FLUXA-CONTROL: AN AUTOMATED MONITORING OF FLUORESCENT PARTICLES IN MAGNETIC PARTICLE TESTING

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1 Introduction

Magnetic particle testing (MT) is the most sensitive method to detect surface cracks in ferromagnetic materials [2]. This method can be executed by mobile equipment or stationary systems [3]. Magnetic particles are used for the visualisation of the surface cracks. The magnetic particles are an iron oxide powder coated with visible or fluorescent paint. They are also called test agent or magnetic ink. For mobile test tasks, the magnetic particles are normally applied as a wet suspension from aerosol cans. The magnetic particles are only used once. Therefore the longterm stability is not an issue. On the other hand, for stationary systems the magnetic particle is contained in a closed circuit and is used for many hours. A suspension of magnetic particles diluted in water (or sometimes oil) is kept in constant circulation. The properties of the magnetic particles degrade over time and have to be controlled in regular intervals.

Due to the higher contrast, fluorescent magnetic particles are used for most test applications, so that fluorescent particle control is more urgently required than control of visible particles. A surface defect should show high contrast under ultraviolet light. The indication should be sharp with virtually no background either from the particles themselves or from the flawless surface of the testpiece. It is very difficult to detect the fluorescent crack indications with high fluorescent backgrounds.

Moreover is it important to have a good sensitivity of fluorescent particles for crack detection. Three reasons arise for the degrading of fluorescent magnetic particles:

1. More and more particles are dragged out of the circuit by sticking on every tested workpiece.
2. An increased pollution by dirt, scale, oil or other media appears during using.
3. Separation between fluorescent colour and the iron oxide occurs.

All these three influences lead to a lower sensitivity of the fluorescent magnetic particles. Some test blocks are used to regularly check the sensitivity of the particles. Two of them (see Fig. 1 and Fig. 2) are described in the standard DIN EN ISO 9934-2 (2003) [4] and this was the first time that reference blocks were standardized in Europe.

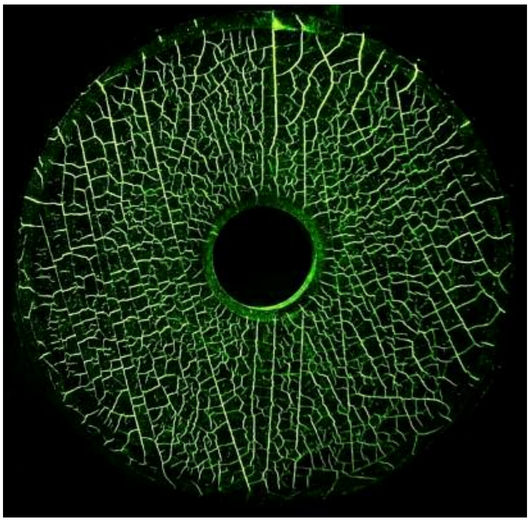

Fig. 1: Reference block type 1 (acc. DIN EN ISO 9934-2 [4]) (former MTU Test block)

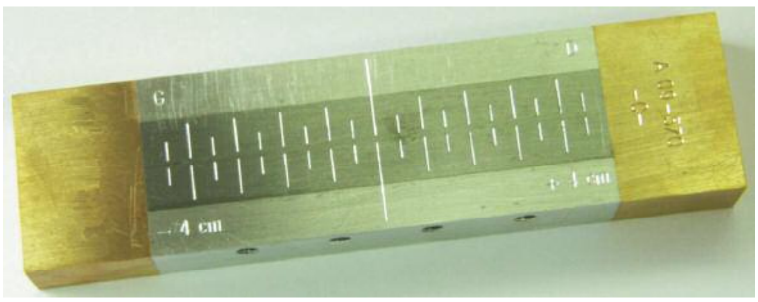

Fig. 2: Reference block type 2 (acc. DIN EN ISO 9934-2 [4])

The test block is first used for the fresh suspension and the crack pattern is observed. After a certain period of time, the measurement is repeated and the results are compared. For reference block 1, the operator should look for a specific region or a specific crack which he has to memorize until the next measurement. Typically a fine crack is used. If this crack is no longer visible, the sensitivity of fluorescent magnetic particles is too weak and the suspension has to be changed. A reduced sensitivity of the magnetic particles can also be detected with the reference block 2 by a reduction of the indication length.

