Ready for Large Tasks

Content:

Where large powers and high torque are required, large gears are the answer: in marine drives, cement and coal mills, wind turbines and hydroelectric power plant. To provide a sustainable guarantee of high standards with respect to running properties, efficiency and low noise emissions, test facilities must assure quality and design in the manufacturing process. KLINGELNBERG has completely redeveloped its range of large industrial measuring centers and adapted them for current market needs.

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In manufacturing, precise measurements are the cornerstone for complying with very tight tolerances and ensuring the efficiency of the entire operation. Large measuring centers have to be fast and easy to operate in order to determine the current quality of the workpiece and decide on any necessary corrections in the process chain.

The inner life of gear trains for wind turbines is especially quality-sensitive. These include cylindrical gears, cylindrical gear shafts, rings with internal gearings and planetary gears. Safe, reliable operation – even in heavy weather conditions – is absolutely essential, as the only way to safeguard a long and economic operating lifetime.

Gear Measuring Centers

	Workpiece diameter	Workpiece weight
	mm	kg
P 150	1,800	8,000
P 150 W	1,500	8,000
P 250	2,800	15,000
P 250 W	2,500	15,000
P 350	3,800	20,000
P 350 W	3,500	20,000

Measurements

	P 150–P 350	P 150 W–P 350 W
Cylindrical gear outside teeth	•••	••
Cylindrical gear inside teeth	••	•••
Cylindrical gear shafts	•••	••
Bevel gear wheel	••	(•••)
Bevel gear pinion shaft	•••	(••)
Bevel gear wheel	•••	••
Gear worms	•••	••
Gear-cutting tools	••	o
MFL-shafts	•••	••
MFL-bores	•	•••
Roughness cylindrical gear	•••	(••)
Roughness bevel gear	•••	(••)
Grinding burn cylindrical gear	••	(••)

Legend: highly suitable ••• *planned* *( )*
very suitable •• *not planned* *o*
suitable •

The increasing size of parts is leading to ever greater challenges for production quality. Customers or classification societies need complete documentation, and this can be assured only by regular measurement and testing. The high requirements for process reliability and the associated quality documentation call for robust metrology near to the production line. Manufacturers of large gears consequently need high-precision measuring devices which can be operated as easily as possible.

The new range of models in the P series meet this need. Klingelnberg now offers continuous measuring technology in the applications sector up to 3,800 mm. This satisfies maximum quality requirements and the standards of the classification societies. The new machine versions combine demanding geometry measuring tasks with high-precision gear measurement.

Main goal: shorter floor-to-floor measuring times

Measuring centers for large gears are suitable for measuring workpieces with an outside diameter up to 3,800 mm and a weight up to 20,000 kg. The machines have a rotary table and three linear measuring axes for acquiring measuring data. The new rotary table provides high running accuracy (radial and axial runout < 0.5 µm) – important prerequisites for accurate measurement of size, shape and position deviations during a single work cycle. A high-precision angle measuring system is integrated in the rotary table axis for rotational position acquisition. 3D stylus systems with digital data encoders are used for optimum measured data logging on the tooth flanks. The traversing paths of the linear axis allow inspection of up to 800 mm in the horizontal plane and vertical distances up to 2,000 mm. The rotary table and the linear measuring axes are powered directly by AC motors for greater guiding accuracy.

The rotary table and the linear axis measuring attachment are supported on a load-bearing machine bed. Combined with a suitable foundation, this provides a geometrically reliable base for the measuring machine. The machine design enables inspection of various diameters and distances on the same workpiece in one set-up. The gear measuring centers are optionally available with a straight horizontal measuring axis, including a 3D stylus system or a downward angled measuring arm. The horizontal axis is useful in versatile applications for disc-shaped workpieces and shafts and for gear-cutting tools. The angled variant is particularly suited for testing gears in planetary systems used in the wind power sector. Here the task of measurement is to test internal gears with large gear widths and to perform high-precision dimension, dimensional (MFL) measurements in workpiece bores. The angled measuring arm can move the 3D stylus head inside the bore close to the measuring point, ensuring high measuring accuracy.

