Induction bending takes an innovative route

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Abstract

A Technology CPU controls the hydraulic and electrical axes of large induction bending machines

Introduction

Precision control of hydraulic and electrical drive axes is essential for high reproducible quality in the induction bending of large, thick-walled pipes. A leading manufacturer of bending machines has coordinated the interplay by means of a PLC with integral motion control and hydraulic functions. This approach is highly accurate, dispenses with a separate hydraulic control, and simplifies and standardises the handling – as well as being cost-effective.

Bending steel pipes of up to 1.6m in diameter, 120mm wall thickness and 18m in length places high demands on the machining process. Despite the large scale, the angle tolerances are small (±0.5° for bending angles up to 183°) and a high repeat accuracy is demanded. For this reason, wall thinning and non-circularity must be constrained in the area of the bend. In the ideal case, it should be possible to implement several bends in sequence to obtain three-dimensional piping constructs in a single clamping operation.

Since bending processes can extend over several hours for certain materials and applications, constant velocity is essential for the hydraulic feed axis, which must be accurately acquired, controlled and coordinated with other axis movements. This ensures that the heat induced in the material can be adequately controlled.

Since the 1980s, AWS Schäfer Technologie GmbH (see below) of Wilnsdorf, North Rhine Westphalia, Germany, has developed into one of the leading manufacturers of induction bending machines [Figure 1]. Some of its patents, in particular, have impressed a growing number of customers, one reason being that in contrast to familiar techniques the company masters almost contact-free bending without the need for expensive tools.

Another factor frequently noted in the decision to purchase is the system-wide control and drive technology favoured by AWS, a perfectly interacting complete package from Siemens.

Expertise in piping

AWS Schäfer Technologie GmbH of Wilnsdorf (North Rhine Westphalia, Germany) has been developing and building efficient machines for manufacturing and bending pipes for more than 50 years. More than 3,000 machines have been commissioned around the world so far.

Induction bending machines are used in various sectors of industry, for applications in the areas of apparatus construction, oil and gas pipeline technology, power plant construction, refineries, shipbuilding, steel construction, architecture and traffic control systems.

In contrast to other pipe bending machines, the AWS Schäfer techniques are characterised by:

- Bends with:
  - Lowest R/D ratio (up to 1.25 x D)
  - Bending angles from 1° to 183°
  - Complex, three-dimensional bending geometries
  - Minimal wall thinning and non-circularity
  - Bending radii from 75mm to infinity
  - Helical bends
- Multiple bends with fewer welds and therefore minimal inspection requirements

- Bending of ferritic, austenitic, demanding duplex materials and materials used in power plant engineering, such as P91/P92
- Maintenance-optimised operation and maximum availability
- Short set-up and handling times

AWS Schäfer also develops and builds high-performance pipe calibration machines, T-joint fitting machines, pipe end expanders, pipe end milling machines, hydroforming machines and special machines.
Noticeable improvement

The bending technique of AWS builds on a rugged machine bed that is traversed by means of hydraulics in the lengthwise direction and servo motors in the lateral direction. The feed trolley is mounted on this bed and features a rotatable collet for three-dimensional bending.

One or two hydraulic cylinders move the feed trolley depending on the feedrate force required. To shorten the construction length, the feedrate force is redirected via rollers and chains, and the pipe is pushed through the inductor at constant speed [Figure 2] into the pivoted bending arm.

The pipe is fixed into the bending lock in the bending arm such that the desired bend is achieved as a result of the forces and movements applied. A decisive process engineering advantage here is that the pipe is not bent over a bending roll that has been adapted to the respective diameter. “This results in considerably less non-circularity in contrast to other techniques,” emphasised sales director Winfried Heinemann and technical manager Dietmar Otte.

Joint response to a single command – High-precision hydraulic feed...

All sequences and traversing movements of the SRBMI machine(s) are coordinated by one Simatic S7 317T Technology CPU from Siemens (referred to from here onwards as the “T-CPU” – Figure 3). The machine manufacturer decided to implement this controller because it enables a combination of hydraulic and electrical axes to be precisely controlled with simultaneous coordination of up to 32 axes. The recently updated FW Version 4.2 also supports advanced hydraulic functions, such as pressure and force control, as well as pressure limiting. This dispenses with the need for a separate hydraulic controller in the more hydraulically demanding hydroforming machines of AWS, thus saving on the associated interface, installation and programming costs. It also ensures that the control cycle times are short.

