



Measuring Chatter

with NOVACAM™ Non-Contact 3D Metrology Systems

Keywords: chatter on cylinders or cones forms, contact bounce, machining vibrations, tube inside or outside diameter (ID or OD) chatter, undulations per revolution (UPR), spiralling, lobing, tool wear, ID surface and dimensional defects, drilling, milling, or grinding chatter, shafts, cylinder gears, threads, rack & pinion, piston pin, sealing surface, non-destructive testing (NDT), non-contact measurement

Introduction

Chatter is a type of defect that can seriously affect the functionality, efficacy, and longevity of machine parts. For example:

- Chatter on spinning parts such as automatic transmission clutch shafts creates noise and causes premature damage to bearings, often resulting in failure and recalls
- Chatter on sealing surfaces affects the quality of the seal, causing liquid leakage
- OD or ID chatter induced by machining tools such as centerless grinders reduces surface quality, causes unacceptable inaccuracy, and ultimately leads to costly production losses.

Chatter waves (lobes) are typically created by vibrations between a machining tool and a part during manufacture or finishing. On both cylindrical and conical surfaces, chatter can be hard to measure, particularly in a non-contact manner, and especially when inside a bore.

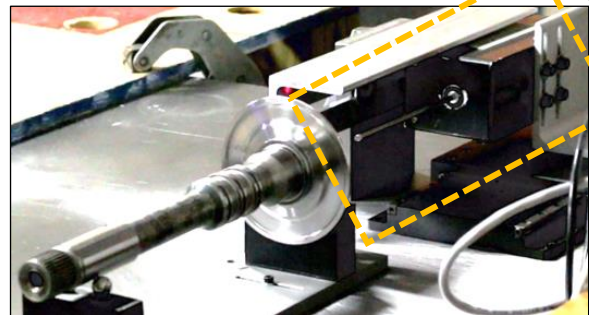
NOVACAM 3D metrology systems measure chatter both on the inside and outside of components. They do so with micron precision, in a highly efficient and non-contact manner, and, if required, right on the manufacture floor as part of an automated inspection station.

Inside Diameter (ID) Chatter

Chatter on the ID can be measured with two of NOVACAM non-contact 3D metrology systems:

- **TUBEINSPECT™ system** reaches with a small-diameter probe into bores or tubes that are fixed in a chuck or collet on a rotational stage
- **BOREINSPECT™ system** reaches inside bores with a rotational small-diameter probe.

Both systems use side-looking probes to scan the ID in a point-by-point manner in a circular or spiral pattern, as set by the operator. The systems obtain micron-precision 3D topography measurements at up to 100,000 points per second. The acquired 3D point cloud is processed, chatter is calculated, and automatic feedback provided to the machining or sorting process and/or to the operator.



BOREINSPECT
rotational
scanner (RS)
probe

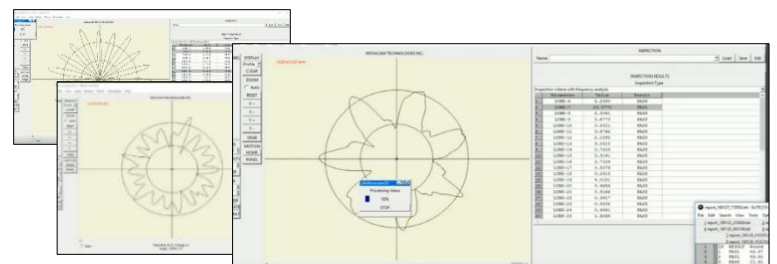


Figure 1: (top) The BOREINSPECT rotational scanner (RS) probe ready to enter and measure ID chatter inside a hollow automatic transmission clutch shaft. (below) Visualization and automated PASS/FAIL analysis of ID chatter measurements as carried out with NOVACAM Chatter Analysis Software.

