YIELD AND TENSILE STRENGTH

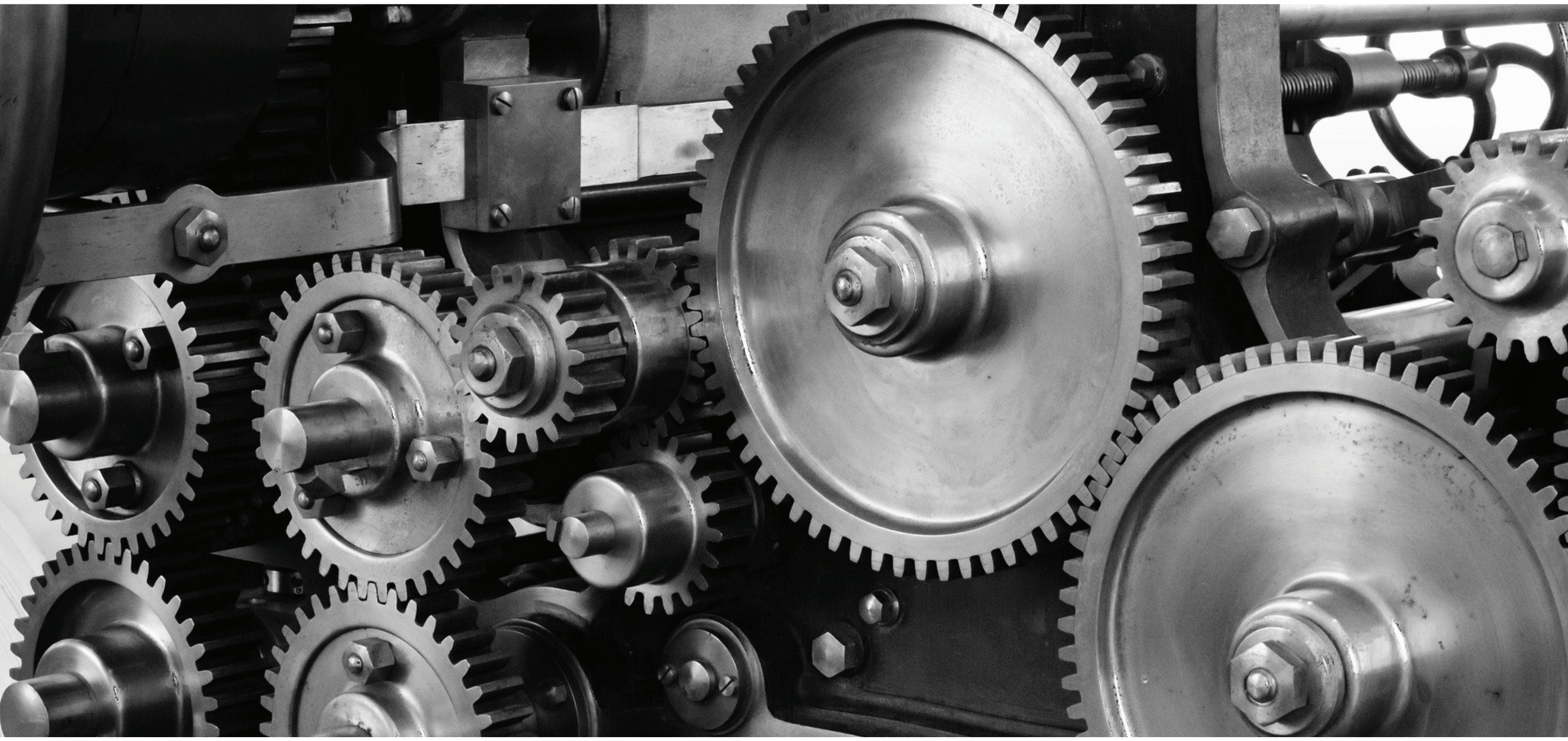
OF

STEEL & ALUMINUM

Prepared by

Duanjie Li, Ph.D, Jonathan Thomas, and Pierre Leroux

NANOVEA.COM
INFO@NANOVEA.COM
EURO@NANOVEA.COM
MEXINFO@NANOVEA.COM



Introduction

Yield strength (YS) is the stress at which a material begins deforming plastically and will not return to its original shape when an applied stress is removed. Ultimate tensile strength (UTS) is the maximum stress a material can withstand before breaking. These two properties indicate the upper limit loads that can be applied to mechanical parts and structures. Yield strength and Ultimate tensile strength play vital roles in material production in annealing, forging, rolling, and pressing processes.