In the case of induction bending, AWS uses hydraulics for precision control of the feed velocity and the clamping forces to generate the necessary bending torques by means of a servo valve and a technology function block. The actual values are acquired by 25-bit SSI encoders throughout which are integrated into the system via a Simatic ET200S SSI Technology Module. A comprehensive package of PLCopen-compatible function blocks is available for the Technology CPU used for closed-loop control, which can be interconnected like conventional standard function blocks in Simatic Step 7. This is possible simply by expanding the engineering platform with the S7 Technology option package. There was no need to learn a new motion control language, which made it easier and safer for the application programmer of the bending machine to make a start with the new system.

The “GetCharacteristics” technology template proved to be extremely easy to use for automatically recording the hydraulic characteristics of proportional and servo valves. It acquires the non-linear characteristic of the controlled system [Figure 4] and transfers this to the technology processor.

The technology firmware compensates for non-linear sections and dead zones on the basis of this information. The result is a reproducible control response with a high degree of closed-loop control accuracy. “We can achieve a tolerance of ±1mm/min at a maximum feed velocity of up to 100 mm/min and a temperature tolerance of ±5°C at a level of 1,000°C,” said Dietmar Otte, “and therefore the accuracy that we need.”

Figure 2: The precise amount of heat is introduced to the pipe via the inductor as determined by the material and the specification.

Figure 3: A Simatic 317T Technology CPU from Siemens maintains the constant velocity of the hydraulic feed axis and perfect coordination with further servo axes – ensuring a constantly high and reproducible bending quality.
A new development from AWS concerns a manipulator controlled via the T-CPU that is also hydraulically driven in the feed direction. This centres and guides the pipe during loading and unloading, so that the inductor and cooling no longer have to be dismantled, thus reducing the setup times by more than half.

... and coordinated traversing using servos

When large forces are less important than precise positioning and synchronisation of the axes, AWS relies on electromotive drives. These can be used to approach the starting position (in the longitudinal and lateral direction), for loading and unloading, for setting the bending radius and for matching the inductor to the feed velocity or to the change in wall thickness, as well as for both driving and balancing the torque of the bending arm and for traversing.

The system-wide Siemens solution used for this purpose is the modular Sinamics S120 drive system in booksize format (poss. in Figure 3) in combination with servo-gearred motors of the 1FK7 series. The T-CPU communicates with the Sinamics drives via the isochronous Profibus DP (Drive) interface. This creates the basis for high-precision, dynamic motion control.

The controller also provides various motion control functions for this purpose, which support position control of single axes, as well as easy synchronisation of the complex motion of multiple individual axes. This is particularly useful for synchronising gears or curves, for example, where the synchronised axes can be coupled to a virtual or real master.

A further three servo axes are available for traversing the inductor in the horizontal and vertical directions (coupling distance from the pipe). The degree of wall thinning can be influenced in this manner and the introduced heat can be varied in the different phases of the bending process.

Apart from the motion control functions already mentioned, the T-CPU Simatic 317T also implements the logic operations of the bending machine in the standard PLC section and ensures smooth execution. “With the T-CPU, we have found the perfect controller for these and other applications, not too complex and therefore cost-effective, easy to operate, and absolutely impervious to the highly inductive power of up to 1.600KW,” says Winfried Heinemann.

Everything from a single source

The T-CPU has given AWS Schäfer their new standard controller for induction bending, calibration and hydroforming machines. Winfried Heinemann: “Aside from the technical and commercial advantages of the T-CPU, the consistent use of Siemens components in large parts of the world has proved to be a genuine sales argument. Because customers know that all components are certified for use around the globe, and that they can obtain spare parts quickly and, if necessary, comprehensive support as well.”

The company has also already appreciated the benefits of this last point when an application engineer from Siemens supported them with replacing the previous automation solution with the Simatic T-CPU, the simultaneous introduction of the new drive system, and subsequent optimisation of the programming and execution. The complete package is such a perfect fit, concluded the North Rhine Westphalian machine manufacturer.

Industry-compatible operator control and monitoring

The latter also applies to the HMI system of the bending machines, an industry-compatible Simatic Panel PC677B with a Simatic WinCC flexible user interface for creating and monitoring bending programs. And to a Simatic touch panel in the control cabinet door of the induction system from another supplier. The panel PC is also an engineering station and gateway for remote access, in this case using freely available software.