

Magnetic Particle Inspection on train components

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Abstract:

Magnetic particle inspection plays an important role in the railway component production as well as in the maintenance workshops of railway companies.

Workshops of the German railway company “Deutsche Bahn AG” rely on the MT systems DEUTROFLUX of KARL DEUTSCH for railway axle inspection. Right after overhaul and before re-assembly, the train axles have to be inspected for surface cracks. Detection of longitudinal defects (defects in axial direction) is executed by a current flow transmitted through the axle. Testing for transversal defects (defects in encircling direction) is done with coil magnetization, moving a motor driven coil along the axle. To reduce the cycle time, the magnetization coil is equipped with two shower rings (one on each side), with alternative activation depending on the direction of the coil movement. That avoids extra time for a non-test return of the coil. Optionally the test machine can be supplied with an automatic clamping length adjustment, which supports a faster change over between different test part geometries.

DEUTROMATs for magnetic particle inspection on forged train wheels and steel tyres, as for example delivered to the German company BVV, use special high-current coils. For testing steel tyres the special high-current coil is combined with an additional yoke to detect cracks of all directions. In both cases the wheels as well as the tyres are rotated for 360° to cover the entire surface. Loading and unloading is done from top by means of a crane.

This presentation will include further examples of test solutions for railway components as complete train wheel sets (axle and wheels tested in an assembled state), laminated leaf springs, large railway springs, pushrods for steam locomotives etc.

Keywords: magnetic particle inspection (MPI), MT, railway, train, axle, wheel, wheelset, tyre, stabilizer bar, driving rod, large spring, motor pendulum-shaft, bogie, welding, weld seam, surface crack, moving coil, hinged coil, mindener coil

1. Portable Applications

Not in all cases does the testing throughput justify a stationary test bench. Random tests and especially many welding seam applications are covered by portable MT equipment like DEUTROFLUX yokes and current flow power units.

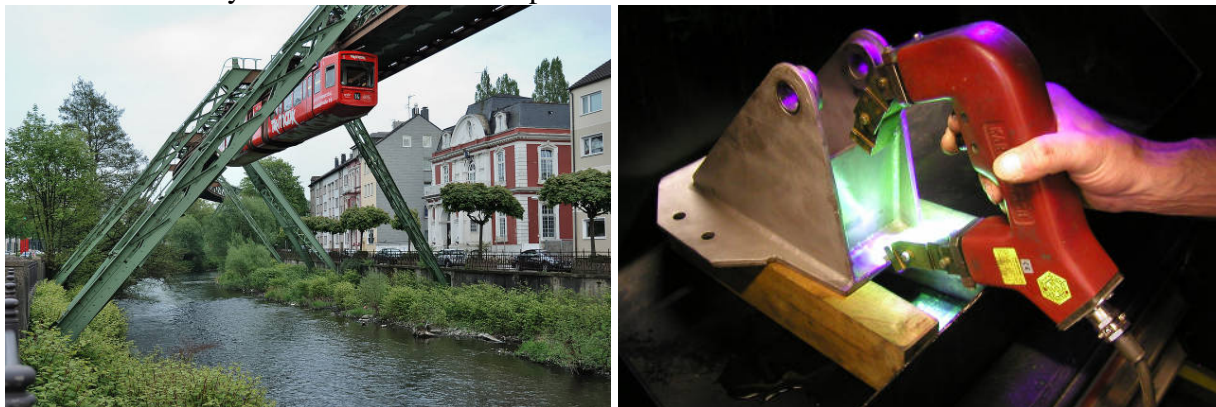


Figure 1. Portable MPI with DEUTROPULS Hand Yoke for weld seam testing on components of the Wuppertal Suspension Train



Figure 2. High current magnetization coil activated by DEUTROPULS current flow unit
 Left picture: Coil with integrated spraying (DB Heavy Maintenance Paderborn workshop)
 Right picture: Hinged coil for axle testing (Franz Kaminski Waggonbau Polska)

2. Stationary systems for railway axles and wheelsets

Five workshops of the German railway company DB (“Deutsche Bahn AG”) already rely on DEUTROFLUX UWS systems of KARL DEUTSCH. Right after the overhaul and before the re-assembly, the train axles have to be inspected for surface cracks. For testing the railway axles on longitudinal defects (defects in axial direction) a current flow is transmitted through the axle, which generates an encircling magnetic field. Testing of transversal defects (defects in encircling direction) is done with coil magnetization, moving the motor driven coil (with the front side shower ring activated) along the part. The implemented bi-directional magnetization movement with appropriate activation of the 1 of the 2 shower rings reduces the cycle time – avoiding extra time for a non-testing return run of the coil.

