EXPANSION OF POSSIBILITIES OF EDDY-CURRENT DETECTION DUE TO APPLICATION OF MULTI-FREQUNCY TESTING METHOD

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Abstract
The report describes advantages of a multi-frequency highly sensitive eddy current flaw detector that uses a pocket PC and satisfies the modern demands of NDT means. The eddy current data acquired using a multi-frequency approach allows for signal-to-noise ratio enhancements and filtering of disturbing signal

1.   VD-90NP eddy current flaw detector

The latest development in eddy current defectoscopy is the VD-90NP eddy current flaw detector (Fig.1.). It features the highest sensitivity and is capable of detecting defects of 0.1 mm and less depth in ferromagnetic and non-magnetic materials. The distinguishing feature of the device is the operating frequency range 100 Hz-2MHz that allows everyone to solve almost all tasks of eddy current defectoscopy. Moreover, the device can be powered by both a battery and mains and it can have a boost battery to prolong the time of free running. The device design employs the PLED high contrast display with the wide viewing angle that features high information display speed at subzero temperatures.

The device design allows the operator to hold the device on his wrist or on his waist belt. Taking into account the low weight of the device, it significantly makes the operation simpler.

Figure 1. VD-90NP eddy current flaw detector. General view.

Differential eddy current probes (Fig.2) are used to transduce nonelectric parameters (local discontinuities) into electrical signal by exciting eddy current in a tested object. Then signal enhancement follows where the amplitude and phase are determined by the acting induced field. To link the units we use a common cable with enhanced noise immunity. Due to that, the device turns out to be compact and has low weight. The probes are wear-proof, the contact point being protected by strong corundum cap. Using of different fixing tools (Fig.3) makes it possible to attain the best results.

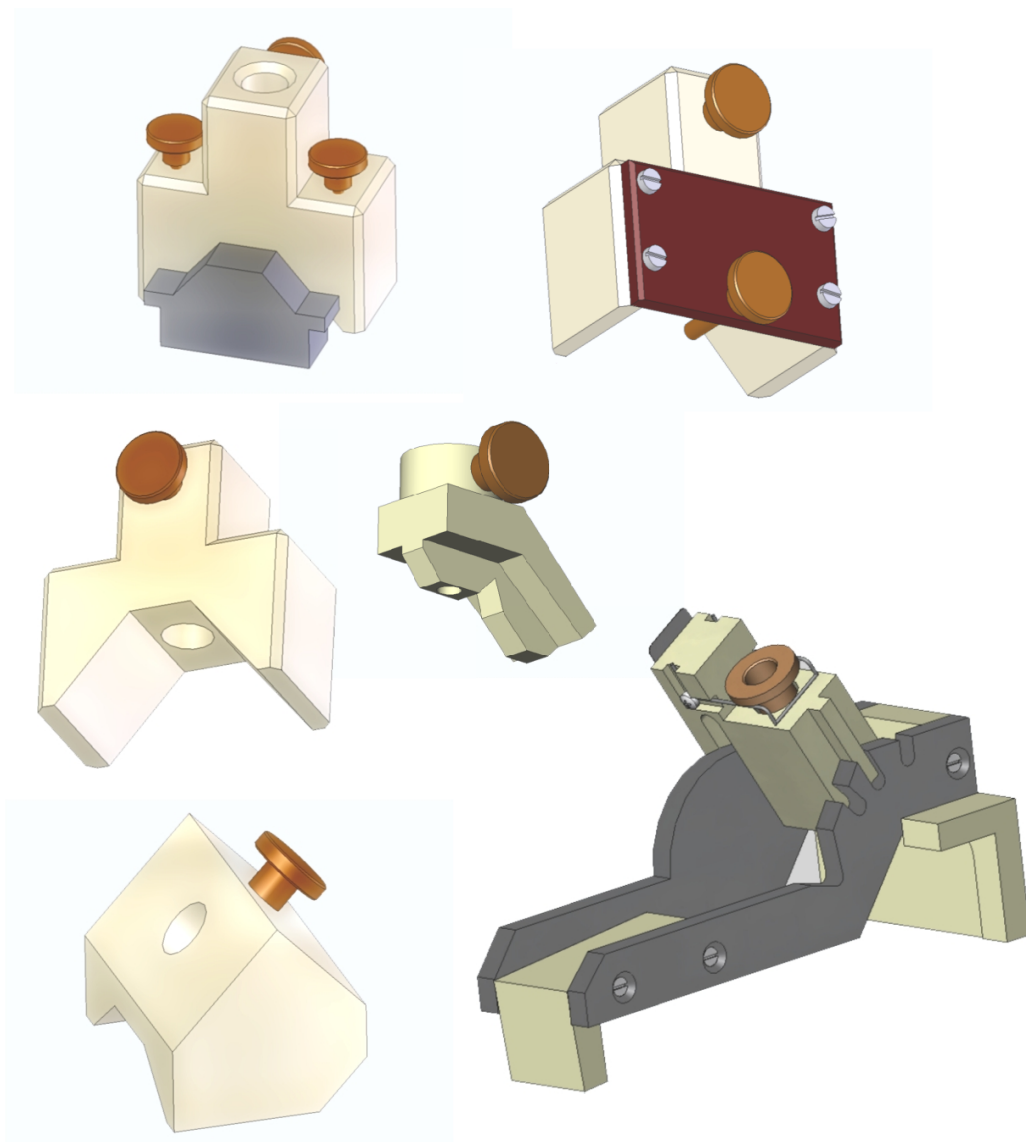**Figure 2. Eddy current probes kit for VD-90NP.**