Importance of YS and UTS Measurement using Indentation

Traditionally YS and UTS have been tested using a large tensile testing machine requiring enormous strength to pull apart test specimens. It is costly and time-consuming to properly machine many test coupons for a material where each sample can only be tested once. Small defects in the sample create a noticeable variance in test results. Different configurations and alignments of the tensile testers in the market often result in substantial variations in testing mechanics and outcomes.

Nanovea's innovative indentation method directly provides YS and UTS values comparable to values measured by conventional tensile tests. This measurement opens a new realm of testing possibilities for all industries. The simple experimental setup significantly cuts sample preparation time and cost compared to the complex coupon shape required for tensile tests. Multiple measurements on a single sample are possible with a small indentation size. It prevents the influence of defects seen in tensile test coupons created during sample machining. YS and UTS measurements on small samples in localized area allow for mapping and local defect detection in pipelines or auto structures.

MEASUREMENT OBJECTIVE

In this application, the Nanovea Mechanical Tester measures the YS and UTS of stainless steel SS304 and aluminum Al6061 metal alloy samples. The samples were chosen for their commonly recognized YS and UTS values showing the reliability of Nanovea's indentation methods.

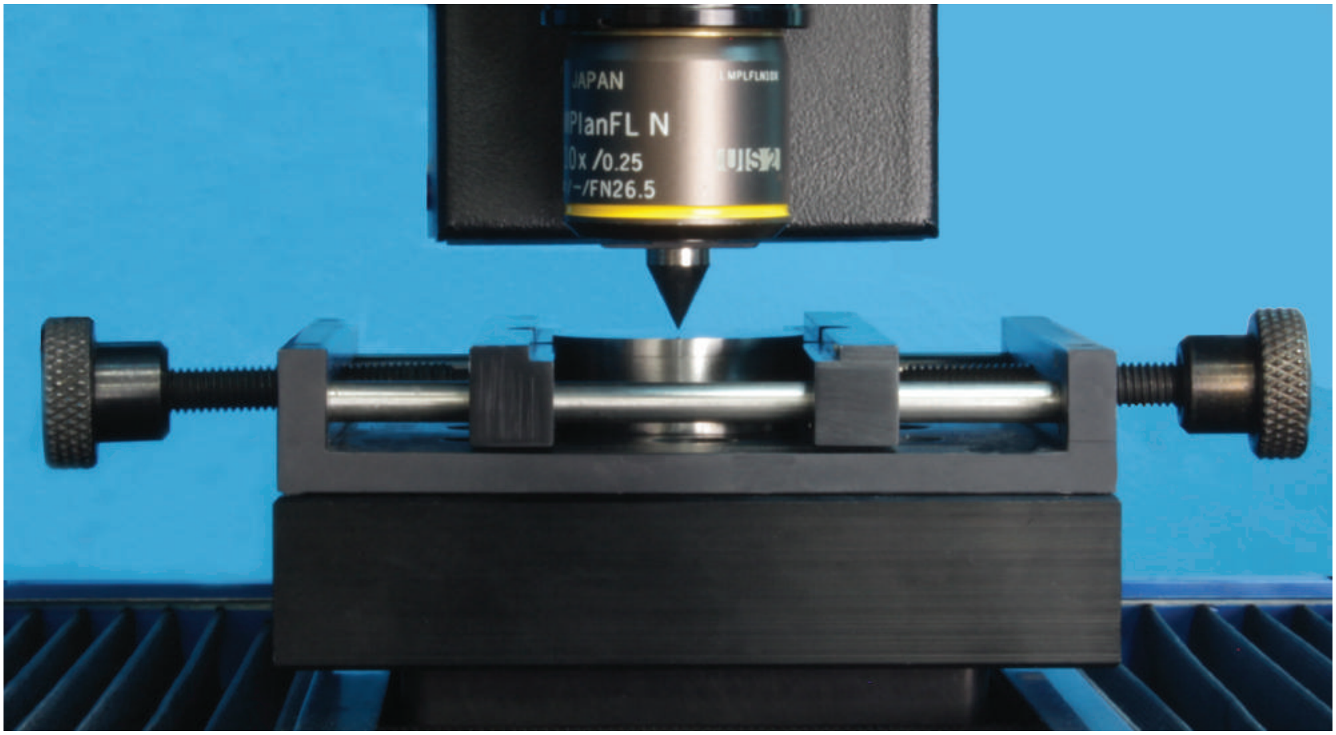


Figure 1: Sample setup with flat tip indenter.

TEST CONDITIONS AND PROCEDURES

The YS/UTS tests were performed on the Nanovea Mechanical Tester in the Microindentation mode. A cylindrical flat diamond tip of 200 μm diameter was used for this application. SS304 and Al6061 alloys were selected for their extensive industrial application and commonly recognized YS and UTS values, in order to show the great potential and reliability of the indentation method. Samples were mechanically polished to a mirror-like finish before testing to avoid surface roughness or defect influence on test results. Test conditions are listed in Table 1. More than ten tests were performed on each sample to ensure the repeatability of the test values.

