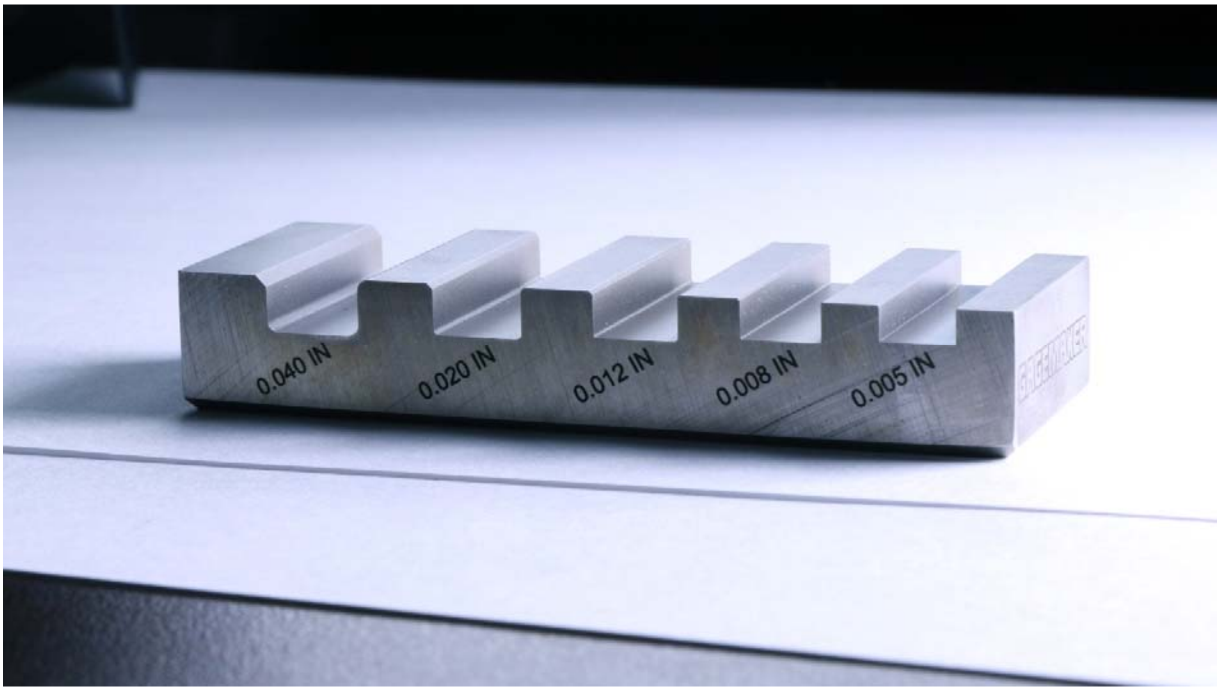
Edge Break Analysis for 3D Optical Metrology

Machined parts commonly have sharp edges and corners that are “broken” for a variety of reasons in a process called edge break--rounding off the sharp corner, creating a rounded edge, or by machining a flat edge transition, creating a chamfer. A machined part may have dozens of edge break call outs. Measuring them is challenging and time-consuming. Quickly, accurately, and conveniently measuring these important callouts speeds up turn-around time and increases confidence in part geometry. Handheld 3D metrology that uses edge break analysis software can bring speedy and precise edge break measurements to the shop floor.

Edge Break Measurement Today

Manufacturers break edges for several reasons: to retain part-longevity and ensure performance, and because sharp edges are a safety concern for those handling the parts. Lack of proper edge breaking can lead to a significant number of workplace injuries. The importance of edge break tolerances for manufacturers leads to part drawings littered with edge break call outs to be measured.



Examples of chamfers and rounded edges on an edge break standard created for edge break analysis. This standard has chamfers as well as internal and external rounded edges of varying size.

Typical radius of curvature (ROC) and chamfer lengths in edge break specifications range from around .002” (50 µm) to .05” (1270 µm). The ROC for rounded edges will ideally be consistent along and across an edge, creating a curved area between the two side planes. Chamfers will typically turn one sharp edge angle (usually a right or an acute angle) into two equal and duller obtuse angles. If you look at a shop floor today, chamfers and radii are being measured with visual tests and stylus-based systems. Visual tests are inherently subjective, depending greatly on the inspector, lighting, and alignment of the visual comparator. Most importantly, a visual test provides no quantifiable data. These methods can be quick and efficient, but they do not provide the data necessary to ensure the part is within specifications.