Special features are used to facilitate loading prior to a measurement. Shaft-type workpieces can optionally be clamped with a column and tailstock for a fixing range up to 2,500 mm, so that they can be fixed between centers. Disc-shaped workpieces are placed on the rotary table of the measuring machine. Depending on the size of the workpieces, extra fixtures are available for this purpose. To make an accurate measurement, the position of the workpiece axis is determined in relation to the rotary table axis. On the P series machines, this can be done by scanning the reference surface. All measuring movements are then performed within the workpiece coordinate system.

The control compensates deviations in a range up to 10 mm. This feature greatly simplifies loading of the measuring machine, as the operator no longer has the time consuming task of aligning the heavy workpieces with the rotary table axis. Centering elements together with a mm scale are quite sufficient. As an alternative, the measuring machines can be aligned mechanically via an air bearing integrated in the rotary table. This can be used to align even heavy workpieces exactly.

Using the control software, the operator can quickly create a measuring program to define the measurement sequence. He enters the test parameters together with the standards or directives for analysis. The desired and actual form can then be compared reliably using the analysis software. This is important, as large gears with high profile and tooth trace loads need especially large modifications. Measuring times are shortened by programming fixed measurement sequences, and the center performs the prescribed steps iteratively.

There are various ways of documenting the results (Fig. 1): apart from print-outs there is the option of further on-line processing. The bevel gear closed loop concept networks the inspection machine with the other production units via a database, so that logged data can be transferred directly to the gear machining process and the tool settings.

Versatile adaptability

In addition to the standard equipment, users can opt for additional features to customize a measuring center. This enables them to respond specifically to a measuring situation.

Depending on the application, the extra features will substantially reduce measuring time and provide more flexibility. Special locating and centering elements aid positioning of disc-shaped workpieces, allowing external or internal centering. A plastic coating prevents the workpiece from being damaged during crane loading.