Material	SS304	Al6061
Applied Force (N)	40	30
Loading rate (N/min)	80	60
Unloading rate (N/min)	80	60

Table 1: Test conditions of YS & UTS for SS304 and Al6061.

RESULTS AND DISCUSSION

Load-displacement curves of the SS304 and Al6061 alloy samples are shown in Figure 2 with the flat indenter imprints on the test samples inset. Analysis of the "S" shaped loading curve using special algorithms developed by Nanovea calculates YS and UTS. Values are automatically calculated by the software as summarized in Table 1. YS and UTS values obtained by conventional tensile tests are listed for comparison.

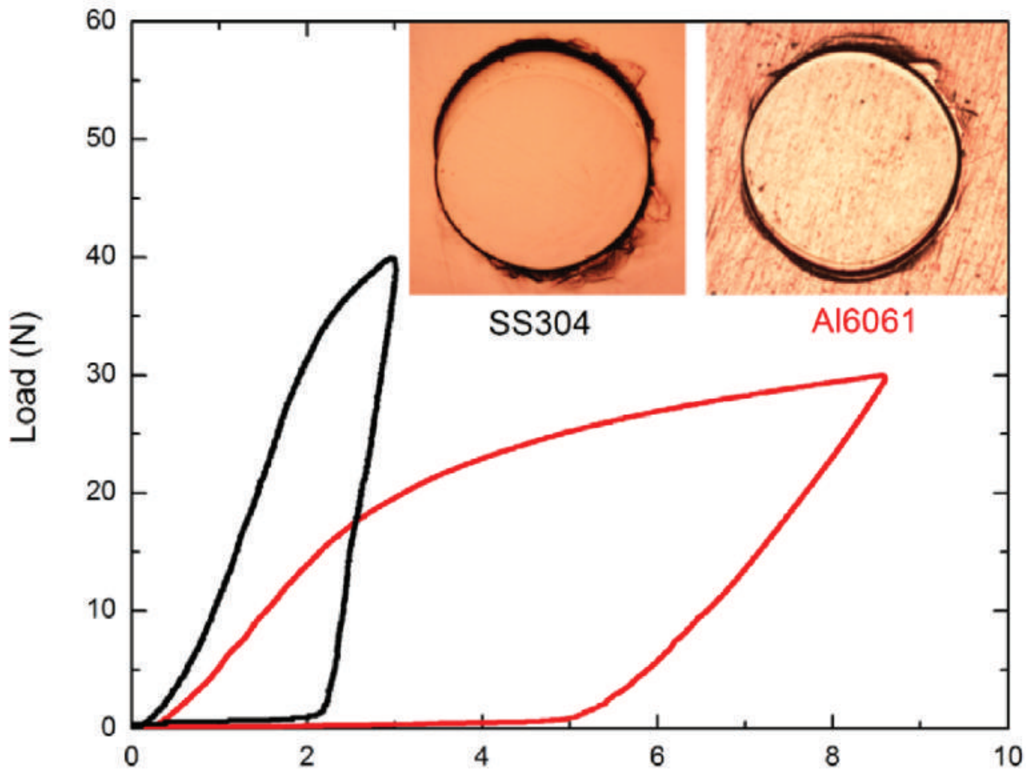
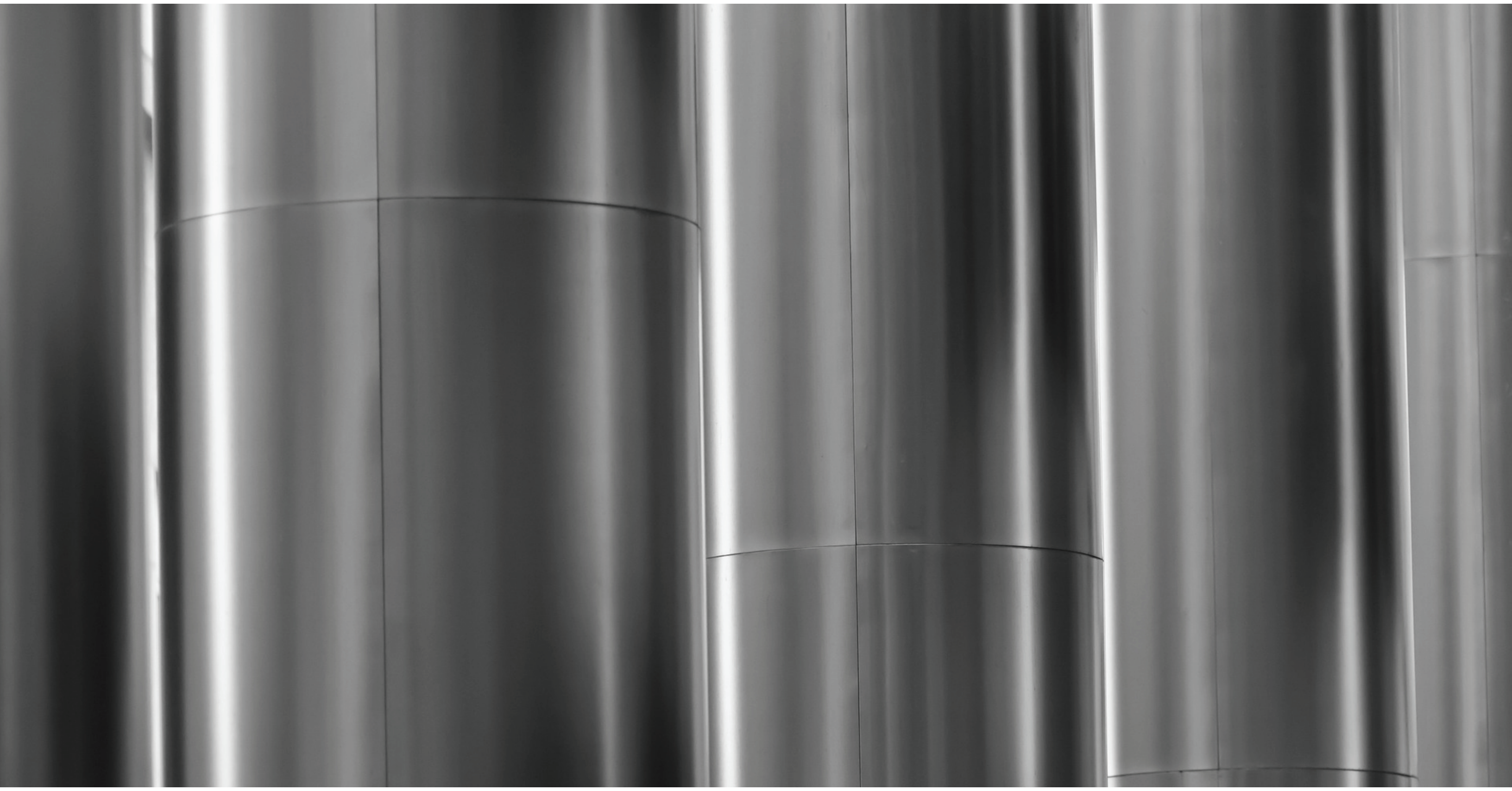


