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Fluorescent dot peen marking for insuring oil steel pipes traceability

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Abstract. “VKO “Simvol” designs and produces marking equipment, reading equipment and traceability software. Fluorescent dot-peen marking (FDMP) is an improved version of dot peen marking (DPM) technology. In FDPM technology information dots are filled with special material – fluorescent composition. Various fluorescent compositions provide high stability of marking in different aggressive media, such as moisture, salt and acid solutions, oils, lubricants or high temperatures. 2D barcode Data Matrix makes the marking machine readable, even if some of the dots are damaged.

1 Introduction

Oil steel pipes (further – pipes) pass many operations and technological processes during their lifetime - transportation, storage, working in the aggressive media, repair, and disposal. An objective of identification and administrating each pipe’s “individual story” during all stages of its life cycle is quite relevant for oil industry.

Manufacturer marking for oil and gas pipes contains product description and all the information for pipes identification. This marking serves to the pipe manufacturer’s purposes only, while oil and gas companies needs stay unsatisfied in case of the information loss.

Identification (individual pipe recognition) requires availability of sustainable identification signs during any operations with the pipe. Marking is the most common way of identification. Machine-readable marking (further – marking), which helps to trace the entire product’s life cycle, is used in modern automated systems.

Pipe traceability provision has a number of features related to the marking’s sustainability to various types of mechanic, climate and chemical or media impacts during manufacture, transportation, storage, operation and repair. Therefore there is need for modern methods of marking that are resistant to aggressive environment [1]. Since exposure in oil and gas environment (high pressure, high temperature, CO_2 and H_2S content) during the operation of pipe or tube causes destruction of equipment [2 – 4].

The aim of this study to ability to survive fluorescent dot peen marking (FDPM) the severe tests, modelling the conditions of oil and gas industry.

2 FDPM reading

Fluorescence of the information dots in FDPM provides better contrast than usual DPM marking. When reading FDPM, the machine records only the fluorescence of the dots, information elements (Fig. 1). The surface of a marked product and its optical properties have minimal influence on FDPM reading, and. This allows to reduce the influence of marked surface brightness, its curvilinear profile, the color of the coatings, rust, roughness during reading FDPM. In case of damage, FDPM can be recovered.

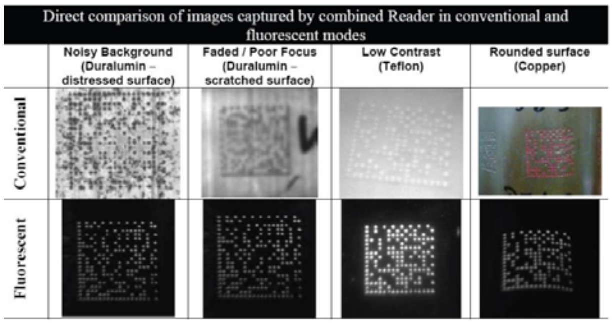

Fig. 1. DPM (top) vs FDPM (bottom) reading.

3 FDPM stability in aggressive media

Various types of polymer compositions and fluorescent dyes application makes it possible to create FDPM with high resistance to various environments, such as:

- Demineralized water;
- Moisture media (Fig. 2), >45 days;
- Sea water, >2000 hours;
- 3% saline solution (NaCl), >720 hours;

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- Detergents, both acidic and alkaline, >720 hours;
- 3% hydrochloric acid (HCl), >720 hours;
- Petrol, oil and lubricants - engine oil, >16 months;
- Petrol, >5400 hours;

Furthermore, FDPM is resistant to:

- High pressure;
- Ionizing radiation;
- High temperatures (1,000 ^{0}C – up to 22 hours, 600 ^{0}C – more than 200 hours);
- Temperature variations from plus 60 ^{0}C to minus 60 ^{0}C over 180 cycles;
- Mechanical impact (10 hammer strokes; abrasive treatment).

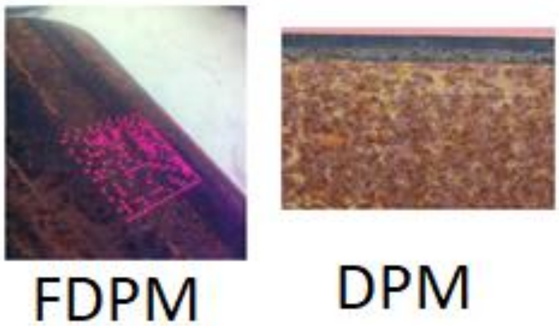

Fig. 2. Comparison of FDPM and DPM after the ASTM D 870-02 moisture resistance tests, 45 days exposure.

FDPM can survive intensive mechanical treatment, which used for paint and corrosion removing from the surface. Photo of FDPM on a steel pipe after shot blasting is shown on Fig. 3.

