

用于油气产业的大口径无缝钢管的高速旋转头

超声波探伤系统的发展

简介

现代钢管厂能以很高的生产速度制造大口径无缝钢管，这就要求检测设备也能匹配这样的速度。为适应这种产能需求，并从原来只有纵向探伤和测厚/分层功能增加更多的探伤配置能力，新一代超声波旋转头开发出来了。下面简要描述该探伤系统：

旋转头机械系统

最早的超声波旋转头是设计为平端管探伤，现在采用独特的探头臂机构，可以对包括非切头管和墩粗管等各种钢管的管体进行探伤。对于热处理无缝钢管，探靴技术被证明是最适应的，该技术在探头的维护方面还做了连续的改进。

一系列水柱探头块配备不同的探头，可以检测钢管的厚度，分层缺陷，横向纵向和斜向（任意角度）缺陷，并且检测速度比原先设计更快。旋转头可以装配更多的探头，并以更快速度旋转，可以适应弯曲的管端（± 10mm），具有不断改进的探靴技术的优异特性。

所有新出产的旋转头均采用液力轴承，该轴承通过多年生产过程中的运行已被证明十分可靠。一个非常重要的对系统可靠运行的部分是信号传输的滑环和电刷，这里电刷组件已被简化并重新设计，已被证明新设计更可靠更易维护。

探靴式旋转头可检测钢管管径范围变更宽了，现在可供货的旋转头如下：

URP200 40mm to 200mm o.d

URP350 101mm to 350mm o.d

URP425 114mm to 425mm o.d

URP500 139mm to 508mm o.d

URP700 350mm to 700mm o.d

电子处理系统

超声波旋转头配套的发电机和超声信号处理电子学系统，现在也开发出来了。这个用于旋转头的最新电子学系统，可以激发和处理超声波信号的脉冲重复频率（PRF）可达每通道 20KHz 以上，通道数可达 128 个或更高，每个通道性能没有任何缩水的情况下数据不会有任何丢失。该系统可以对不同用户的特定需求进行编程，虽然内置的软件已包含常规的处理和分析功能。其功能包含如下：

厚度测量

- 厚度分析—比较回波信号幅度，确认是否有壁厚缺陷
- 根据多个回波值计算的厚度值的偏差，对厚度测量有效性检查。这对于高速旋转钢管检测方式很有用。
- 界面波和回波跟踪，以得到在厚度方向上能检测出最大的分层缺陷能力。
- 分层信号和背波信号幅度的比较

- 厚度的最小最大偏离度显示，C 扫描显示钢管方向的厚度趋势，这些对钢管轧制都是很有用的反馈信息。
- 自动计算钢管的近似重量和长度。

缺陷分析

- 可选择的连续触发次数和比例触发次数
- 一对探头对射布局同时检测。对于增加灵敏度检测特定类型的缺陷很有益处。
- 自动校正——门位和增益设置
- 门内增益调节——特别对横向探伤有益
- 缺陷长度甄别
- 缺陷信号轮廓捕捉，比较对射探头信号，用于缺陷刻槽外形特征分析
- 探头超声波自发自收，对于横向探头检测孔形缺陷有益。
- 缺陷信号幅值与厚度缺陷比较，优先标出能证实的操作。
- 多组门位及触发顺序，以获得横向缺陷最小的检测盲区
- 自动诊断系统，包括探头输出退化的识别

辅助设备

通常情况，即使采用最好的机械和电子设备，要获得可靠的检测结果，也必须依赖和设备相连的辅助设备的。可靠操作至关重要，所以 Unicorn 也非常注重辅助设备的可靠性和有效性，诸如跟踪和喷标系统，水循环系统，安全保护

系统，辊道传感器，编码器，驱动系统以及为便于维护的自动故障诊断系统。

钢管良好的夹送对于可靠检测也是非常重要的。Unicorn 推荐，在旋转头的入口和出口均附加两棍夹送系统。

新一代高速旋转头系统的优点概述：

新一代超声波旋转头检测系统，现在可为 OCTG 管制造商工厂以更灵活的方式进行超声波无损探伤。更快的检测能力，以及可以在切管头之前对管体进行探伤的能力，允许将检测设备布局于生产线的更前端，这就有很明显的优点：**管体检测之后再切管头**，这样就保证了整个管体被完全检测了（无管端盲区，无需管端检测设备），并且，探伤机提前，钢管的品质便可提前些检测到，从而可以更早的采取修正措施。每根钢管的详细检测结果，可对缺陷特征进行分析，以质量控制，提高生效率，另一方面可向下游用户提高检测质控信息，这些都可以带来真正的效益。

这些设备及其在工作环境下 7x24 连续工作的能力，现代超声波旋转头检测系统，可以作为钢管生产线的组成部分，而不仅仅视为是生产线的瓶颈，仅仅在必须的时候才使用。

原文:

Development of High Speed Rotary Probe Ultrasonic Testing System of Large Diameter Seamless Pipes for the Oil and Gas Industries

Introduction

Modern tube mills now produce large diameter seamless pipes at relatively higher production rates and as such the demands made on testing systems are also that much greater in terms of testing speeds. To meet this ever increasing demand and also to accommodate the need for more inspection directions than just longitudinal and thickness/lamination checking, a new generation of Ultrasonic Rotary Heads has been developed. The following summary descriptions provide details of the capabilities of these new rotary test systems:

Rotary Head Mechanics

The original operation of ultrasonic rotary heads were generally designed to test tubes with square cut ends but now more recent designs incorporate a unique probe arm lift mechanism which enables tubes with a variety of end conditions e.g. un-cut or upset ends, to be tested. The contact shoe principle has always proved to be the best technique to use when testing hot finished seamless pipe, and this technique has been retained with improvements to probe assemblies in terms of maintainability.