ID of CYLINDRICAL bores

When ID chatter of automotive or aerospace engine components exceeds acceptable limits, both efficiency and safety are at stake. The BOREINSPECT system recently measured chatter inside thousands of automatic transmission clutch shafts to identify those exhibiting out-of-spec ID lobing. While troubleshooting an intermittent problem on the manufacture line, the manufacturer still needed to fulfill a large order, so 100% part inspection with focus on chatter measurement was required.

To this end, a highly efficient chatter gauge was quickly constructed (Figures 1-3), combining NOVACAM BOREINSPECT system for measurement, Universal robot UR5 and Robotiq gripper for part loading and sorting, and NOVACAM Chatter Analysis Software for data analysis and categorization of parts as PASS or FAIL as per user criteria.

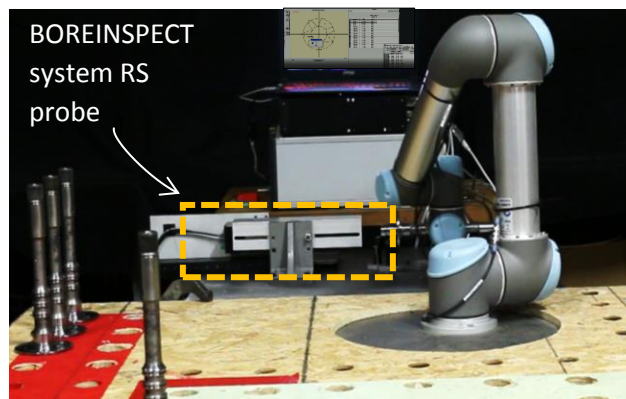


Figure 2: As part of an automated ID chatter measurement gauge, a robot feeds parts to be measured to the RS probe.

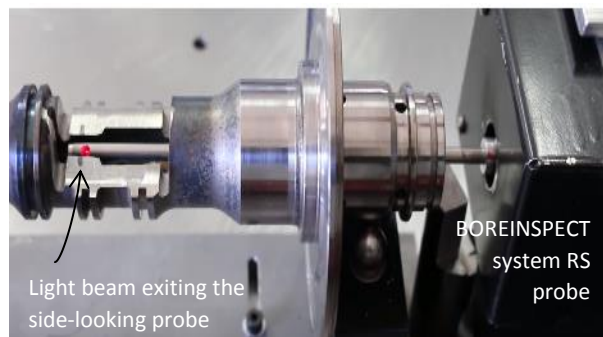


Figure 3: The light beam of a BOREINSPECT system rotational scanner RS2 probe traces the ID of a hollow shaft

Over four weeks, the gauge measured 16,000 shafts to determine which of these, if any, met the high quality required. With the gauge,

- Shaft ID measurement and chatter analysis were fully automated
- 45 second inspection cycle time was achieved (~20 seconds for measurement, the rest for robot work)
- 65% of shafts whose ID characteristics were analyzed as acceptable were salvaged from otherwise throwaway stock
- Downtime of a downstream major automotive production line was avoided.

ID of CONICAL bores

Chatter inside conical bores can be measured with the BOREINSPECT or TUBEINSPECT system and sometimes also with NOVACAM SURFACEINSPECT™ system, which scans surfaces in a raster manner as shown in Figure 4.

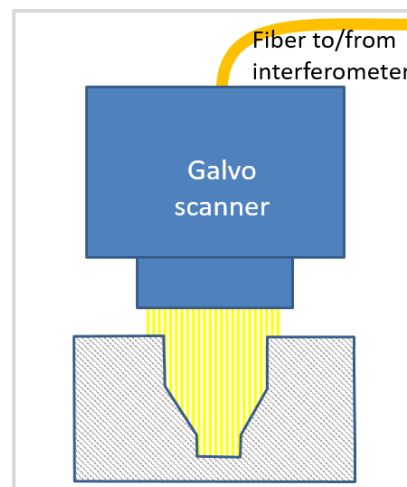


Figure 4: Using a galvo scanner as optical sensor, the system can measure ID conical surfaces from above.