The usage of reference block 1 and 2 is common practice for stationary MT, but this procedure also has some disadvantages:

- The evaluation of the visibility of weak cracks (reference block 1) and of the indication length (reference block 2) depends on the person who carries out the reference measurement. The measurement by different persons could result in different indication lengths (reference block 2), so that these reference measurements should always be carried out by the same person.
- The reference measurement has to be performed always on the same reference block. To use two different reference blocks for two consecutive measurements is forbidden because different reference blocks have different indications.
- Regular cleaning of the reference blocks is required and this could be a problem in a robust industrial environment
- The viewing conditions might change in dependence on the daytime, weather and especially the viewing angle
- The operator might not properly remember the results of the last crack measurement

With these disadvantages the reference measurement is quite subjective and a more precise control is required. Thus, a new automated unit called “FLUXA-Control” which constantly measures the properties of wet fluorescent magnetic particles was developed.

2 Principle of automated monitoring by Fluxa Control

The main idea is to constantly evaluate the sensitivity of fluorescent magnetic particle powder by measuring the intensity of the fluorescent response from two crack indications. To increase the reproducibility of the unit these cracks are artificially made. The magnetic field is produced by a magnetization coil and is guided to the artificial cracks by a yoke and a magnetizing bar (see Fig. 3). The flux leakage penetrates through a glass tube. Magnetic particle suspension is flowing through the tube. The crack indications are illuminated by UV-LEDs and the brightness of the crack indications are measured on the other side of the tube by means of photocells. Each photocell measures the intensity of the fluorescent light from the respective crack indication. Thus, the measured values are a reference for the sensitivity of the fluorescent magnetic particles.

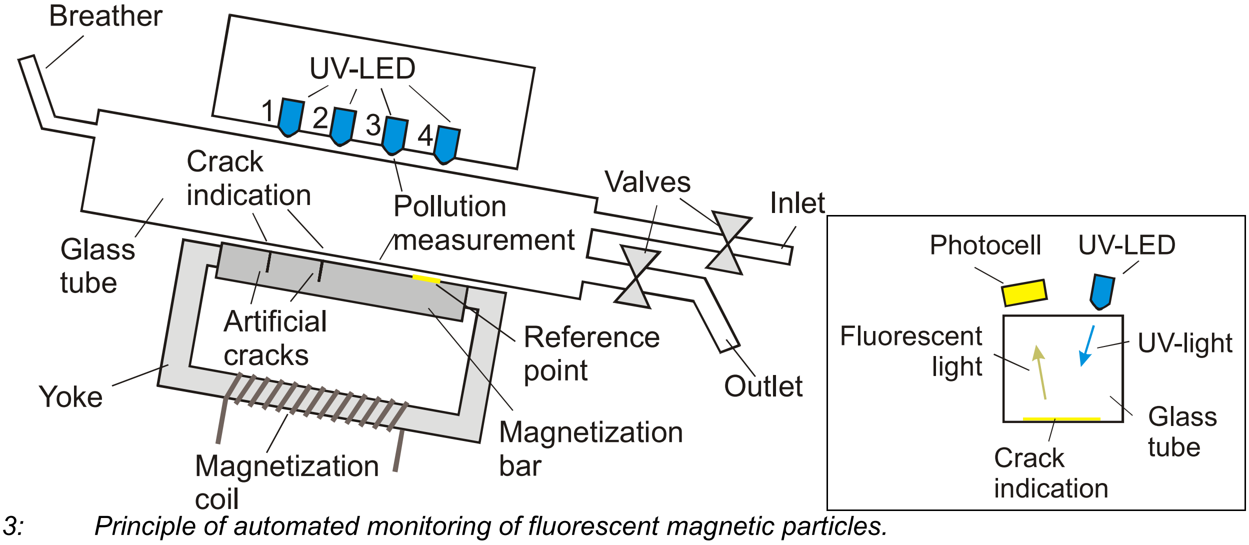

Fig. 3: Principle of automated monitoring of fluorescent magnetic particles.

The glass tube is made from special material and fulfils the following tasks:

- Transparent for UV-light and visible (fluorescent) light.
- Minimum pollution of the smooth inner surface with magnetic particles. After every measurement cycle the complete magnetic particles are washed out to keep the glass tube as clean as possible, so that the sensitivity measurement can carry out during many cycles.

