

Encircling ET Inspection on Corrugated Tubes Destined to Gas Tubes for EGR Heat Exchanger

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Abstract

Subsidiary of Vallourec Group, Valtimet is the world leader for specialized welded tubing products, both straight and special formed tubes. On titanium, stainless steel, super stainless steel, as well as copper alloy, they are dedicated to markets of condenser, feedwater heater and MSR (Modular Stellarator Reactor) applications of highly sophisticated power generations. Valtimet is also the leader for tubing products of desalination, chemical processing, petrochemical and automotive industries.

Located in France, China, the United States, India, and South Korea, Valtimet always keeps the most demanding quality control on its premium products.

This article describes the solution developed by Valtimet, together with CEV (the Research Centre of Vallourec), for the Eddy-Current (ET) inspection of corrugated tubes, which are destined to automotive industries as gas tubes for EGR (Exhaust Gas Recirculation) heat exchangers. The special corrugated form of these welded tubes generates noises stronger than the signals of reference notches, making the inspection impossible nowadays by existing systems.

This solution, based on the signal analysis, has been validated on the ET bench of Valtimet France, and can potentially be industrialized in the plant of Changzhou Carex Valinox Components Co. Ltd in China for its production of these corrugated tubes (Carex Corrugated Tubes).

Keywords: Encircling ET, Noise diminution, Frequency analysis, Corrugated tube

1. The Vallourec Group

With more than 50 industrial and commercial companies all over the world, being full or major shareholder of over 50 plants on four continents: Europe, North America, South America and Asia, the Vallourec Group is the world leader of steel tubes products on the world markets of Oil & Gas and Power Generation, with a complete product range for each market. Having a good balance between its main markets and its numerous speciality products, the Vallourec Group is also the world leader on numerous niche markets of Petrochemicals and Mechanical Engineering.

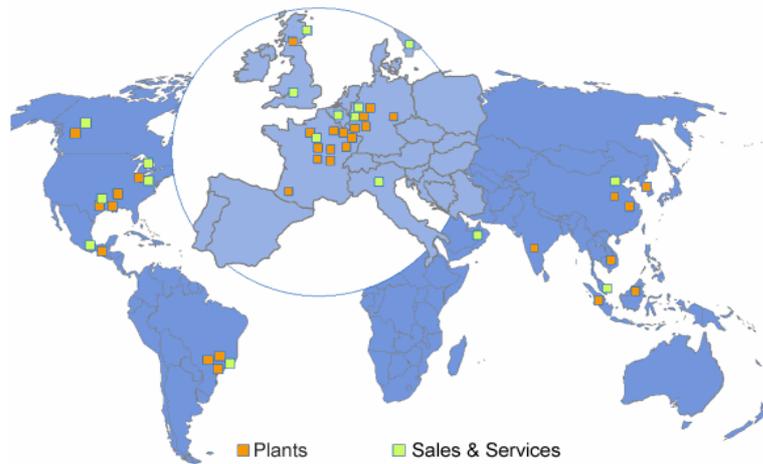


Figure 1: Subsidiaries of Vallourec Group all over the world

Development through innovation is the Vallourec Group's key policy through the past and for the future. The Research Centre of Vallourec (CEV) is the most active contributor to this policy. Designing, improving and promoting products, equipment and processes of tomorrow are the main tasks of our research team. Specialised in Non Destructive Testing (NDT), Metallurgy, Corrosion, and Calculation, to mention a few, represent the basic foundations of CEV's know-how.

2. Valtimet Society of the Vallourec Group

Valtimet is the world leader in the manufacture of specialized welded tubes. Providing a complete range of tubing for high sophisticated power generation applications: titanium, stainless steel (ferritic, austenitic, duplex), super-stainless steel and copper alloys tubing for condenser, feedwater heater and MSR applications. Not to forget its tubing products for desalination, chemical processing, petrochemical and automotive industries.

With plants in France, the United States, China, India and South Korea, the company remains close to its customers and offers a competitive range of products engineered to the highest quality standards.

3. Subsidiaries of Valtimet in China

Three plants of Valtimet are located in China: Changzhou Carex Valinox Components Co. Ltd, Changzhou Valinox Great Wall Co. Ltd, and Xi'an Baotimet Valinox Tubes Co. Ltd. This last one is a joint-venture between Valtimet, Changzhou Valinox Great Wall and Baoji Titanium (China) and Timet (USA).

Focused on the Asian and European markets, their tubing products for power generation, surface condenser and feedwater heater applications, such as straight and U-bent welded tubes of stainless steel, titanium and copper alloys, have been qualified by customers as ALSTOM, BALCKE DÜRR, DONGFANG, HBW, HTW, SIEMENS, SPEC, TOSHIBA ... Not to forget their tubing products for the local chemical processing industries as well as desalination plants.

All of the three plants of Valmet in China are equipped with modern NDT installations: Eddy Current Testing (ET) in-line at Changzhou Carex Valinox Components Co. Ltd; Ultrasonic Testing (UT) and ET in-line & off-line at Changzhou Valinox Great Wall Co. Ltd; UT and ET in-line at Xi'an Baotimet Valinox Tubes Co. Ltd.

4. Carex Corrugated Tubes



Figure 2: Photo of CAREX Corrugated Tube

Diameter of ~7mm and wall-thickness of ~0.26mm, these tubes are welded and then corrugated to improve the efficiency of heat exchange.

