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1 - Introduction

The on-line check of the finished diameter of parts machined by centreless grinders or N.C. lathes is becoming a "must" in today's factories, especially when total quality achievement is considered to be a Company's strategic goal.

Traditional methods are based upon electronic probes that touch the part to measure the outside diameter, which is the dimension that must be accurately gauged. Alternatively, different types of air-probes can also be used to avoid any contact with the part and to allow through-feed operation. Both of these methods have some severe limitations especially when flexibility and through-feed gauging capability are concerned.

Touch probes usually require that the part be stopped and inserted into a customized fixture where several probes gauge the diameters to be measured: it is evident that such an arrangement is tailored to the specific shape of each part and makes impossible the through-feed measuring. The handling of the part requires additional costly mechanics and the overall measuring time is usually too long to allow 100% checking.

Air probes, mostly shaped like a ring, allow through feed measuring of single diameter parts, but require that the air gap between the part and the ring be very small: even a small change of the dimension of the part being manufactured requires the replacement of the probe and the re-alignment of the measuring equipment. In addition both systems are basically "comparators": This means that the measuring range is very small and the result is given as a "deviation" compared to the dimension of the "master" which is used as a reference part to set the "zero" or to "calibrate" the equipment. Re-calibration or re-mastering of the gauge can be very frequent; in addition each part needs its own master, which in turn must be to submitted to periodical check and validation.

In the mid 80's Aeroel introduced a new family of measuring equipment based on laser light technology. This was break through over the existing technology since it featured extraordinary flexibility, better measuring accuracy and higher working speeds. (Fig. 1)

2 - Laser Technology Sets New Performance Standards

The high accuracy laser gauge is the heart of these systems which measures the outside diameter of the part while it is moved through the laser beam. The working principle is quite simple: the transmitting section of the gauge emits toward the receiver a laser beam, which scans at very high speed the measuring plane: every object placed between the transmitter and the receiver stops the light for a time which is proportional to its diameter. Since the scanning speed is a known constant, by measuring the time of the shadow it is possible to compute very accurately the dimension of the part.

The most important features of such a system are listed below.

- **Large measuring range**: the height of the scanning area can be as high as 80 mm: every part whose diameter is included between 0 and 80 mm can be measured with the same unit and without the need to pre-set the gauge to a varied diameter range.

Fig. 1: Typical layout of Grindline System

- **Through-feed measuring capability**: as a result of the contact-less technique and The optical design, the workpiece does not need to be accurately placed within the beam. Moving or vibrating parts can be gauged with utmost accuracy!

- **Short measuring time**: the high scanning frequency enables many as 400 samples per second, each one with some µ repeatability. By averaging several samples the repeatability can be boosted to ±1µ in 0.06 s or, even better, to ±0.25 µ in 1 s (figures guaranteed in a ±3σ interval, 99.7 % confidence level).

- **No measuring drift**: an exclusive and patented self-calibration device cancels any measuring drift and guarantees permanent gauge accuracy. The time wasting task of periodical re-mastering is no longer required. In addition, the same device allows automatic compensation of the measuring error due to ambient temperature change, making possible applications in a workshop environment.


The above listed features yield excellent results when laser gauges are used as post-process measuring equipment at the output of centreless grinding machines or N.C. lathes, to measure the diameters of parts like small shafts, piston pins, rolls, shock absorber rods, steering racks and a lot of other components to be used in the automotive or home appliance industry.
The Grindline Systems have been specially designed by Aeroel to accommodate these applications, giving to the customer a complete turn-key solution.

The laser gauge is installed at the output of the grinder, to measure the finished part after the process. The parts coming out of the machine are cleaned by blowing away the water+oil emulsion, which could otherwise affect the measurement accuracy: a significant development effort has been made to assure suitable cleaning by using specially designed air-cleaning devices, included in the Grindline Systems (Fig. 2). After cleaning, the parts pass through the measuring field of the laser gauge: the part can be supported and moved by a belt conveyor or by the gantry loader that feeds the machine (Fig. 3); in some other cases they simply push each other over "V" shaped rolls.

During the pass through the beam, the laser gauge carries out hundreds of measurements distributed along the axis of the piece. Thanks to exclusive advanced processing and filtering techniques, the Grindline software only extracts those measurements carried out on diameters specified by the operator, thus ignoring shape irregularities that might otherwise compromise the result.
Chamfers, grooves, threads, through holes and even drops of emulsion on the workpiece are not able to deceive the system. (Fig. 4)

Several diameters can be measured on parts ground by plunge type grinders or average diameter and taper on parts ground by through-feed machines. (fig. 5)

The values measured by the laser gauge are displayed and compared with nominal diameters and their tolerances, pre-programmed by the operator in the electronic control unit. Dimensions of each component can be stored in a “product library” and instantly retrieved by the operator every time production changes.

If the wear condition of the grinding wheel results in an excessive deviation from the nominal diameter, a series of “increase” or “decrease” pulses automatically corrects the grinding wheel position, thus keeping the part size within tolerance.
To achieve optimum control, the Grindline software automatically takes into account the pieces already machined that are between the grinding wheel and the laser gauge; in addition any out of tolerance part can be easily discarded thanks to GO/NO-GO signals provided by the control unit.

The results of all measurements are stored and processed in real time: simple but effective statistical reports can be printed to prove product quality and process capability.

4 - The Benefits Of The Grindline System.

In conclusion, the Grindline systems have proved to be a simple and effective solution in most cases where on-line check and machine feed-back is required, giving important advantages over traditional equipment.

- **Excellent flexibility**: the system enables measurement of a wide number of different diameters and types of components without specific dedication.

- **Zero defect production**: the real time adjustment of the machine and the discarding of every out of tolerance piece eliminates "returns" for diameter non-conformity.

- **Quality certification is made easier**: the on-line capability makes sample measurement systems obsolete, since 100% checking is possible. By connecting the system to an existing SPC network, real time data can be processed to certify product quality and process capability.

- **Cost effective solution**: thanks to simpler application requirements and minimum cost of associated mechanics, the overall price to performance ratio is very competitive compared to traditional solutions.