The measurement process is controlled by an electric circuit. One cycle consists of the following steps:

- Filling of the glass tube with magnetic suspension via the inlet,
- magnetization by the magnetization coil,
- flow out during magnetization via outlet,
- evaluation of the intensity of crack indications,
- demagnetization of the yoke containing the artificial cracks,
- filling of the glass tube via inlet,
- flow out without magnetization via outlet and wipe off the former crack indications.

3 Control mechanism

The sensitivity evaluation of the fluorescent particles is based on the crack measurements with the UV-LEDs no. 1 and 2. In addition, the automated monitoring system includes two different control mechanisms:

1. A pollution measurement of the inner surface of the glass tube. It is possible that the magnetic particles stick to the inner tube surface. In this case the background fluorescent increases showing a maintenance problem. This measurement is done by the UV-LED no. 3 and normally having to a very small value. If this value exceeds a threshold, then the FLUXA-Control unit produces a warning.
2. A control measurement from a reference point. UV-LED no. 4 measures the visibility of a reference point which is placed on the magnetization bar with the artificial cracks. This measurement leads to a very high value and the high value indicates that the glass tube is free of dirt, scale or other pollutions.

The measured values of the crack indications (by UV-LED no. 1 and 2) are between the value of UV-LED no. 3 and no. 4 and should be as high as possible (see Fig. 4).

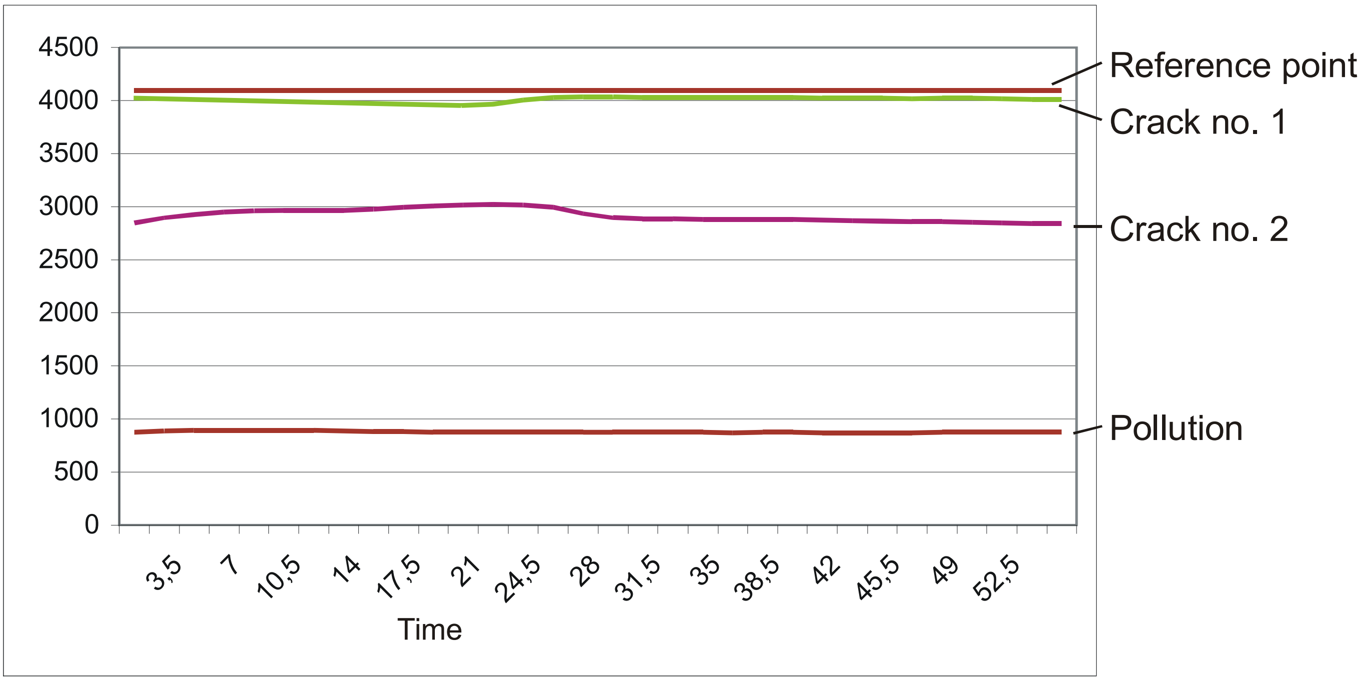

Fig. 4: Measured values from the crack indications, the pollution measurement and the reference point.