Outside Diameter (OD) Chatter

CYLINDRICAL and CONICAL ODs

The manufacture quality of diesel fuel injector nozzles and nozzle needles (Figure 5) is critical to the performance and emissions of today's diesel engines. One aspect of nozzle quality is the fit of the needle within the nozzle, i.e., the interface between the needle seat and the nozzle seat, as shown in Figure 6.

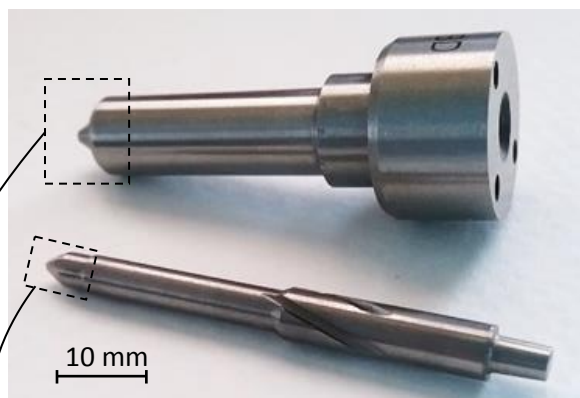


Figure 5: Common rail fuel injector nozzle and needle

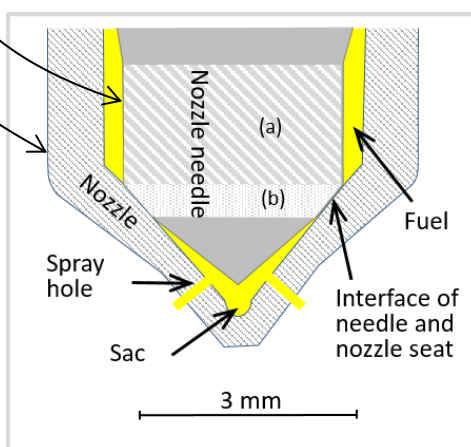


Figure 6: A tight seal between a fuel injector nozzle and nozzle needle tip ensures adequate pressure on the fuel towards the spray holes. The needle tip features both a cylindrical (a) and a conical (b) section.

The needle tip of the above injector nozzle was measured with TUBEINSPECT system. In the acquired 3D point cloud data, chatter marks (undulations) are visible and have been measured on both on the cylindrical and conical sections of needle tip (Figures 7 and 8).

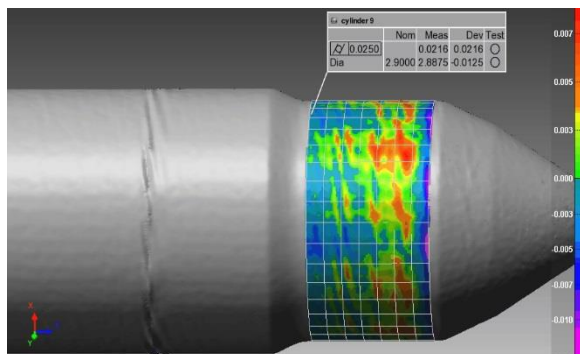


Figure 7: Chatter marks on the cylindrical section of the nozzle needle (viewed with InnovMetric PolyWork®s Inspector software)

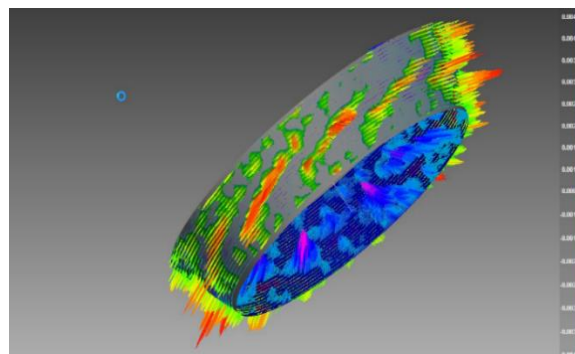


Figure 8: Chatter marks on the conical section of the nozzle needle (viewed with PolyWorks Inspector™)

Process improvement through continuous monitoring

Chatter induced on parts by high-volume machining tools such as centreless grinders can cause major workpiece quality issues and production losses. NOVACAM metrology systems offer a reliable approach for early detection of chatter phenomenon onset. With automated non-contact inspection of parts right after machining, out-of-spec chatter is detected early and process parameters can be adjusted quickly, before product quality deteriorates.