In some cases we delivered even DEUTROFLUX test benches for railway axles of complete wheel set systems, with wheels still mounted. The wheels itself are tested separately with a special high-current coil. Further options like automatic span length adjustment, connection of the test machine to a supervisory system, automatic control of the test fluid in the test machine with the patented FLUXA-Control are available and for example integrated in the DEUTROFLUX UWS machine at DB Heavy Maintenance Wittenberge workshop.



Figure 3. DEUTROFLUX UWS for railway axle test with automatic span length adjustment (DB Heavy Maintenance Krefeld workshop)



Figure 4. Magnetization of a railway axle shaft with a motorised moving coil



Figure 5. Motorised turning of the axle for inspection under UV light
The UV lamp is smoothly fixed in a linear rail for easy movement into inspection position



Figure 6: The cabin roof can be pneumatically opened for (un-) loading by crane
The UV lamp is automatically retracted into a safety position

3. High flexibility of stationary systems for a big variety of components

Leading bogie manufacturer like Bombardier demands a high flexibility from a test system. The Bombardier location in Siegen is the worldwide centre of excellence for bogies. There are the FLEXX bogies (example in Figure 6) manufactured, which cover the whole range of railway applications. Furthermore Bombardier provides also a comprehensive lifetime service for their bogies at the Siegen location.

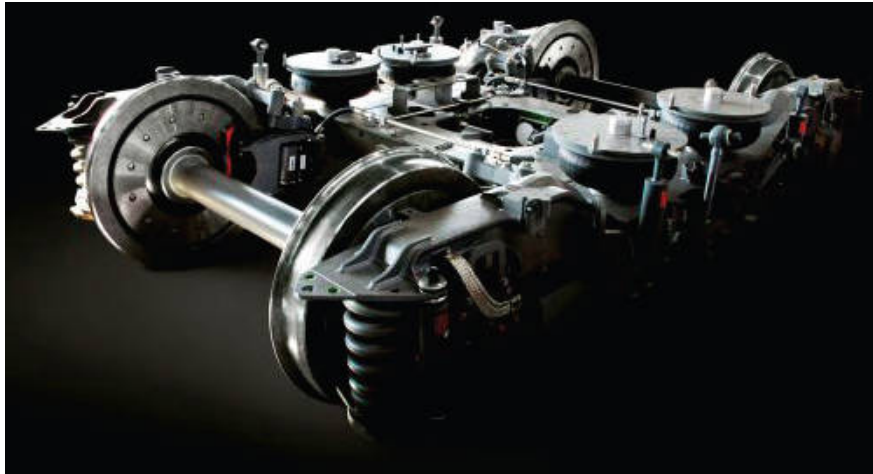


Figure 7. Example of a FLEXX bogie

To cover all the testing needs of a preventive maintenance for a big variety of bogie types, KARL DEUTSCH delivered a special version of the DEUTROFLUX UWS 3000 (Figure 8). A big variety of bogie components have to be tested with the same machine as for example wheelset, wheelset link, large spring, motor pendulum-shaft, stabilizer bar and much more. Especially the flexibility to test also the large springs presented a particular challenge, as it requires a completely different type of magnetization. A reconnectable magnetization mechanic provides the switching between shaft testing and spring testing. The clamping length of 3000 mm of the UWS 3000 corresponds to the maximum component length. Axles, shafts etc. are tested on longitudinal defects (defects in axial direction) by a current flow transmitted through the axle. Simultaneously happens the test on transversal defects (defects in encircling direction) with coil magnetization, moving the motor driven coil (with the front side shower ring activated) along the part.

For testing the springs an additional current-carrying copper bar is introduced into the machine (Figure 9). For testing the spring on longitudinal and transversal defects a high current is transmitted directly through the spring itself and a 2nd high current is simultaneously transmitted through the centrally (along spring axis) introduced copper bar.

The simultaneous magnetization by current and magnetic field (as for axles, shafts etc.) or by two currents (as for springs: with direct current flow through the spring and 2nd current through a central copper bar) is based on a phase-shift between the 2 simultaneously applied AC magnetizations. This so called “combined magnetization” assures the optimal sensitivity for all defect orientations in one measurement cycle. The spraying is always provided by one of the 2 shower rings, which are mounted on both side of the moving coil.