Perhaps the most common instrument-based systems used for characterizing edge break geometries are 2D profilers, such as styluses or laser-based gauges. Two dimensional measurements of edge break suffer from alignment errors and can be affected by irregularities that may be on the edge. With tactile systems, measurements can take up to 30 minutes because of the need to align precisely. Laser devices are affected by surface finish and do not perform well on reflective materials. With lateral and vertical resolutions of tens of microns, they are not capable of measuring the fine geometries seen for edge break specifications and create uncertainty for any given result.

Moving away from the shop floor, rubber replication materials can be used to make a facsimile of the edge and which can be sent for analysis on an optical comparator or shadowgraph. These replications can then be cross-sectioned so the ROC or chamfer length can be measured. The cross-sections fall victim to alignment errors just as the other 2D measurements do. Making the replicate, cross-sectioning it, and measuring it on an optical comparator can be a time-consuming process.

Handheld 3D Metrology on the Shop Floor

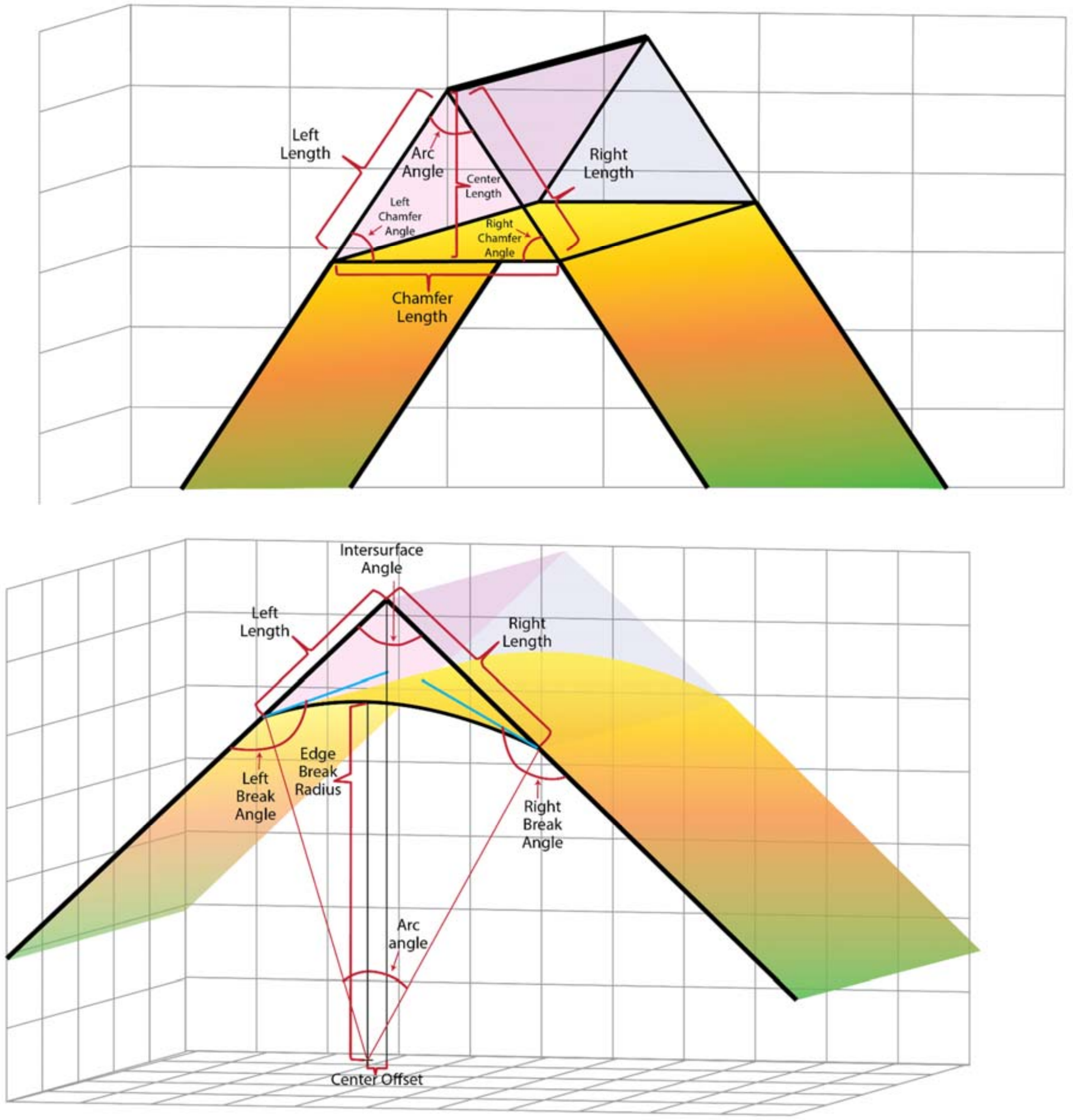
Fringe projection techniques can produce 3D metrology, but most systems rely on multiple cameras—these are easily affected by vibration and therefore not capable of being handheld on the shop floor. To achieve handheld functionality and portability with a fringe projection system while retaining high precision, a method polarized structured light (PSL) can be used. This technique allows 3D measurements to be taken with one camera and one video frame, achieving the vibration immunity and portability needed for shop-floor metrology. With such a gauge, an inspector can take a handheld PSL instrument either handheld, and quickly secure 3D surface maps. Vibration immunity also enables robot arm positioning for fast, automated metrology.