Figure 3. Fixing tools for VD-90NP.

The flaw detector's generator ranges widely the excitation current frequency from 100 Hz up to 2MHz, the excitation circuit current ranging 5-500 mA, that allows the use of the full range of both pencil and hole probes. The flaw detector automatically defines the probe type and sets the necessary excitation current and frequency that significantly simplifies the compensation.

Basic specifications

Scanning speed	- 0,02...0,1 m/s
Frequency range	- 100Hz-2MHz
Rotation	- 0-359°
Rotation step	- 0.1^{o}
Operating temperature	-30°C…+40°C
Level sealing protection	- IP54
Distance of radio transfer	- 20 m

Power supply – 4 x 2.7AHr NiMh AA batteries;

Consumption current, max
- passive radio channel   - 0.7 W
- active radio channel   - 0.9 W

Set time for operation mode, max   - 1 min
Running time, not less
- passive radio channel   - 20 hours
- active radio channel   - 15 hours

Electronic unit weight (with batteries), max   - 0,38 kg
Dimensions, mm:
- Electronic unit (LxWxD)   140x72x40

Complete mean lifetime, years, min   − 10
Set lifetime, years, min   - 2

Tables 1 and 2 show sensitivity threshold and maximum allowed insulant thickness for the VD-90NP flaw detector.

Table 1

Material	Sensitivity threshold, mm		
ferromagnetic	Surface roughness, max	R_a 1,25	R_z 320
	Depth	0,1	1.0
	Width	0,05	0,1
nonmagnetic	Surface roughness, max	R_a 1,25	R_z 160
	Depth	0,1	0,5
	Width	0,05	0,1

Table 2

Maximum thickness of insulant, mm	
Specimen material	
ferromagnetic	nonmagnetic
10	3

VD-90NP can be implemented to non destructive testing of heat-exchanger tubing using a differential probe. Tubes are made from nonmagnetic material. The shape of output signal from the probe reflects properties of tested material.

The fundamental problem is to determine according to the signal shape, whether there is some defect, structural element, roughness or impurity in the tube. The measurement has been accomplished at few frequencies. Low frequencies are more suitable for evaluation of identifiable anomalies at the outside wall of the tube, e.g. of the presence of construction elements of the steam generator. At high frequencies there are dominant signal components corresponding to the changes of internal tube wall, e g to the changes of profile tube. Middle frequencies enable to obtain phase separation of 2D curves corresponding to defects that are important for quantification of percentual material drop.
Also multi-frequency eddy current testing increase both testing speed and sensitivity by using combined with a scanning system for corrosion detection in multi-layered structures Using previously determined optimal single frequency as a start, frequency combinations were determined to give in-

creased detectability for the different structures and defects. The influence of different disturbing signals, e.g. signals from rivets, thickness variations, noise, and how to reduce them using the multi-frequency technique was studied.

The choice of suitable representation of indication data is very important. The use of a pocket PC considerably increase the device functionality, an operator has the widest possibilities to store, process and represent the data including setting of test parameters on the pocket PC display (Fig.4)), setting of marks on a signal graph, direct printing of reports by Bluetooth. The use of radio channel for data transfer allows us not to use tie cables providing high mobility and easy integration into automated test workbenches.

