**Latest Development in the UT inspection of train wheels and axles**

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**SUMMARY**

AREVA NDE-Solutions specializes in mechanized non-destructive testing (NDT) systems and services and have succeeded in transferring our extensive experience in nuclear inspection techniques and know-how to the inspection of the axles and wheels of trains. Today we have several great references in this market and we have four key product lines to address all the needs of its customer, either in maintenance or in manufacturing.

Since the early 2000’s, intelligeNDT systems & Services has developed many innovative techniques for the inspection of trains wheels and axles in the maintenance depots. In particular we have developed and qualified for DeutscheBahn (DBAG) two important wheel inspection systems: UFPE (underfloor inspection system for train wheels) and the AURA (wheels inspection during re-profiling) 2nd generation. We also have developed two axle inspection units: HAIS (Hollow Axle Inspection unit) and SAIS (Solid Axle inspection unit). All these units, for wheels and axles incorporate our proprietary phased array technology.

The development of phased array based systems was driven by purely industrial considerations: Phased array was the only way to improve the inspection quality while still keeping or even improving the inspection times.

In this presentation we show examples of our qualified systems for wheels and axles as well as our systems for newly manufactured wheels and axles.

**INTRODUCTION**

AREVA NDE-Solutions Germany, intelligeNDT Systems & Services specialized in automated non-destructive inspection systems and services worldwide for the most varied applications and materials. Based on many years of experience we provide a wide-range of highly skilled innovative products and inspection services, and are involved in the development of leading-edge ultrasonic and eddy-current sensor technology, inspection equipment, software and documentation.

Our activities are focused both on the inspection services in the nuclear power plant business as well as the industrial market, as a leading manufacturer of automated and mechanized inspection equipment for the Aerospace und Steel industries. These inspection systems are relying on a state-of-the art multichannel SAPHIR ultrasonic inspection hardware and various software which can be used in a wide range of applications and adapted to suit the task at hand and to comply with customer requirements. Due to our extensive and long experience with automated inspection using both conventional and phased array technologies, as well as having faced the challenges of the nuclear industry (constraints in space and time, high level of automation, no place for failure or unreliability) we have been able to develop ranges of non-nuclear inspection units which all share the
same high level of reliability, ergonomy, precision, repeatability and ability to fit in their industrial environment. Technology is only used if key and tangible improvements can be demonstrated. In this sense Phased array technology has not been deployed as a fancy artifact but because in many instances it is the only solution to improve detectability of defects and provide a better evaluation of the defects while keeping up with inspection times, or even improving inspection times. In other cases phased array technology help reduce the footprint of the inspection heads by combining in one probe many conventional angle probes, as it is the case of inspection of train wheels under the train.

In the Railway industries the wheel sets on the train are the components that are subjected to the highest loads. For the wheels this applies for the heavy loads caused by the rail-wheel-contact. The axles are subjected to continuous cycling stresses. To prevent the occurrence of safety-relevant defects in these components- or at least to safely diagnose the presence of defects before they may cause a failure of these components, reliable NDE-techniques have to be used periodically in order to guarantee a safe operation of personnel transportation. On the other hand, these inspections have to comply with the demand for high availability of the railway rolling stock. This means that there must be a synergy between high reliability and productivity of the NDE-systems involved in the maintenance processes.

INTELLIGENDT supplies automated inspection systems for use in a wide variety of applications for the inspection of wheels and axles, both on and off the car.

INSPECTION OF TRAIN AXLES

Hollow Axle Inspection System (HPS2)

Hollow axle inspection can be performed either on the disassembled wheel set using a stationary assembly, or a mobile unit can inspect the axles while still mounted to the train. INTELLIGENDT has supplied stationary units with phased array techniques to DB AG for optimized coverage of a variety of axle geometries including ICE train axles. To inspect axles from the borehole, the probe is mounted on the end of a shaft. Simultaneous rotation and axial movement generate a helical scan of the entire axle.

The ultrasonic probes are arranged in the internal probe in order to inspect for circumferential and axial defects. The total inspection and handling time per axle is approximately six minutes. For this system, online roll-out C-scan and B-scan images are presented to allow a reliable assessment of the integrity of the axle being inspected.
Hollow axle inspection unit (phased array) in Kassel (Germany)
SAFT: a better solution for hollow axle inspection

Using specific arrays probes, we can use SAFT (synthetic aperture focusing technique) to improve detection and evaluation of small defects or defects located close to geometrical features.

Solid Axle Inspection System (VPS2)

Inspections of solid axles are performed on the wheel sets being disassembled from the train. The wheel set is automatically positioned and rotated in a gantry with four vertical arms delivering flexible gimbaled holders carrying the ultrasonic probes. Phased array technology allows coverage of the entire axle with six probes (search units) distributed over the length of the axle.
The solid axle inspection system enjoys high signal-to-noise ratios over the entire beam angle range allowing clear classification and distinction between defect and geometric indications, even if the defects are very close to the geometric reflectors like geometry transitions.