A range of water column probe blocks have been designed to carry novel transducer arrays and inspections for thickness, laminations, transverse and oblique (variety of angles) defects can now be carried out simultaneously and at much higher testing speeds than ever before. The rotary heads can be equipped with many more transducers and can run at faster rotational speeds; the ability to cope with off-centre pipes ($\pm 10\text{mm}$) due to hooked ends, has always been an excellent feature of the contact shoe design and this aspect has been improved still further.

All the new range of rotary heads have retained the tried and tested hydrostatic bearing designs which have proved very reliable in a production environment over many years of operation. One area which is vital to the reliable operation of the system is the signal transfer system via slip rings; here the brush assembly has been simplified and re-developed in recent times to provide easier maintenance.

The range of pipe diameters that can be tested with the contact shoe design has been extended, and the rotary heads that currently can be supplied are:

- URP200 40mm to 200mm o.d
- URP350 101mm to 350mm o.d
- URP425 114mm to 425mm o.d
- URP500 139mm to 508mm o.d
- URP700 350mm to 700mm o.d

Processing Electronics

As with the rotary head mechanics the multichannel electronics for generating and processing the ultrasonic data has recently been developed to take advantage of the advances of the new data processing technology that is now available. The state of the art electronics used in conjunction with the rotary head, can generate and process ultrasonic data at P.R.F. rates greater than 20KHz per channel and from 128 channels or more without any compromises being made or loss of data from any individual channel. The electronics is fully programmable to cater for any customisation requirements and standard software is available for a whole array of facilities and analysis; the following list (although not exhaustive) provides an idea of the new systems capabilities:

Thickness Measurement

- Thickness Analysis – Comparison of back wall signal amplitudes to ascertain presence of bore drop out type defect.
- Thickness Measurement Validity checking by means of division of various back wall counts; ideal for high-speed rotary tube testing.
- Interface and back wall following to maximise through thickness inspection depth for laminations.
- Signal amplitude comparison between lamination signal and back wall.
- Min Max Eccentricity chart displays; C Scan display showing thickness trends along the pipe; useful feedback for setup information at the production mill.
- Automatic computation for approximate tube weight and tube length.

Defect Detection

- Selectable successive shots and proportional shots.
- Coincidence detection from opposite pairs of probes. Useful for testing with increased sensitivity for certain types of defect.
- Auto calibration – gates and gains.
- Gain step profile gates – particularly useful for transverse inspection.
- Defect Length Discrimination.
- Defect Signal Profile capture; look at comparison of capture from opposite side – defect signature analysis!
- Pitch and Catch technique concurrent with pulse echo technique with same probes; useful for transverse probes for detection of bore drop-outs.
- Priority list for prove up operation. Defect signal amplitude compared with thickness.
- Multiple gates and sequence correlation to achieve minimum un-inspected end length for transverse inspection (end testers).
- Automatic diagnostics including recognition of probe output deterioration.

Ancillary Equipment

Very often, even with the best test mechanics and electronics a good reliable production test also relies on the ancillary equipment used in conjunction with the test system. Reliable operation is crucial and Unicorn have also paid particular attention to ensuring the reliable and efficient operation of items such as

the tracking and paint gun marking of detected defects, water Recirculating systems, operator safety features, conveyor sensors and encoder driving mechanisms and automatic fault diagnosis for ease of maintenance.

Good tube restraint is also a very important aspect in performing a good test, and Unicorn recommend to customers that they use two pinch rolls on both to inlet and outlet side of the rotary head.

Advantages of the New High Speed Rotary Systems

The new generation of ultrasonic rotary test systems available today provide the OCTG pipe manufacturer with more flexibility in terms of location of the ultrasonic test systems within the production plant. The ability to test at faster throughput speeds and to test prior to end-cutting operations allows the option of siting the test system much earlier in the process route; this provides the obvious benefits of having a completely tested pipe after the pipe ends are eventually cut back. In addition the quality of the pipe produced is determined much earlier in the process route, thereby allowing possible corrective action and/or savings been made. The detailed results information for each pipe, together with the ability to carry out a defect signal profile analysis on each defect detected, can lead to genuine savings in terms of production efficiency, as well as providing a wealth of quality control information.

With all these facilities and proven ability for the systems to work in a production environment for 24 hours 7 days a week the modern ultrasonic Rotary Testing Systems now available should be considered as an integral part of a Pipe Production Plant and not merely be viewed as a production line bottleneck which should only be used when absolutely necessary.

Author

C. James

C.Phys., M.Inst. P., M.Inst.NDT

<http://www.unicorn-automation.co.uk/article7.htm>