Figure 2: Load-displacement curves of SS304 and Al6061 samples. The flat indenter imprints on the test samples are inset.

Material	Yield Strength (MPa)		Ultimate tensile strength (MPa)	
	Indenation	Tensile Test	Indenation	Tensile Test
SS304	277±21	275	609±16	620
Al6061	231±18	241	301±9	300

Table 2: YS and UTS of SS304 and Al6061 measured using indentation and tensile tests.

The results show good agreement in YS and UTS measurements of the SS304 and Al6061 alloys between indentation and tensile techniques. YS and UTS tested by indentation with Nanovea's Mechanical Tester exhibit superior precision and repeatability. The indentation technique for YS and UTS evaluation is substantially more time- and cost-effective than conventional tensile testing procedures. Indentation does not require expensive and complicated sample machining, enabling fast quantitative mapping of YS and UTS values on small samples while detecting localized mechanical defects of mechanical parts in service.



Conclusion

This study showcased the capacity of the Nanovea Mechanical Tester in evaluating YS & UTS of stainless steel and aluminum alloy sheets. The simple experimental setup of indentation tests significantly cuts sample preparation time and cost normally required for tensile tests. Multiple measurements are possible on a single sample with small indentation size. Indentation provides localized YS/UTS measurements on small samples with mapping and local defect detection of various applications in pipelines or auto structures.

The Nanovea Mechanical Tester modules include ISO and ASTM compliant indentation, scratch, and wear tester modes, providing the widest and most user-friendly range of testing available in a single system. Nanovea's unmatched range is the ideal solution for determining the full range of mechanical properties of thin or thick, soft or hard coatings, films and substrates, including hardness, Young's modulus, fracture toughness, adhesion, wear resistance and many others.

In addition, optional 3D non-contact profiler and AFM Module are available for high resolution 3D imaging of indentation, scratch and wear track in addition to other surface measurements such as roughness.