To provide an easy and safe operation despite the big variety of different test parts and the different types of magnetization, the test machine is equipped with the DEUTROFLUX MEMORY module (Figure 10). All parameters (e.g. magnetic field, current) are accessible by touch panel. After the component-specific parameter settings are once defined and stored by a supervisor, the operator just has to select the component to be tested from a menu to start the testing. The MEMORY module also logs the testing process and provides test reports, which can be downloaded via USB connection.



Figure 8. Special version of DEUTROFLUX UWS 3000 for testing a big variety of bogie components like wheelset, wheelset link, large spring, motor pendulum-shaft, stabilizer bar (Bombardier, D)
The picture shows the cabin roof opened for (un-) loading from top by crane

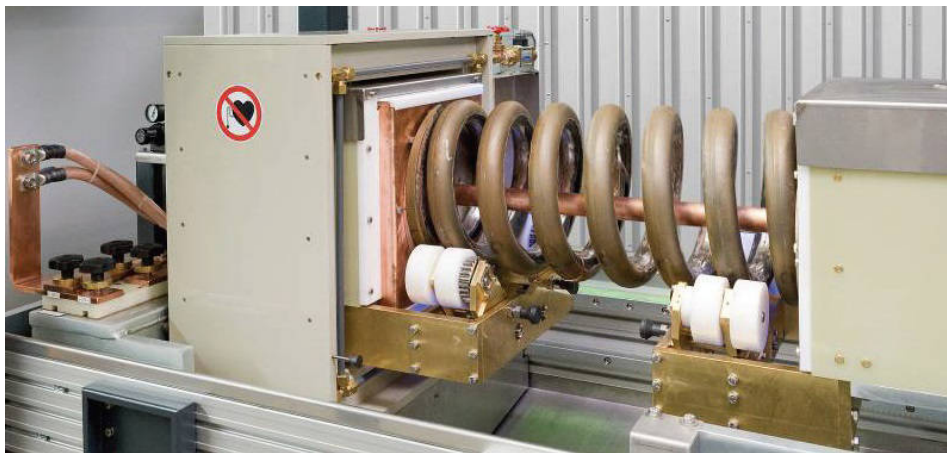


Figure 9. Spring magnetization with 2 phase shifted AC currents (Bombardier, D)
(direct current flow through the spring and 2nd current flow through central copper bar).
Left hand of the test coil is the reconnection mechanism visible, which allows to switch from 2 current magnetization for springs to standard current & magnetic field magnetization

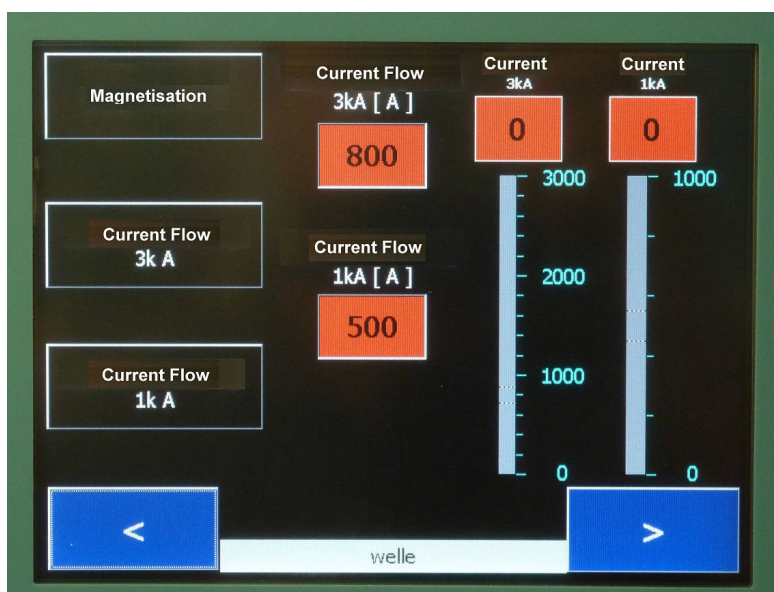


Figure 10. Screen shot from DEUTROFLUX MEMORY module

4. Testing of complete wheelsets

In some cases it is even demanded to test the complete wheelset with the wheels, brake discs and even gear components still mounted. Despite the fact, that wheels, brake discs and even gear components are still mounted, the axles have to be tested on surface defects in all directions with a high sensitivity. That requires a huge moving coil for the axial magnetic field, which is big enough to move all along the axle with wheels etc. still mounted (Figure 11). The DEUTROFLUX UWS assures that this moving coil with huge inner diameter provides a sufficient axial magnetic field strength along the axle (much smaller diameter = bad fill factor). The wheels itself are in this case tested separately with a special high-current coil (so called “Mindener Coil”), using the high current generator of the test machine or a separated high current flow unit.