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The proper threshold for the crack indications (no. 1 and 2) were determined by comparison of the measured values with the standard reference measurement by reference block 1 and reference block 2. This comparison leads to a scale which reflects the sensitivity of the fluorescent particles in a magnetic inspection system. With the control unit (see Fig. 5) this scale is visible for the user by a LED array from green over yellow to red. The meanings of the different colors are:

- green: high sensitivity
- yellow: sensitivity is high enough but the powder should be replaced soon
- red: poor sensitivity, magnetic particle testing should stop.

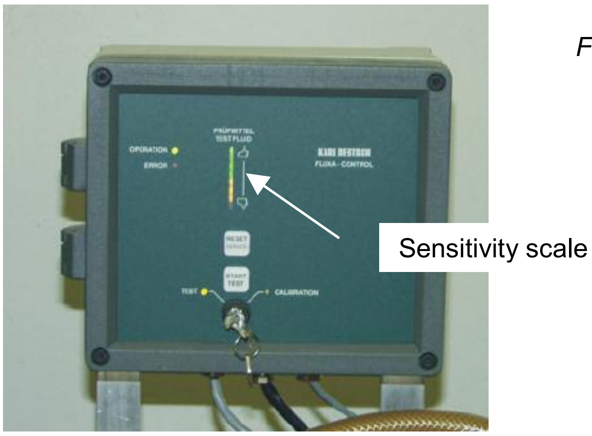
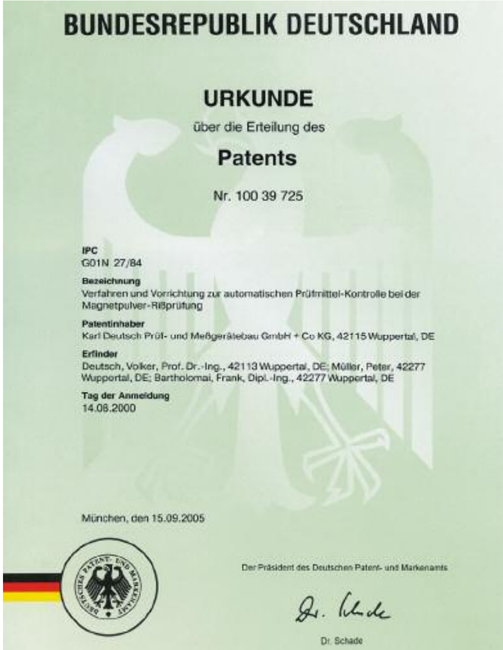


Fig. 5: Control unit of the automated monitoring system.

4 Conclusion

Various tests with different types of magnetic particles were carried out under laboratory conditions with positive results. The “FLUXA-Control” has now been approved as a German patent [1] (see Fig. 6). For the last months the system is under test within a rough industrial environment and the results are also very satisfying. With this FLUXA-Control it is possible to replace the old sensitivity measurement with reference block 1 and 2 and the corresponding disadvantages. Moreover, the sensitivity of a magnetic particle test can now be carried out under well-defined conditions where constant inspection sensitivity is guaranteed. This might be also an important point for future developments, such as the camera based evaluation of the crack indications.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Bezeichnung
Verfahren und Vorrichtung zur automatischen Prüfmittel-Kontrolle bei der Magnetpulver-Rißprüfung

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Der Präsident des Deutschen Patent- und Markenamts

Dr. Schade

Fig. 6: Patent of “Fluxa Control”.

5 References

[1] German Patent No. 100 39 725, Verfahren und Vorrichtung zur automatischen Prüfmittel-Kontrolle bei der Magnetpulver-Russprüfung (*Procedure and instrument for the automated test agent control in magnetic particle testing*), issued September 2005.

[2] V. Deutsch, M. Vogt, M. Platte, V. Schuster: NDT Compact and understandable Vol. 3 - Magnetic Particle Crack Detection, Castell publishing house, Wuppertal, 1999.

[3] ISO 9934-1: Non-destructive Testing - