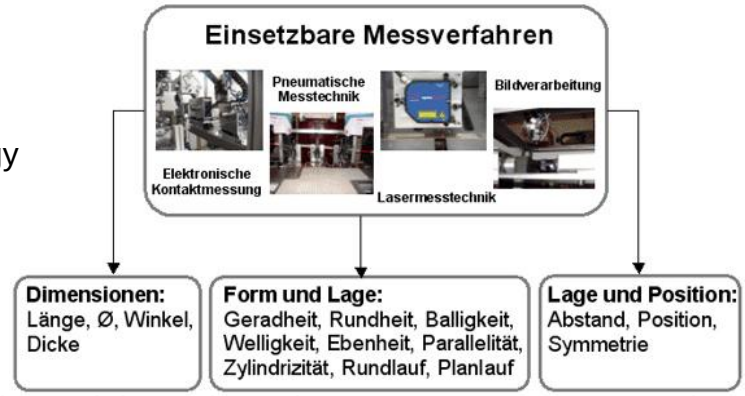
EXAKTMESS GmbH

Measurement Methods in Dimensional Checks

Various methods can be used to perform a measurement task. As a standard, measuring by means of measuring units and measuring machines is divided into 4 major fields:

1. Electronic contact measurement
2. Pneumatic measurement technology
3. Laser measurement technology
4. Vision application



The decision which of these methods is used depends on the type of measurement task, the desired accuracy, the ambient environment and the required cycle time.

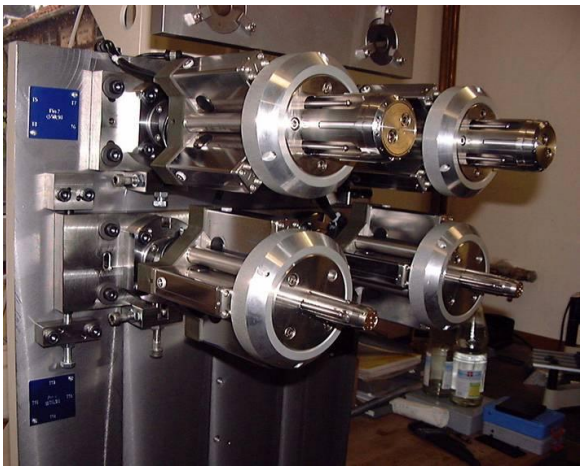
The following table gives a small overview of the criteria for selecting a measurement method, making no claim to be exhaustive.

Comparison of the Different Measurement Methods

Group	Electronic contact measurement			Pneumatic measurement		Laser measurement		Camera measurement	
Function	Inductive	Incremental	Capacitive	Differential pressure	Dynamic pressure	Triangulation	Micrometre	Reflected Light	Transmitted Light
Performance									
Resolution up to 1 µm	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Resolution up to 0.1 µm	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No
Absolute measurement	No	With automatically supplied setting piece	With automatically supplied setting piece	No	No	No	Yes	Yes	Yes
Contact with the part	Yes	Yes	Yes	Contact with the guide body	Contact with the guide body	No	No	No	No
Influences on the Measurement Result									
Vibrations	Damping measures	Damping measures	Damping measures	No	No	Damping measures	Damping measures	Damping measures	Damping measures
Part with particles	Cleaning the part	Cleaning the part	Cleaning the part	No	No	Cleaning the part if possible	Cleaning the part if possible	Cleaning the part if possible	Cleaning the part if possible
Part with humidity	No	No	No	No	No	Cleaning the part if possible	Cleaning the part if possible	Cleaning the part if possible	Cleaning the part if possible
Part with swarf	Cleaning the part	Cleaning the part	Cleaning the part	No	No	Cleaning the part if possible	Cleaning the part if possible	Cleaning the part if possible	Cleaning the part if possible
Dusty environment	No	No	No	No	No	Sealing air if possible	Sealing air if possible	Sealing air if possible	Sealing air if possible
Spray mist environment	No	No	No	No	No	Yes	Yes	Yes	Yes

In order to select the appropriate measurement method for each measurement task in hand it is necessary to know all the relevant data of the device under test and the process. This also includes knowledge of the strengths and weaknesses of all measuring systems that might be considered.

Electronic Contact Measurement



Due to several reasons, electronic contact measurement is the most frequently used method for special measuring units. The main reason is that it is easy to integrate into measuring units and measuring machines. A further reason is its large available measuring range as compared to e.g. pneumatic measuring devices. If inductive measurement technology is not sufficient (measuring range > 10mm), the measurement task is performed with capacitive and incremental probes.

The most common way is to use commercially available measuring probes, offering the advantage that they can easily be replaced when repairing and servicing the unit. However, this method has its limits when high demands are placed on the protection class.

If the conditions of the ambient environment are too extreme, specially designed elements are used. They can be integrated into the measuring device as external add-on elements, special probes or special measuring heads.

Electronic contact measurement technology is the type of measurement technology that is easiest to design and integrate by engineering offices and mechanical engineers because the probes can be moved directly to the part to be measured or the measurement can be performed indirectly via mechanical design elements such as measuring levers or measuring slides.

Basically, in tactile measurement technology three groups of tactile probes can be distinguished:

Inductive travel sensor:	Limited measuring length (max. 10 mm), characterized by its sinusoidal characteristic line of the error of measurement, high reproduction rate, insensitivity to soiling, low costs per measuring point; a high measuring point density is possible.