Edge Break Analysis of 3D Measurement

With the ability to acquire 3D surface data, extensive data-processing techniques are needed to analyze edge break measurements. A PSL system, as described here, acquires millions of data points per measurement, and not just along a single trace. This allows any anomalous data to be eliminated. Using software analysis, the data points can then be fit to the planes of the edge's sides. Depending on the edge break's shape, the surface between the sides is fit as a chamfer plane or the best fit cylinder to a rounded edge. With 3-dimensional data, more points allow for more confidence in the lengths that can be mathematically calculated. The data points identified as planes or curved surfaces can be realigned so that all calculations are guaranteed to be exactly perpendicular to the edge. Through this normalization, any alignment errors, such as those that were seen with 2D measurements, are eliminated.

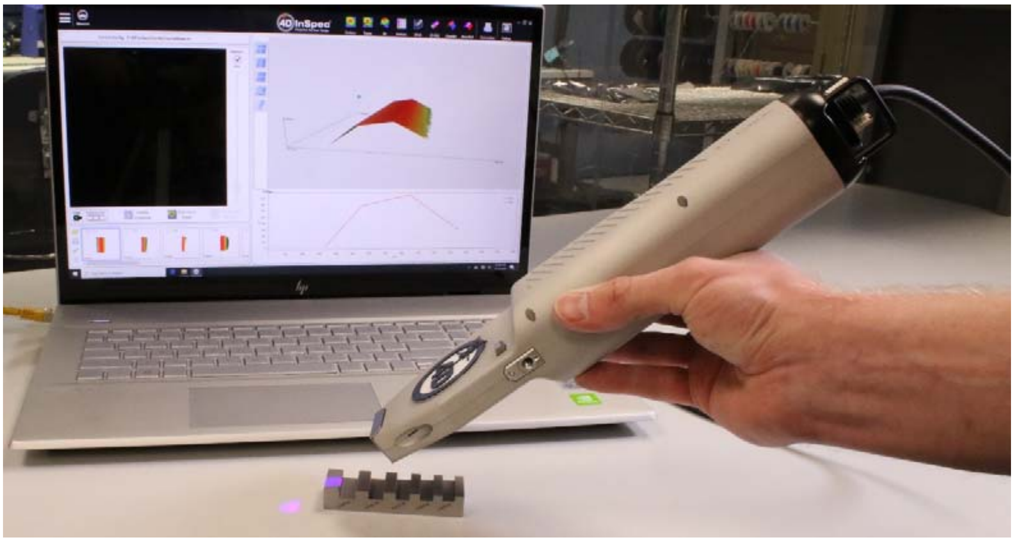
In addition to eliminating any anomalous points and realigning the data, analysis software can extrapolate theoretical distances and geometries of material that was removed from the part. The analysis software can calculate the distance between where a side plane ends and where the two side planes would intersect. Angles between these planes as well as any other parameters desired by manufacturers can be determined in seconds.