The watertightness testing of these tubes is carried out only before the corrugation nowadays. This is because encircling ET coils are used for this kind of testing, and the form of corrugation on the corrugated final products (Figure 2) make this testing impossible by existing systems:

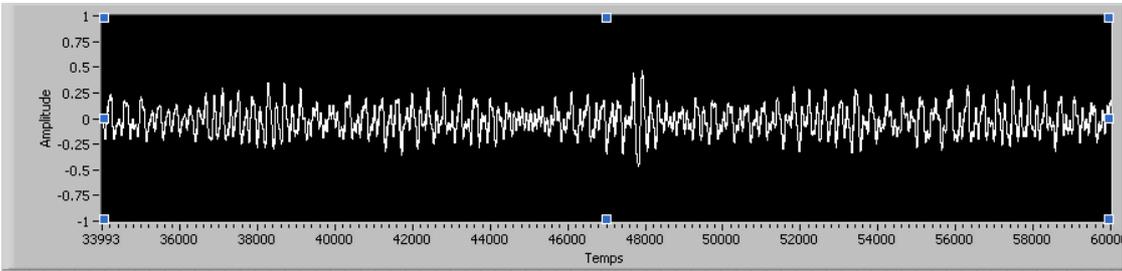


Figure 3: Original encircling ET signals of a corrugated tube, with two reference drilled-through holes, one of Ø0.8mm, another of Ø0.8mm

The encircling ET signals of the reference drilled-through holes, one of Ø0.8mm and another of Ø0.6mm, are completely drowned by the noises generated by the corrugations.

5. Solution for ET Inspection on Carex Corrugated Tubes

CEV (the Research Centre of Vallourec) together with R&D department of Valmet, have developed a system dedicated to the encircling ET inspection of these corrugated tubes.

Thanks to powerful signal analysis instruments, the signals of defects can be distinguished from all the noises of corrugations shown in the Figure 3. The spectrogram of the total signals of the corrugated tube (with defects) can be obtained and analysed:

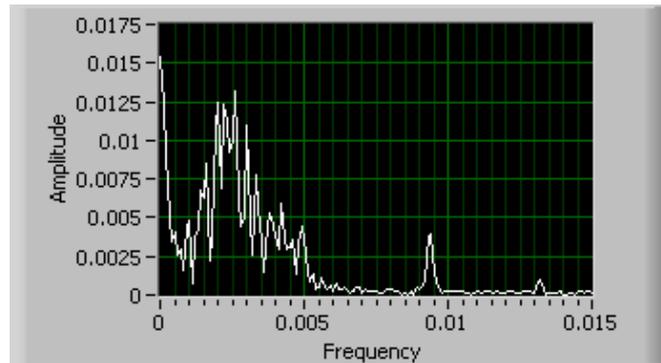


Figure 4: Spectrogram of the entire corrugated tube

Then the spectrogram of a defect (e.g. a drilled-through hole) alone can also be obtained:

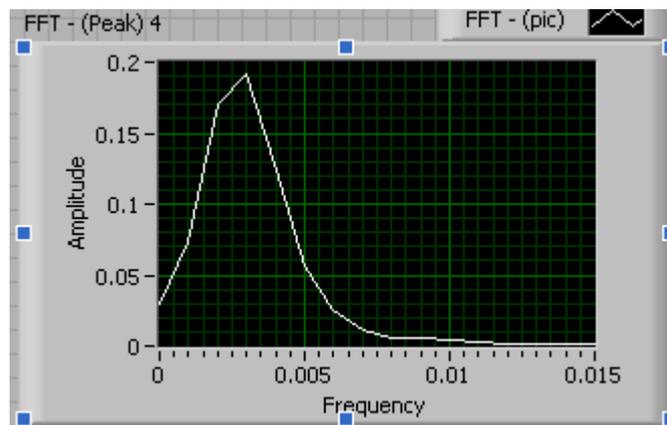


Figure 4: Spectrogram of defects to detect

By comparing the two spectrograms, we obtain necessary information about the characteristic frequencies of signals which interest us, as well as those to eliminate.

Studies on the differences of these characteristic frequencies give us main ideas of the kind of filtering algorithm to apply and its parameter settings for a satisfying S/N of defects on a corrugated tube, e.g. sharp transition between the passband and the stopband, etc.

Faster execution speeds is also required to meet up with the industrial inspection speed. The solution has been tested on industrial recordings, and the S/N of a drilled-through hole of $\varnothing 0.8\text{mm}$ after treatments is satisfying according to the international standardization.

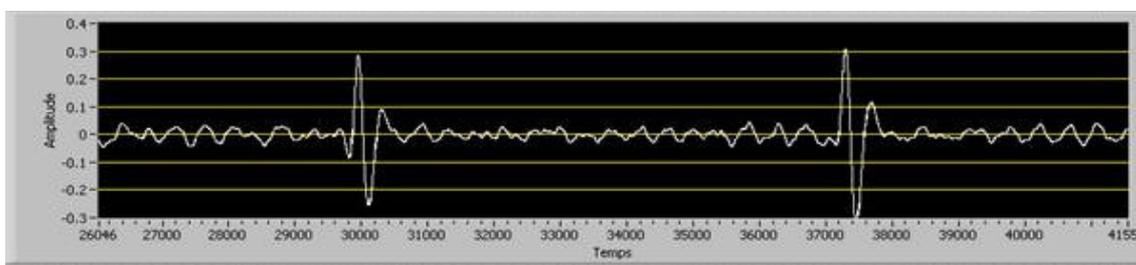


Figure 4: Encircling EC signals of a CAREX corrugated tube, after treatment, with two reference drilled-through holes of $\varnothing 0.8\text{mm}$

All the treatments are real-time processing, and the system keeps the industrial cadence without generating additional delay.

6. Conclusion

This article demonstrated the interest of using signal analysis instruments for the NDT testing on special formed tubes. This solution described above has been validated on the ET bench at Valtimet France, and can potentially be industrialized in the plant of Changzhou Carex Valinox Components Co. Ltd in China for its production of CAREX Corrugated Tubes.