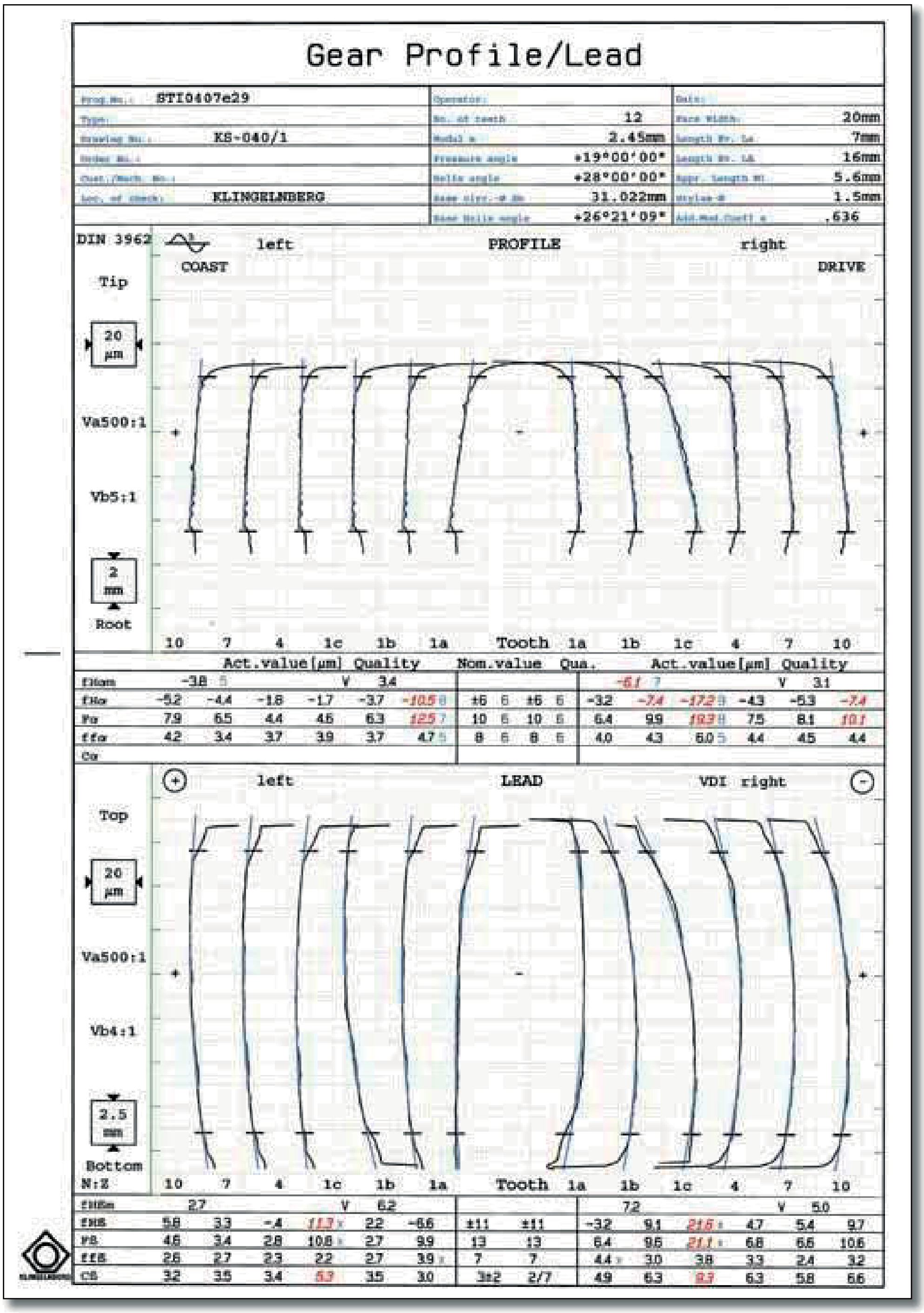

Fig. 1: Inspection chart: Involute and Lead

Fig. 2:
Mounting table with support and centering element

The resulting centering accuracy in the millimeter range is sufficient to start the measuring run immediately. Additional mounting tables with different diameters (Fig. 2) are available for large ring-shaped workpieces. These are designed to be changed with a short set-up time and effort. The fixtures used on the rotary table also fit the mounting tables.

Centers are preferred for fixing shaft-type workpieces. Tailstocks in different types are available. Detachable columns with a tailstock are used for small workpieces or gear-cutting tools. Fixed columns with tailstock are available for testing extremely long and large shafts, enabling measurements on up to 2,500 mm fixing lengths. The column can be moved using a wireless remote control to adjust the arm for the necessary fixing length or to adapt it for the loading position.

An optional automatic stylus changer speeds up the process if a number of different measurements are made in succession. The stylus is then changed automatically during the measuring sequence. Precision is maintained due to the high centering accuracy of the stylus holder plate. If the stylus still needs to be calibrated for certain measurements, this is done outside the center of the machine. The operator sees the necessary instructions for a manual stylus change on the screen.

The P series machines also have an optional feature for measuring surface roughness on the tooth flanks. The procedure is simple to adapt and functions on the skid plate principle. The parameters it provides a single run, together with other measurements, are the center line average (Ra), the average peak-to-valley height (Rz) and the maximum peak-to-valley height (Rt). The special stylus system is changed either manually or automatically. Appropriate roughness sensing systems are available for the respective module sizes.

Precise results can be obtained only if the workpiece temperature at the time of measurement is taken into account. A difference of a few degrees Celsius from the reference temperature (20 °C) will cause results to deviate by two-figure micrometer amounts when determining test parameters for profile tooth traces and for the base tangent length. To avoid such inaccuracies, the new P machines provide an optional workpiece temperature sensor. This has to be placed manually on the workpiece prior to the measuring run. The temperature measurement takes only a few seconds. All subsequent measurements are then related to the reference temperature.

The angled measuring arm of the W version is fitted with a monitoring camera. The ultra-compact camera can be fixed flexibly on the measuring arm according to the intended measurement and the required viewing angle. Its primary task is to let the operator view the position of the stylus on the monitor of the control unit when measuring inside gear teeth, and make any necessary corrections.

Fig. 3: Gear measuring center P 150 W
Accurate and fast measurements of workpieces upt to 1,500 mm diameter and a weight of up to 8,000 kilograms

Fig. 4:
Measuring arm with monitoring camera

Feedback from the industry is the basis for developing new gear testing machines and measuring concepts. The main focus is on key market requirements for faster processes with simultaneously high quality standards. The modular design enables us to customize measuring devices for individual demand in the industry.

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