Figure 11. DEUTROFLUX UWS for testing railway axle while the wheels are still mounted
In front of the test machine is the separate test coil “Mindener Coil” for testing the wheels itself (Remar, Romania)

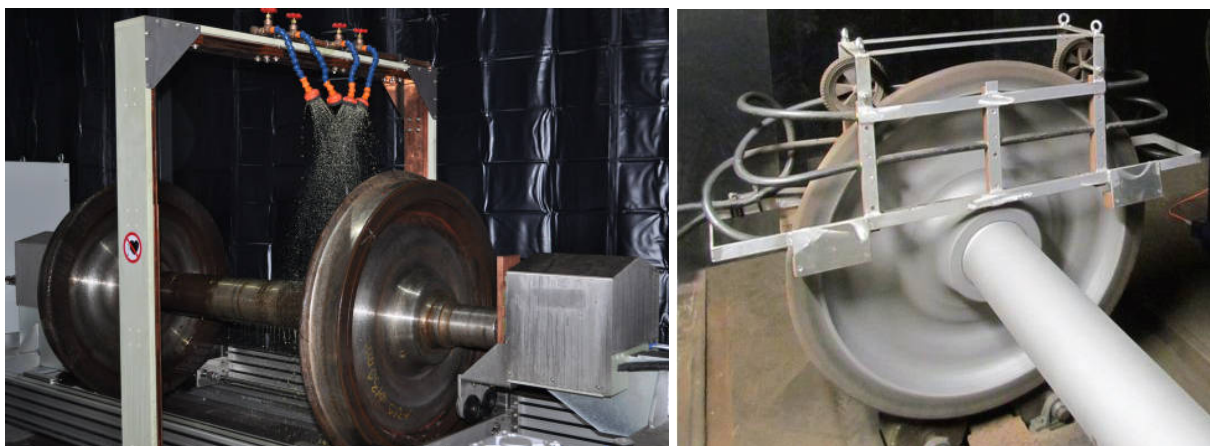


Figure 12 Testing a complete wheelset with wheels still mounted
Left picture: Testing axle inside the test machine (Remar, Romania)
Right picture: Testing wheels with separated Mindener Coil (Kaminski Waggonbau, Poland)

5. Testing weld seams on stabilizer bars

Standard requirement is the control of the weld seams on both ends of the stabilizer bar. Even though a stabilizer bar has a typical length of 1.5m, the reduction of the evaluation area on the both ends of the stabilizer bar allows an economical alternative solution with the yoke magnetization machine DEUTROFLUX UWE, but in an extended length version (1500 mm clamping length). Integrated in the test machine is a pneumatic turn of the stabilizer bars by 60° for a comfortable inspection of the complete welding (Figure 13). For (un-) loading by crane the cabin roof is provided with a pneumatic opening mechanism and the UV lamps are automatically moved into a safety position.