Technology

NOVACAM systems are based on low-coherence interferometry. Their non-contact probe directs a beam of light on the surface. Reflected signal is sent through an optical fiber to an interferometer for processing. The acquired 3D point cloud data provides a basis for PC-based software to calculate chatter parameters and/or other required surface measurements: GD&T parameters (dimensions, cylindricity, circularity, etc.), roughness, defects, or coating thickness.

Chatter analysis software

NOVACAM Chatter Analysis Software is available to analyze measurement data and categorize parts as PASS or FAIL as per user criteria. Interactive viewing and analysis of the acquired 3D data is done with PC-based metrology software (PolyWorks® Inspector). Views such as deviation maps (e.g., Figures 7 and 8) provide key insight into machining processes.

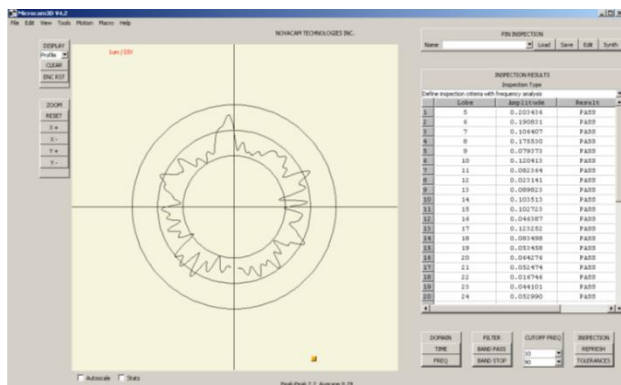


Figure 9: Chatter measurement visualization and analysis. For each listed lobe, values such as the amplitude or RMS value and PASS/Fail category can be reported.

Automation and shop-floor ready

Automated ID or OD chatter inspection is supported by:

- System capabilities such as datum alignment, automated pass/fail reporting, and exportable reports
- Ability to interface with data loggers, enabling trend analysis with SPC software
- Fiber-based nature of NOVACAM sensors that can be mounted on a variety of precision stages or robot arms for

integration in automated plant-floor inspection stations

- System resistance to air perturbation, ambient lighting, and to cutting of the beam
- Ability to function in harsh environments – e.g., radioactive, very hot, or cryogenic.

Additional chatter measurements

NOVACAM 3D metrology systems also measure chatter on IDs of connecting rod bearings, piston pin bores, gudgeon and wrist pins, bushings, valve seats and actuators. OD chatter has been measured on turbine and compressor shafts, crankshaft rod journals, camshaft bearings, and ball screw threads used in automotive power steering.

Conclusion

With NOVACAM 3D metrology systems, chatter measurements are fast, precise, automatable, and easy to interpret. Novacam encourages technicians and engineers in charge of quality control to contact us to discuss your particular applications and metrology challenges.

NOVACAM 3D metrology systems for chatter measurement

System name	Type of optical sensor	Chatter measurement
TUBEINSPECT system	Side-looking probe	ID or OD of a part on a rotational stage
BOREINSPECT system	Side-looking rotational probe	ID
SURFACEINSPECT system	Galvo (raster) scanner	ID (of conical surfaces from above) and OD

- All NOVACAM 3D metrology systems include MICROCAM™-3D or 4D interferometer (19" rack-mountable instrument) and a mini desktop-size PC or laptop that hosts NOVACAM data acquisition software and, typically, either NOVACAM or other chatter analysis software
- Watch a short video on chatter measurements with BOREINSPECT system: <https://www.novacam.com/resources/novacam-metrology-videos/chatter-measurement-video/>



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