The bottom-bottom time per axle is approximately four minutes, with a scan time of approximately 1 minute.

Online roll-out C-scan and B-scan images give a clear view for assessing the integrity of the axle being inspected.
INSPECTION OF TRAIN WHEELS

The wheels of high speed train like the Siemens ICE3 (but also the Alstom AGV and TGV, the Bombardier and Kawasaki trains) are inspected at regular intervals. These intervals vary between the operators but in all cases it is rather frequent. The inspection of the wheels as mounted on the train is performed typically every 250,000km and within one shift only (typically the night shift not to interrupt regular operations. At larger intervals, either for repair or simply for re-profiling, the wheels set are disassembled from the train and tested. The inspection technology for both systems are very similar but the mechanics are very dissimilar, we the inspection under the train imposes severe constraints on the dimensions of the probe head.
Under-Floor Wheel Inspection System (UFPE2)

The new-generation UFPE inspection system of intelligeNDT allows inspection of the railway wheels on the train without removing any adjacent parts close to the wheels. The system is travelling in the groove underneath the train and automatically positioned under the wheel set. Subsequently, the system expands its clamps onto the rails and is lifting and rotating the wheelset. The probe system carrier is automatically positioned in a preprogrammed approach onto the tread and the inner face and inspecting the wheel during one rotation. These probe systems are comprised of advanced state-of-the-art phased array technology offering clear advantages over the conventional probe systems for clarity of results, coverage of the areas to be inspected, and user-friendly operation due to the fully automated process and compact probe system design. The compact system allows full coverage of the wheel rim, the wheel flange, and the wheel web with high sensitivity as required by Deutsche Bahn AG experts.

It is important to note that all wheels of the advanced ICE trains are inspected exclusively with the seven phased array UT-Systems from intelligeNDT which have replaced older conventional systems. Based on this experience with the advanced UFPE, another UFPE has recently been installed by intelligeNDT and successfully passed acceptance for the depot in St. Petersburg, Russia.

The bottom-bottom time of these systems for the two wheels of one wheel set is approximately 20 minutes and 2 minutes of scanning time per wheel (2 revolutions of 1 min each).

UFPE 2 probe head with phased array for reduced footprint
UFPE systems

V-Path (patented) technique for defect detection in the web
Stationary Automated Wheel Inspection System (AURA2)

The AURA inspection systems can inspect dismounted railway wheel sets. This inspection is generally performed after re-profiling. Similar to inspection of solid wheel axles, the wheel sets are positioned under a gantry with one or two vertical arms carrying the probe system(s) being lowered onto the tread and the inner face of the wheel during its rotation. Based on the excellent signal quality, high productivity performance, plus the focus on continuity and compatibility of test results with those obtained with the UFPE systems, the Deutsche Bahn AG has ordered four new AURA second generation systems with the options for two additional ones to replace first generation AURA systems.

The first AURA system second generation has recently passed the final acceptance, the second the technical pre-acceptance according to the respective schedules. The approach is very similar to UFPE incorporating advanced phased array techniques allowing for full coverage of the wheel rim, the wheel flange, and the wheel web with the same high sensitivity as required with the UFPE-systems. The total inspection time for two wheels (one wheel set) is approximately six minutes.
Wheel Inspection System within Fabrication (RWI)

Based on our extensive experience with the UFPE and AURA, intelligeNDT has designed and lab-tested an advanced system for inspection of the wheel rim, web and hub according to commonly applied codes and standards. This system uses line scan arrays coupled with conventional probes allowing contact technique inspections of the entire target inspection volume. This offers major advantages in wheel handling particularly regarding adaptation to different tread profiles. The contact approach offers distinct advantages over immersion
techniques which are very sensitive to the high influence of refraction between water column and steel and therefore affecting the beam angles and the beam directivity. Additionally, immersion water management and concerns for continuous supply of clean couplant is eliminated.

Sketch views of the RWI, with inspectable zones

CONCLUSION:

On the basis of more than 35 years of experience in the field of automated testing and inspection technology this presentation contains examples of the railway industries in the development and application of innovative non destructive inspection systems using advanced ultrasonic techniques. These examples presented demonstrate the more than adequate answer to the challenges and stringent tasks for NDE to meet in the overall industry market as well as with specific boundary conditions in the railway industry. The implementation of leading-edge—technology like phased array techniques perfectly adapted to the specific task helps to comply with both – at first sight contradictory – aspects of high reliability and productivity for assisting in the effort to maintain a very high availability of the rolling for a safe transportation operation.