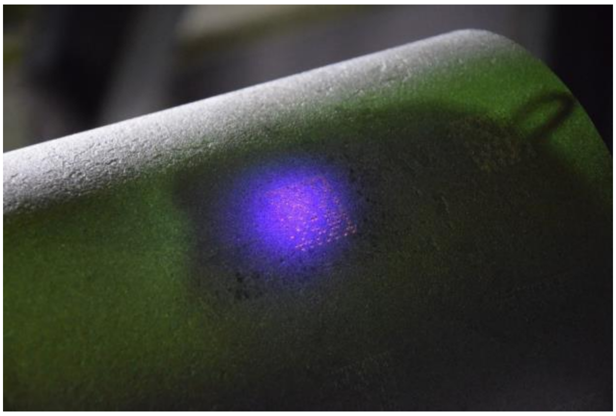

Fig. 3. FDPM on a steel pipe after shot blasting, photo in fluorescent light.

The high contrast and stability allow to read FDPM after transporting, mounting and operating oil pipes. The photo on Fig. 4 shows fluorescence of FDPM dots on the pipe after high temperature and shot-blasting treatment, the marking remains readable.

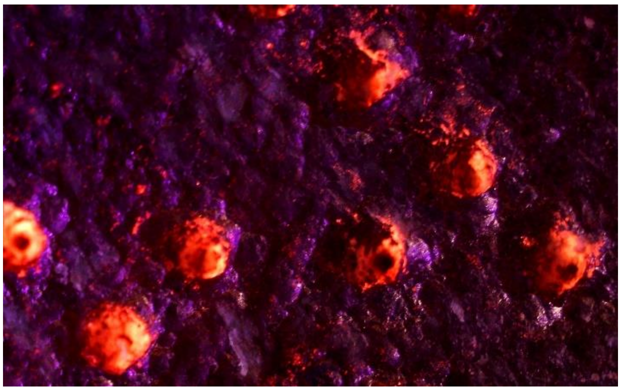

Fig. 4. Micro photo of FDPM on the pipe after thermal and shot blasting, application and removal of the protective coating with heat shrink tape.

The developer patented a number of processes, devices and compositions used in his hardware and technology complex, which provides for the application of FDPM, their reading and use for building an automated system of product identification and traceability. Patent list is given in the Literature section [5 – 13].

The effect of marking on the mechanical and corrosion properties of pipe and tube material has been studied by several researchers [14]. The requirements for resistance to aggressive media must be applied for FDPM.

It was performed a set of FDPM stability tests on pipe samples. The samples were tested in environments, modelling climate conditions and oil pipe operating media. Tests with 11 different fluorescence compositions were performed, this allowed to find the most persistent compositions.

In high-pressure corrosive media primary corrosion products (rust) were formed on the surface of the samples during testing. Fig. 5 gives an example of the marking before and after the test in the simulating oil well conditions: 5% NaCl solution P=(1,0 ± 0,5) MPa, p(CO_2)=(1,0 ± 0,5) MPa, t=(120 ± 3) °C for 24 hours. FDPM was readable after the mechanical removing the corrosion products.

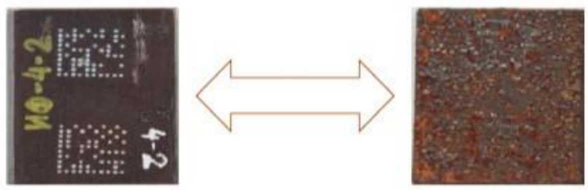

Fig. 5. Fluorescent dot-peen marking before (left) and after (right) tests for 24 hours in 5% solution NaCl at total pressure (1,0 ± 0,5) MPa and partial pressure CO_2 (1,0 ± 0,5) MPa; temperature (120 ± 3) °C. Corrosion products are not removed.

Test results of the best FDPM fluorescent compositions for pipes are shown in Table 1.

Table 1. Reading FDPM with several fluorescent compositions after aggressive environments tests. "+" – readable, "-" – unreadable, the "*" sign means corrosion products removal.

Test environment	Fluorescent composition code and sample number	FDPM reading results
Climatic factors		
Temperature minus (60 ± 3) to plus (60 ± 3), 15 cycles	KJ-55	+
	KL-56	+
Variable temperature, elevated humidity and solar radiation according to GOST 9.401, method 4	KL-54-1	-
	KJ-53-1	-
	KL-54-2	+ *
	KJ-53-2	+ *
Operating factors		
Acid composition (T= 20 ± 3 °C), 24 hours: - HCl – 12%, - corrosion inhibitor – 0,5 %; - iron stabilizer – 1%; - demulsifier – 1%.	KJ-3	+
	KJ-4	+
	KL-50	+
NaCl 5% (T= 80 ± 3 °C), 240 hours, partial pressure CO_2 (1,0 ± 0,5) MPa, total autoclave pressure (5,0 ± 0,5) MPa	KL-5	+
	KL-6	+
	KJ-59	+
NaCl 5% (T= 120 ± 3 °C), 24 hours, partial pressure CO_2 (1,0 ± 0,5) MPa, total autoclave pressure (1,0 ± 0,5) MPa	KJ-51-1	-
	KL-52-1	-
	KJ-51-2	+ *
	KL-52-2	+ *
Shot blasting	KL-57	+
	KJ-58	+

4 Conclusion

The results show the FDPM ability to survive the severe tests, modelling the conditions of oil pipe lifetime. Although most of the compositions tested did not show acceptable stability, some of them showed good reading results and should be developed further. According to the results of the laboratory experiments, FDPM based on composition «K» and luminophore «J» was recommended to test on pump-compressor pipes and oil and gas pipes in pilot industrial operation.

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