The software helps to use the pocket PC display instead of the device display that also broadens test possibilities.
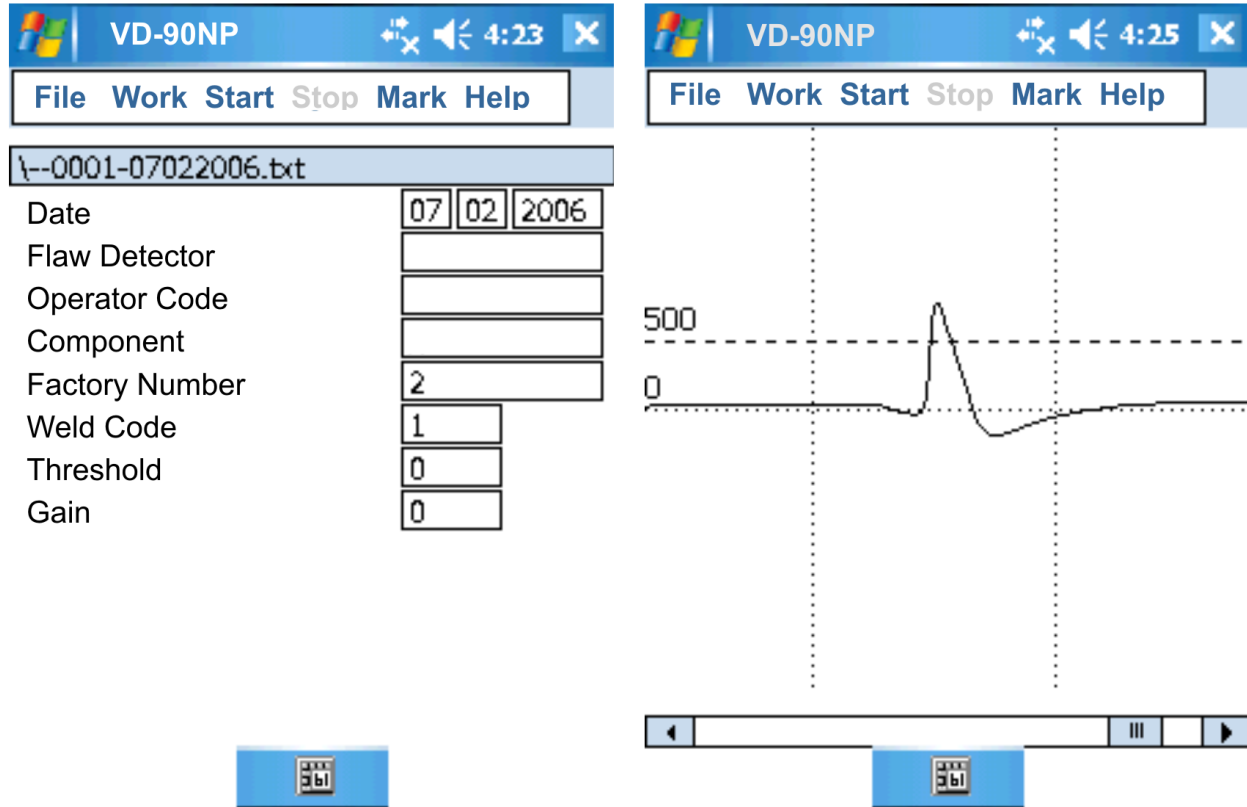

Figure 4. a) Test parameters set mode   b) Defect location mode

At present, the wide use of microprocessor means of data receipt, its process and transfer enables the employment of digital filtration methods. The relevant ones are folding method and digital filtration by a window function. The results received by the use of these methods make us conclude about considerable enhancement of signal-to-noise ratio as well as results reliability.