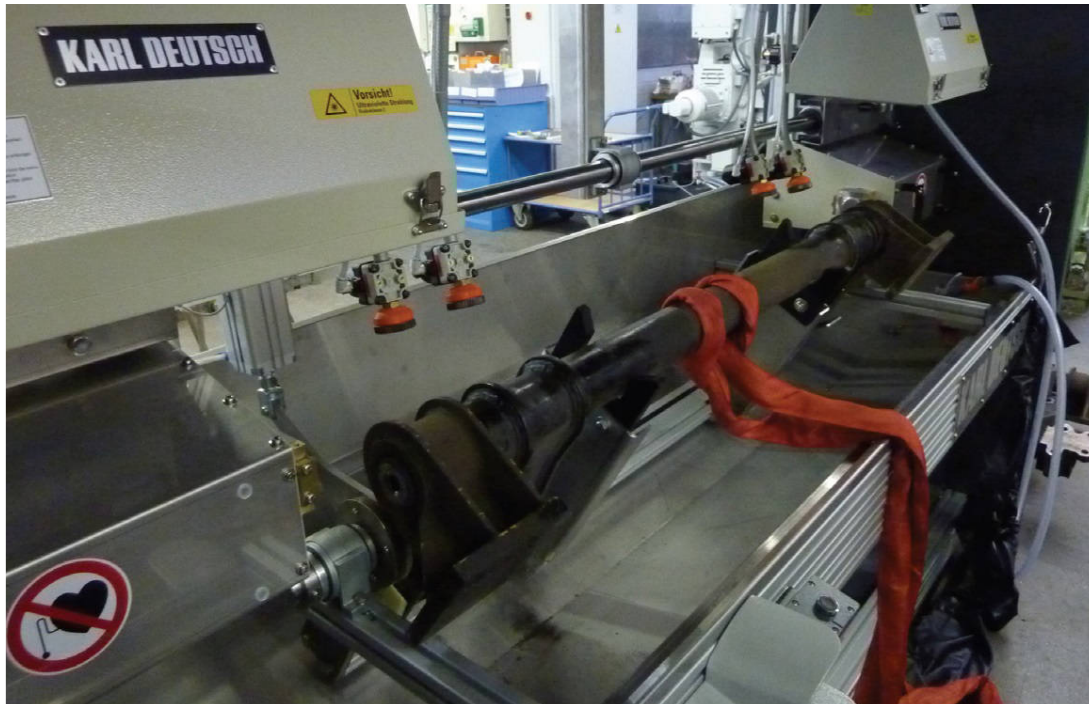


Figure 13. DEUTROFLUX UWE 1500 for stabilizer bars (DB Heavy Maintenance Wittenberge workshop)



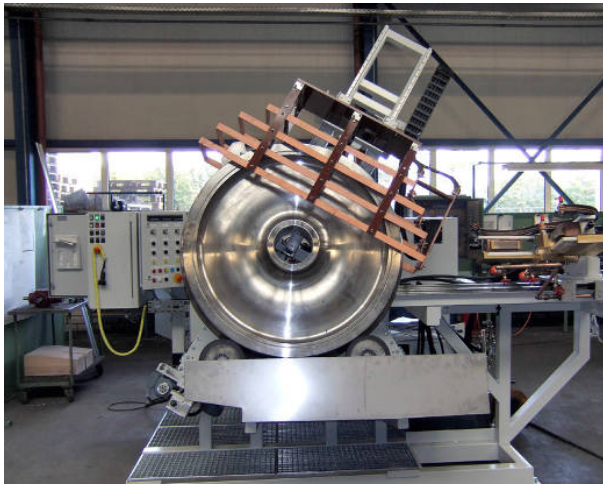
Figure 14. Weld seam testing at both ends of the stabilizer bars

6. Testing of railway wheels and steel tyres in the same machine

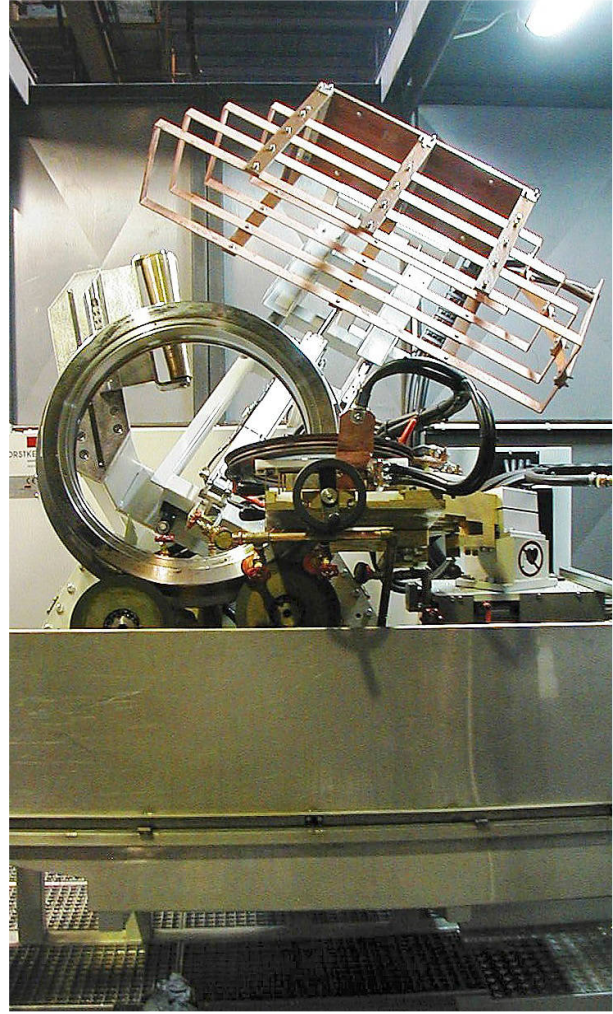
A DEUTROMAT unit for testing forged wheels and steel tyres was installed at the German company BVV (Figure 15). A special trapezoidal high-current coil ("Mindener Coil") is used for magnetization of the wheels. The steel tyres are tested with a combination of high current coil and yoke within the same measurement cycle to assure optimal sensitivity for cracks in all direction. In both cases the parts under tests are rotated for 360° (during magnetisation, spraying and inspection at the same time) to cover the entire surface and to detect cracks of all directions. Loading and unloading is done from top by means of a crane. All magnetization units are installed in the same machine and are separately activated depending on the incoming test part (wheel or tyre).



