New Hand-Held Eddy Currents Flaw Detector

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Abstract
New eddy current flaw detector EDDYCON (VD 3-81) is developed after long inspection life of previous models and imbibes all field experience and customers case comments. Due wide operational frequency (from 50 Hz to 12 MHz) and possibility for different type eddy current probes connecting EDDYCON (VD 3-81) type flaw detector have universal large-scale properties to solve different inspection problems. The presented device is supplied with two frequency mode and different type signal processing and filtering algorithms. Device has convenient for customer interface and 3,5” high resolution color display. Flaw detector can be supplied with rotary scanner and distance sensor also. Due small size and weight (only 0,8 kg) it is really hand-held device possible to be operated only by single hand.
Due such EDDYCON (VD 3-81) flaw detector features in combination with selective multidifferential type eddy current probes many difficult inspection problems were solved, for example:
- The detection of the subsurface hidden fatigue cracks in multilayer aircraft constructions;
- The detection of subsurface flaw in aluminum alloy welded joints;
- The detection of surface cracks in steel castings with roughly finished surfaces;
- The detection of the fatigue cracks on side surfaces of fastener holes;
- The detection of cracks and near welding stress-corrosion damages through wrapping of operated pipelines and so on.

Keywords: eddy current (EC) flaw detector, EC probe, operational frequency, stress-corrosion cracks,

1. Introduction

Some years ago eddy current (EC) flaw detector VD 3-71 was developed and proposed to NDT market. This device held universal properties typical for majority of the modern portable EC flaw detectors, such as: a wide operational frequency range, possibility to use different types of EC probes, 2-frequency mode for noise suppression, different filtering algorithms, possibility to store results obtained and so on. During VD 3-71 inspection life some ordinary and extraordinary NDT problems were solved [1,2]. All this time the process of permanent device improvement was carried out and many comments obtained from customers were realized. Consequently new EC flaw detector EDDYCON (VD 3-81) with advanced functionality was proposed (fig. 1).

Figure 1. EDDYCON (VD 3-81) eddy current flaw detector
2. EDDYCON (VD 3-81) description and technical specifications

EDDYCON (VD 3081) was designed to be really easy-to-use hand-held device possible to be operated only by single (for example left) hand with EC probe for inspected surface scanning in the another (for example right) hand (fig.2). The form of device housing is very comfortable and realizes optimal weight distribution on the operator palm. EDYYCON is portable (18.8×10.7 cm) and light (only 0.8 kg) device with easy-to-use function keys. Flaw detector was supplied with bright 3.5” color display with 320×240 pixels image resolution (fig. 3). Day or night screen modes and full screen mode also are possible. The device side-strip menu is easy understanding by experienced operator. Due to the new processor unit implementation the main memory capacity and clock frequency were increased to 128 MB and 400 MHz respectively. Due to the new software-logical integrated chip with increased memory more effective algorithms for signal processing and filtering are applied.

![Figure 2. Easy operated by left hand thumb with free right hand for probe scanning operation](image)

Other EDDYCON (VD 3-81) specifications are presented in the next table.

<table>
<thead>
<tr>
<th>Specification</th>
<th>Details</th>
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<tbody>
<tr>
<td>Frequency range</td>
<td>50.0 Hz – 12.0 MHz</td>
</tr>
<tr>
<td>Phase</td>
<td>0-360° with 0.1°, 1° increments</td>
</tr>
<tr>
<td>Pre-gain</td>
<td>-6.0 to 40.0 dB with 0.1; 1; 6 and 10 dB steps</td>
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<tr>
<td>Gain</td>
<td>0 to 30 dB with 0.1; 1 and 10 dB steps</td>
</tr>
<tr>
<td>Sampling frequency</td>
<td>1 to 8 kHz</td>
</tr>
<tr>
<td>Filters</td>
<td>Conventional High, Low and Band Pass. Additional Differential or Average Modes.</td>
</tr>
<tr>
<td>Test modes</td>
<td>Single, Two frequency and Mix</td>
</tr>
<tr>
<td>Flaw alarm</td>
<td>Circle, Level, Sector or Trapezium (figure 3)</td>
</tr>
<tr>
<td>Setting number</td>
<td>&gt;100</td>
</tr>
<tr>
<td>Interface</td>
<td>USB 2.0</td>
</tr>
<tr>
<td>Casing</td>
<td>20.0×11.0×9.5 cm</td>
</tr>
<tr>
<td>Temperature range</td>
<td>-20°C to +40°C</td>
</tr>
<tr>
<td>Internal power</td>
<td>NiMH Battery with 5.5 hours life and 3 hours full charge time</td>
</tr>
<tr>
<td>External power</td>
<td>AC – 100-240 V, 50-60 Hz, 50 Watts</td>
</tr>
</tbody>
</table>
EDDYCON (VD 3-81) flaw detector is supplied with two separate connectors for Absolute (one coil) or Reflection (bridge) EC probes. When absolute one-coil EC probe is connected to single Lemo00 connector the resonant test mode is realized.