Incremental travel sensor:	Almost unlimited measuring length, absolute measurements are possible, almost no deviations in linearity. It is sensitive to soiling and vibration; lower reproduction than with inductive systems.
Capacitive travel sensor:	Almost unlimited measuring length, absolute measurements are possible, almost no deviations in linearity, lower reproduction than with inductive systems.

Pneumatic Measurement

Pneumatic measurement technology is a real classic that has often been declared dead but is coming to the fore again today. On the one hand, this is due to its sturdiness – there are no moving parts and the measuring nozzles themselves blow the measuring surface clean (self-cleaning effect). On the other hand, production with its continuously increasing precision has reached areas where the restricted measuring range of pneumatic measurements does not constitute a direct restriction any more.

With the pneumatic measurement technology, the important characteristic of the dependence of the measurement result on the surface condition must be taken into account. In the case of larger surface roughnesses, electronic contact measurements deviate from pneumatic measurements. If the surface roughness stays more or less constant, this deviation can be compensated electronically. With a large variation, larger measurement errors have to be expected and it is useful to switch to contact measurement technology if the operability of the system is affected.

A considerable degree of experience in configuring and adjusting the measuring nozzles is required for designing and constructing pneumatic measurement technology. Therefore, the number of suppliers of pneumatic measuring devices is a lot smaller than that of electronic measuring devices.

There are two established methods for converting the signal from pneumatic to electronic, namely the differential pressure method and the dynamic pressure method.

With the differential pressure method, the generated measurement pressure is compared with an accurate reference pressure and this way the measurement signal is generated. The considerable benefit of this method is the fixed measuring range it offers and also the fact that an average size setting ring is sufficient. The drawback is that after any change to the system a readjustment has to be carried out or a correction factor for the measurement has to be determined.

The more frequently used pneumatic measurement procedure is the dynamic pressure measurement method. With this method, the dynamic pressure that is created by the air escaping from the measuring nozzle is determined in the measurement system itself by means of a piezo pressure sensor. The stability of the measurement system as well as the option to change the measuring range without having to carry out a readjustment constitute the great advantages of this method. Its drawback is that a minimum and a maximum setting piece are required for the calibration because the measuring device to determine the factor for the P/E conversion has to be calibrated with these setting pieces

Laser Measurement

As one of the new measurement technologies, in recent years this type has produced better and better and more and more accurate measuring heads. Nevertheless, the efficiency of its use is affected by the ambient environment and the surfaces of the parts.

The flexibility of a laser measurement device is its great benefit: in its measuring range no mechanical retooling is required for different types. The changeover is just carried out by means of the existing software.

The accuracy of the measuring heads is comparable to the one of tactile measurements if the metrological environment is in accordance with the specifications of a precise laser measurement.

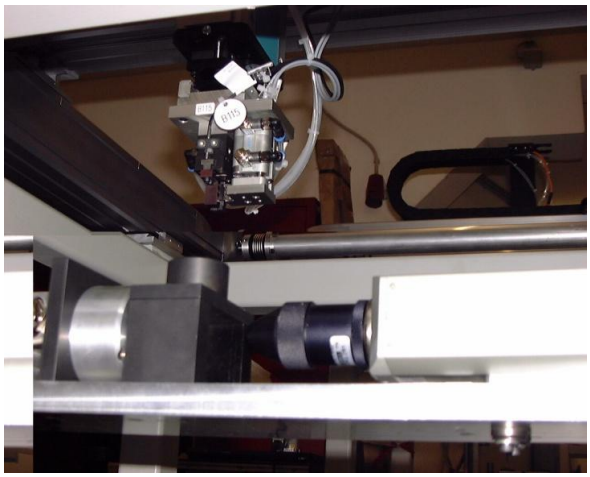
These benefits are still accompanied by considerable drawbacks.

1. Only projectable contours and dimensions can be measured. Depth measurements, e.g. in grooves, are almost impossible.
2. Varying lighting conditions change the measurement results; with some triangulation lasers and micrometres this behaviour has been improved considerably.
3. Varying quality of the surface and colour of the part to be tested change the measurement result.
4. Soiling of the surface or humidity films on the surface change the measurement result.

Basically, one can say about laser measurement technology that it has a lot of potential, but with many measurement tasks its full potential can only be realised with the help of accompanying design and procedural measures.

Vision Application

Due to the constantly growing capacity of the evaluation computers and consequently of the pixel resolution of the cameras, more and more accurate measurements with camera technology are possible. By now a point has been reached, where with a restricted image section an accuracy is attainable that is comparable to the one of tactile measurements. With vision application, too, only projectable contours and dimensions can be measured.



Great benefits of the camera measurement technology are the fast recording of readings and the fact that the position of the part to be tested is irrelevant.

Some points have to be taken into account when analysing the vision application data:

1. The ambient environment must be free of soiling, i.e. it must be ensured, if necessary by means of design measures, that the camera lenses are clean.
2. The design must ensure constant lighting conditions.
3. The attainable accuracy of the vision application measurement can be determined by means of the image section, the test results and the resolution of the camera.
4. The selection of the appropriate light source and lighting has a major influence on the quality of the result of the camera measurement.