Darkening cabin and (un-) loading crane



Railway wheel tested with "Mindener Coil"



Wheel tyres tested with hinged coil and yoke

Figure 15: DEUTROMAT for forged railway wheels and steel tyres (BVV, Germany)

7. Testing driving rods of steam locomotives.

Yes they still run! Thanks to the Meiningen Steam Lokomotive works, which is nowadays the last locomotive works for maintenance, repair and overhaul in Western Europe. They use a KARL DEUTSCH machine with moving coil and integrated spraying ring (Figure 17) to test a big variety of components of steam locomotives. Biggest components to be tested are driving rods of up to 4.2m length. For a convenient inspection of all areas the heavy test parts, a motorised turning of the clamped part is provided.

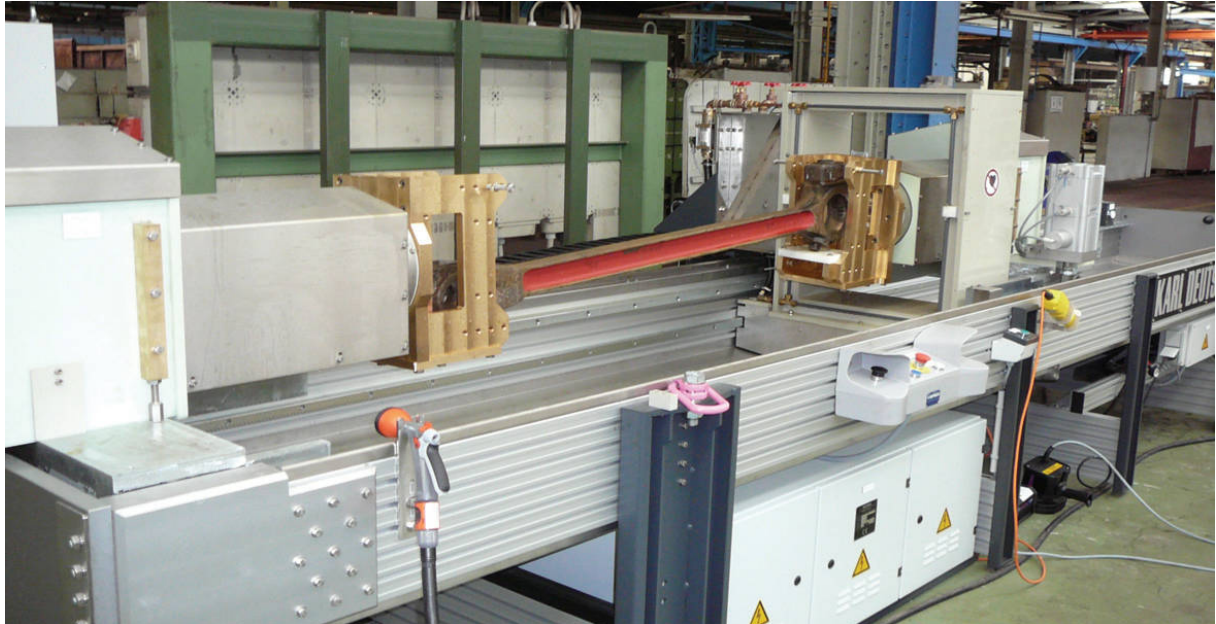


Figure 17. Driving rod of steam locomotive is tested by moving coil (Meiningen Steam Lokomotive works)