![Figure 3. “Level” (left) and “Sector” (right) type boxes for automatic alarm](image)

EDDYCON (VD 3-81) flaw detector can be supplied with rotary scanner and distance sensor (figure 4). The rotary scanner is very important for hole sidewall inspection. The rotation speed can be selected by software in the range from 600 to 3000 rev/min.

![Figure 4. Rotary scanner (left) and travel distance sensor (right)](image)

Due to the developed rotary scanner the actual problem of fatigue crack detection in aircraft fastener holes in dynamic mode was solved. On figure 5 we can see hole part of relevant NDT 1084-10DIA reference standard with corner artificial like crack slots and signal responses obtained for minimal size slot (B = 0.5 mm, C = 0.5 mm) in 3.2 mm diameter hole.

![Figure 5. Reference standard with corner slots in hole and EC signal response obtained](image)
As it was mentioned above different types of EC probes can be work with EDDYCON (VD 3-81) flaw detector. But most difficult and important NDT problems were solved by multidifferential type EC probes developed some decades ago [3,4]. The main features of such probes are: high sensitivity with sharp signal response to lengthy (cracks) and local (pores, pitting and local corrosion) flaws; good lift-off suppression; high penetration when low operational frequency is applied etc [4-6]. For local flaw this probes have 4 point signal distribution [5] (figure 6).

3. Some representative examples of EDDYCON (VD 3-81) application.

3.1 Inspection of components with roughly finished surfaces

The goal of this chapter is to show the EC method possibility to detect surface breaking flaws in casting components with rough surface [7]. For these investigations special samples with \( R_z \) 320 roughness and artificial flaws were prepared. In addition the component fragments with natural crack and pores were selected out from casting manufacturer. The investigations show that MDF 1201 EC probe demonstrates the best signal to noise ratio during the inspection of samples with rough surface. The MDF 1201 type EC probe signal responses obtained on the operational frequency 17 kHz are presented on fig. 7-8. Fig. 7 represents the signals obtained from 0.6 mm depth and 10 mm length crack without the differential signal processing. On time-base defectogram (fig. 7, right) the noise connected with tested surface irregularities also is visible.

Fig. 8 represents the signal from the same crack after the differential signal processing with 10 signal samplings. The comparison of signal on fig. 7 and 8 shows the effectiveness of differential signal processing for slow signal trends suppression. The differentially processed signal reverses the sign during the scanning the flaw zone.
Presented results show that EDDYCON (VD 3-81) flaw detector in connection with multidifferential EC probe and simple differential signal processing algorithm can be effectively applied for cast rolling stock component inspection [7].

3.2 The detection of stress-corrosion cracks in near welding zone of long distance pipelines

To prevent long distance gas pipeline accidents nondestructive testing (NDT) methods are needed to be applied for well-timed detection of stress-corrosion cracks. Some special techniques based on different nondestructive methods for internal along pipe passing usually are applied for this purpose. Majority of these techniques are based on electromagnetic-acoustical or magnetic methods. But long practical experiences show that all these methods have limited reliability and additional NDT methods are needed to localize the damaged zone after relevant part of pipeline was uncovered. In this chapter we present preliminary investigations about possibility of EDDYCON (VD 3-81) flaw detector to solve this problem by application the technologies presented in previous chapter. The investigations were carried out with real the pipeline fragment with real stress-corrosion crack in near welding zone obtained from pipeline operator. In this fragment 3 specific zones were selected for scanning by EC probe. The scanning line was executed in transversal relatively welding and stress-corrosion cracks direction (fig. 9).
The “Circle” type flaw alarms were adjusted by 0.5 and 1.0 mm depth slots. Signal response from 0.5 mm slot must don’t exceed the 1 level. And signal response obtained from 1.0 mm depth slot must be bigger than the 2 alarm circle. The operational frequency was 130 kHz. Firstly the signal responses were obtained from welding in free crack zone without any coating to obtain maximal signal response from welding (figure 10).

As we can see the welding signal response is not bigger 1 alarm circle even without coating. Next inspections were executed in presented on figure 3 zones with stress-corrosion cracks through 1.5 thick standard dielectric coating.

Presented result shows the EC method effectiveness to localize stress-corrosion cracks without protective coating removal.

4. Conclusions

EDDYCON (VD 3-71) flaw detector in combination with selective EC probes can be applied to solve the most difficult NDT problems. As representative examples in this paper the results of surface crack detection in steel castings with roughly finished surfaces and stress-corrosion crack detection without protective coating removal.

References