To eliminate random noise from a received signal, the VD-90NP uses methods of adaptive digital filtration (Fig.6) that provides high accuracy and noise immunity for the equipment. Also it using window function for digital filtration (Fig.5). It is important to correctly choose a window function that is widely used for spectrographic analysis of signals. The processing by windows is used to control the effects caused by side lobes in a signal spectrum. The wisest way is to make up an optimal window function to solve a specified task rather than to choose from the list of acquainted ones.
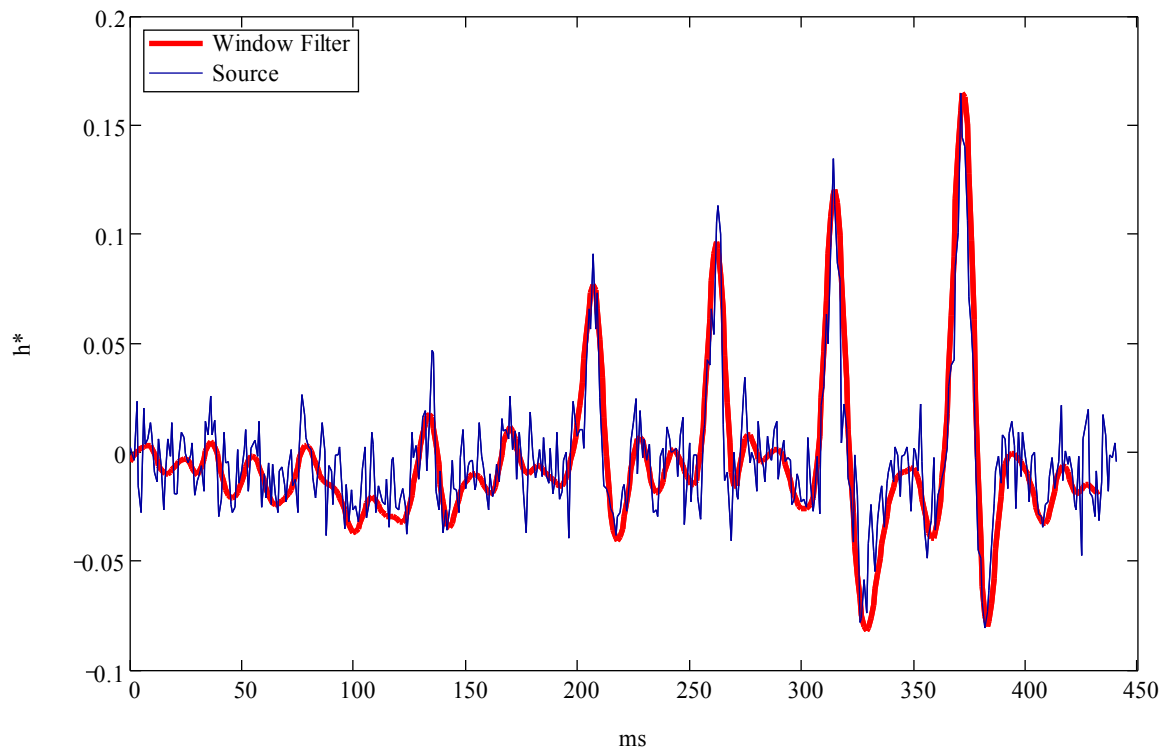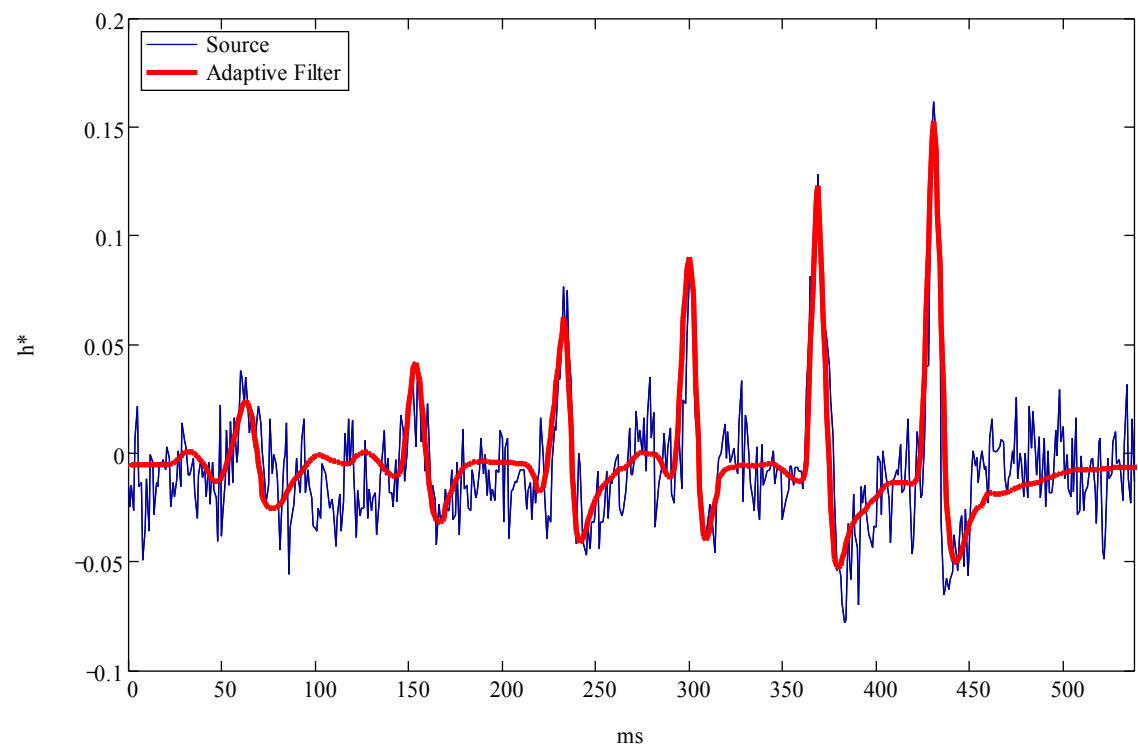
Figure 5. Window function digital filtering.

Figure 6. Adaptive digital filtering.