky, tough/friable, micro/microfracture of grits, when to use which grit • wheel structure & porosity, when porous wheels help, when they hurt • grit size & surface finish, the biggest cause of grinding burn & chatter • The Grinder's Mantra: big-&-dull bad, small-&-sharp good • grinding power & *The Grindometer* • fundamental calculation: Q' in surface grinding, in cylindrical grinding • Group Exercise: calculating Q', choosing a good Q' & applying it across all production • using *The Grinder's Toolbox* to calculate Q' • specific energy, what it means, how to use it • wheel wear: break-in, steady wear & wheel collapse • The *No-Dress Test*, using it to evaluate wheels, optimize cycles.

Day 1: Afternoon – diamond dressing, stationary dressing • different types of dressers • effect of depth, why typically not a problem • effect of traverse speed, why most important parameter • fundamental calculation: dressing overlap ratio • how overlap ratio affects wheel sharpness & burn • diamond wear, how this changes, how it affects overlap ratio and burn & chatter risk • Group Exercise: calculating Overlap Ratio for increasing diamond-flat size, how it affects burn risk • rotary dressing • uni-directional vs. anti-direction, sharp & dull • rotary plunge roll, calculating effective depth, dwell, how this affects sharpness, using *The Grinder's Toolbox* to quantify dressing sharpness • traverse disc dressing • RPM ratios & "integer values", how this causes wheel "eggyness" • Introduction to Aggressiveness • Group Discussion: How to quantify multiple changing parameters.

Day 2: Morning – Aggressiveness defined, how it's different from equivalent chip thickness & grit penetration depth • using aggressiveness it to increase feedrates, reduce burn, reduce wheel wear, find the "sweet spot" of the wheel • Using *The Grinder's Toolbox* to calculate aggressiveness • keeping the same aggressiveness to reduce set-up time • Group Exercise: calculating Q' & aggressiveness, keeping the same aggressiveness, increasing feedrate for same aggressiveness • cooling • the hot-spot in cooling • pressure, velocity, flowrate in cooling • Cooling Rule 1: V-coolant = V-wheel • The bucket-&-stopwatch technique for calculating velocity • Group Exercise: Calculating coolant velocity & pressure • Cooling Rule 2: aim at interface • partition ratio & arc length, when good cooling is needed, when it's not, when good cooling can actually cause problems • nozzle options: Dr. Cool Rouse/Webster-style, Grindaix needle-nose, SwivelJet, crimped-down copper tubes – when to outsource, when to build yourself • cooling for genuine thermal damage vs. oxidation burn • film-boiling "burnout" • using *The Grinder's Toolbox* to calculate cooling parameters • hydroplaning in cooling, the hidden cause of chatter, deflection, taper, barreling, difficulties holding size, how to handle it • scrapers, false nips & shoe nozzles: do they work? • cleaning nozzles: why they are usually worthless, how to design them correctly.

Day 2: Afternoon – superabrasives, definition, chemical reactions, why diamond doesn't like iron, why CBN doesn't like water • coatings/claddings • reading a superabrasive-wheel specification • concentration, when to choose high, low • grit size & surface finish, common mistakes • CBN on steel & nickel alloys, how they work, getting the wheel to "open up" quickly, then slowly • Group Discussion: choosing CBN parameters to avoid the early burn period • tungsten-carbide/cobalt "hard metal" • the ooze layer • loading in carbide grinding, how to cope • cleaning nozzles to reduce loading, why they usually don't work • sticking to reduce loading • sticking speed, sticking aggressiveness • sticking grit size • truing of diamond wheels with SiC & alumina, which grit size to use, which parameters • hybrid-bond wheels, when to use, how to use • Paradigm wheel, when to use, how to use • electroplated wheels • extending life of electroplated wheels • water-based coolants & CBN, why so much trouble? • grinding of ceramics, fundamental contact mechanisms, how different • depth of damaged layer.

Day 3: Morning – loading, types, causes, in "soft" materials, in "hard" materials, ways to reduce loading, the "coolant quench effect" • burr, causes, how to reduce, dummy workpiece • up-grinding vs. down-grinding, is there a difference, cooling in up- vs. down-grinding • reducing cycle times, cycle mapping, "low hanging fruit", where not to waste your energies • chatter: forced vs. self-excited • determining root cause from chatter spacing • out-of-balance & out-of-true chatter • snakeskin chatter, cause of • bouncy-diamond fishscale chatter, cause of • resonant frequencies, avoiding, frequency response function • why you should dress & grind at same RPM • wavelength obliteration • Group Exercise: determine source of chatter from number of chatter marks • thermal damage & "grinding burn" • different types: oxidation burn, thermal softening, residual tensile stresses, rehardending "white layer" burn • the biggest cause of burn: big-&-dull • testing for burn: nital etching, Barkhausen, x-ray diffraction, hardness testing • the danger of thinking "no cracks = no burn" • the danger of thinking "no discoloration = no burn" • material "sensitivity" & the risk of thermal damage.

Day 3: Afternoon – "ceramic abrasives": how they work, how to get them to work, Norton SG, Cubitron, Cubitron II tortilla grit, Norton TG spaghetti grit, when it's worth the cost, with which workpiece materials • cylindrical grinding: traverse & plunge • calculations in plunge grinding, in traverse grinding, overlap ratio in traverse, common mistakes in traverse, how to reduce cycle times & reduce burn risk in cylindrical traverse grinding • cup-wheel grinding, taper development • centerless grinding, choosing formulas, getting height-above center, swivel angle, dressing angle & dressing offset correct • Group Exercise: choosing cylindrical parameters wisely • using The Grinder's Toolbox for cylindrical grinding • avoiding RPM-ratio "integer values", the cause of waviness • 30-degree swivel, using *The Grinder's Toolbox* • face-grinding, pain-&-suffering in face grinding, how to cope, sidewall relieving • barber-pole thread-pattern in traverse grinding, cause, how to eliminate it • barreling, taper, bell-mouth, deflection, thermal expansion, causes • inner-diameter ID grinding, challenges, cooling in, hydroplaning as cause of taper, bell-mouth • new developments in grinding, in grinding machines, in abrasives, when they're worth the effort, when they're not • closing, creation of a game-plan.

[1]Note that time and day where particular topics are presented may shift slightly.
[2]At the end of the course, each attendee will receive a framed, personalized diploma.
[3]All of *The Grinding Doc*'s courses center around the 4000-page ***Book of Grinding***. Each attendee receives a copy of ***The Book of Grinding*** and ***The Grinder's Toolbox***.