Performing measurements this quickly expedites turn-around time for parts being measured. What typically takes minutes, hours, or, if being sent to a lab, days to complete is now almost instantaneous. With micrometer-scale resolution and mathematical analysis of the data, any doubt in measurements disappears. As inspectors err on the side of caution when deciding to scrap a part, having greater confidence in your measurements reduces this doubtful gray-zone. Using a PSL system, an inspector can confidently measure up to the specification limit. Fewer quality parts are thrown out, and yield is increased.

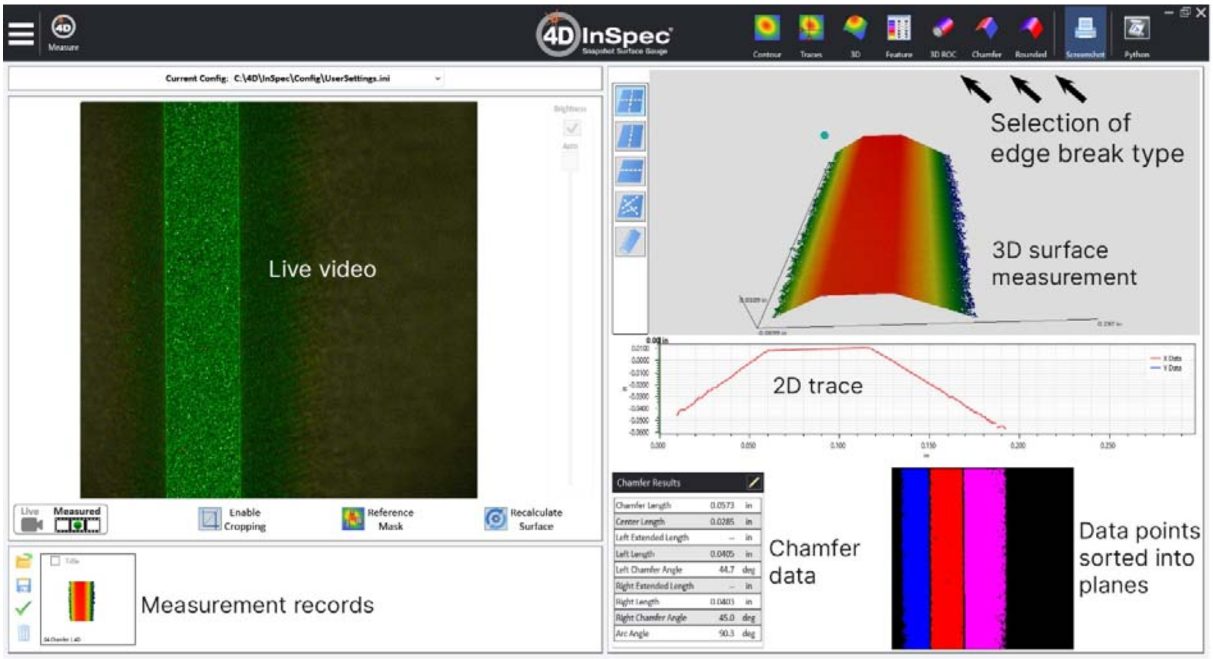


The parameters on a a chamfer (top) and a rounded edge (bottom) that are identified by edge break analysis software, including lengths of material that has been removed.

Edge break measurements have historically been inconvenient and tedious. As performance needs increase, a simple way to measure chamfers and radii is a necessity. A PSL system can take an edge break measurement with the same simplicity as taking a picture of the edge. The software analysis removes any guess work with precision down as far as .002". All parameters that make up edge break geometry are then displayed instantly within the software window.



A handheld PSL system measuring a chamfer on an edge break standard.



Software analysis of a chamfer. The 3-dimensional surface map, calculated chamfer parameters, and data points the software identified as part of the 3 individual planes can be seen.