Topics covered in *The Grinding Doc*'s three-day *High Intensity Grinding Course* – *Tungsten-Carbide Focus*

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 wheel specification • angular/blocky, tough/friable, micro/microfracture of grits, when to use which grit • why diamond doesn't like iron, steel/carbide combinations • coatings/claddings • reading a superabrasive-wheel specification • concentration, when to choose high, low, edge-holding • wheel structure & porosity, when porous wheels help, when they hurt • grit size & surface finish • 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 – 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 • grinding of tungsten-carbide/cobalt "hard metal": how it's different to "soft" materials • the ooze layer, how it affects adherence of coatings • loading in carbide grinding, how to cope • choosing parameters to get a "self-sharpening wheel" to minimize sticking • cleaning nozzles to reduce loading, why they usually don't work, how to design them correctly • sticking to reduce loading • sticking speed, sticking aggressiveness • Group Exercise: calculating sticking velocities with auto-stickers, hand-held stickers • 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 • grinding of cermets: a quick introduction.

Day 2: Morning – 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?

Day 2: Afternoon – On a tool grinder: evaluating the process • Cycle mapping with the power signal • evaluating wheels with the *No-Dress Test* • Increasing feedrates while keeping the aggressiveness constant.

Day 3: Morning – Group Exercise: discussion of shop-floor results • 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" • oxidation burn • cooling just for oxidation burn.

Day 3: Afternoon – wheel balancing, results of Vollmer/Grinding-Doc collaboration • 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 • Group Exercise: choosing cylindrical-traverse parameters • cup-wheel grinding, taper development • centerless grinding, choosing formulas, getting height-above center, swivel angle, dressing angle & dressing offset correct • Group Exercise: choosing cup-wheel parameters, break-in period, taper period • 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 • peel grinding & pinch/peel grinding • 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***.