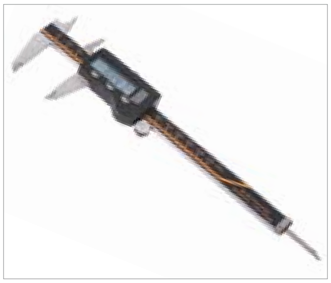
There are several different tools available for the measurement and inspection of parts and products. The specific application often determines the best choice as each tool has its own benefits and drawbacks. Over the years, these tools have become more advanced in order to keep up with improved quality standards.

Manufacturers are increasingly adopting quality standards such as Six Sigma and ISO-9000 in order to continuously improve their products and processes. In addition to reducing or eliminating product defects, these programs strive to detect problems during the manufacturing process. This allows companies to prevent adding value to already-defective works in progress. In order to be successful with this approach, manufacturers need to measure every step of their processes, including the various stages of product assembly that may never have been measured before.

Traditional Measurement Methods

Hand Measurement Tools



Hand measurement tools, such as calipers and micrometers, are often appropriate for simple geometric measurements, including hole diameters or for the length and width of a rectangular component. Their use for complex part measurements, however, is very limited. They also do not allow for measurements to be compared directly to CAD models of the part, are very susceptible to human error, and do not provide results that are rich in data. For example, calipers can return a result quickly for a hole diameter at the two points used to take the measurement, but do not give any information about how circular the hole is (this is called the circle's "form") or tell the user if the diameter differs greatly at other points of the circle. To gather this data using calipers is a time consuming process whereby the user must take multiple measurements at various points along the circle and then compare them to each other.

Optical Comparators and Machine Vision Systems

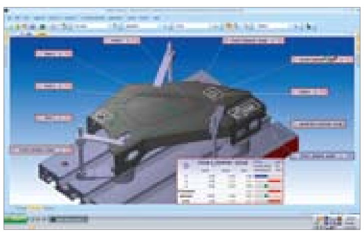
Optical comparators are a mature technology that use magnified profiles of back-lit parts that are then compared to a scale on the viewing screen. In this way, two dimensional features can be measured relatively quickly although the accuracy is limited and the process is manual. Machine vision systems are similar to optical comparators except that they utilize cameras and imaging software to perform the inspection analysis. Machine vision systems are very fast, but can be expensive, are limited to specific tasks, and are only useful for two dimensional inspections of small parts.

Coordinate Measuring Machines

Coordinate Measuring Machines (CMMs) are mechanical systems designed to track a mobile measuring probe to determine the coordinates of points on a work surface. CMMs are comprised of four main components: the machine body including the measurement bed, the measuring probe, the control or computing system, and the measuring software. Machines are available in a wide range of sizes and designs and with a variety of different probe technologies.

The Use of CAD

Many manufacturers are adopting CMM technology due to the prevalence of CAD in product development. CAD software facilitates the design process and provides manufacturers with virtual 3D design models. Manufacturers use CAD software to create designs and engineering specifications for new products as well as for quantifying and modifying designs and specifications of existing products. The use of CAD can shorten the time between design revisions; current manufacturing practices must accommodate more frequent product introductions and modifications while satisfying stringent quality and safety standards. Assembly fixtures and measurement tools must be linked to the most up-to-date CAD design in order to allow production to keep up with the rapid pace of design changes.



Traditional (Fixed) CMMs

The first CMM appeared in the early 1960s and was a device with a simple digital read-out that displayed the XYZ position of the machine. Traditional types of CMMs include bridge, cantilever, and gantry.

Fixed CMMs provide very high levels of precision and offer a link to the CAD model. However, they require the object being measured to be brought to the CMM (typically in a temperature-controlled room) and the object must fit within the CMM's measurement grid. As manufactured subassemblies increase in size and become integrated into even larger assemblies, they become less portable, thus diminishing the utility of a conventional CMM. Manufacturers must also continue to use hand measuring tools, or expensive customized test fixtures, in order to measure large or unconventionally shaped objects. The fixed CMM is also complex to operate, therefore limiting the number of potential operators and users.

Portable CMMs

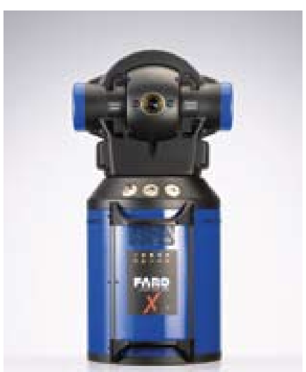
Many advances in CMM technology have occurred over the decades, including the development of portable CMMs. Portable CMMs provide all the benefits of traditional CMMs but with added flexibility. They are lightweight and can therefore be used anywhere measurement is needed (the machine goes to the part). A controlled environment is not required and operation is very simple. They provide highly accurate results and are robust enough to work in a wide range of environments. Portable CMMs are also typically much less expensive than a traditional CMM.

Types of Portable CMMs
There are two main types of portable CMMs: articulated arms and laser trackers.

Articulated Arms
An articulated arm determines and records the location of a probe in 3D space and reports the results through software. In order to calculate the position of the probe tip, the rotational angle of each joint and the length of each segment in the arm must be known. Radial reach when extended typically ranges from 2 feet to 6 feet (4-foot to 12-foot diameter or working volume).

The angle of each rotating joint within the arm is determined using optical rotary encoders. These encoders count rotations incrementally via detection of accurately spaced lines on a glass grating disc. The software converts the counts into angle changes. Arms typically have 6 or 7 axes of rotation, which means the instrument moves throughout a wide range of orientations.

Typical applications for an articulated arm are:
- Dimensional Analysis: Calculate measurements for geometric and GD&T analysis
- CAD-Based Inspection: Measure directly against CAD data to see real-time deviations
- On-Machine Inspection: Inspect parts on the machine tool producing them
- First Article Inspection: Measure individual parts to compare with nominal data
- Alignment: Align parts to assess variation in relative position
- Reverse Engineering: Digitize parts and objects to create fully-surfaced CAD models



Laser Trackers
The operation of a laser tracker is easy to understand: It measures two angles and a distance. The tracker sends a laser beam to a retroreflective target held against the object to be measured. Light reflected off the target retraces its path, re-entering the tracker at the same position it left. Retroreflective targets vary, but the most popular is the spherically mounted retroreflector (SMR). As light re-enters the tracker, it goes to a distance meter that measures the distance from the tracker to the SMR. The distance meter may be either of two types, interferometer or absolute distance meter (ADM).

Laser trackers offer extremely high accuracy levels and much larger measurement ranges (hundreds of feet in diameter). They collect coordinate data at very high speeds and require just one operator.

Typical applications for a laser tracker are:
- Alignment: Real-time feedback of object positioning
- Installation: Lay out / level machine foundation
- Part Inspection: Digital record of actual versus nominal data
- Tool Building: Set up and inspect tools with only one person
- Reverse Engineering: Acquire high-accuracy digital scan data

Summary

Despite the wide range of options in quality measurement tools, portable CMMs continue to grow in popularity. Companies are experiencing the accuracy results they need, while gaining the flexibility to use the unit wherever and whenever it is most convenient. The savings that result from using portable CMMs include reduced scrap, shorter measurement times, and improved product quality. These savings have allowed companies to see a complete return on their portable CMM investment – in many cases within twelve months.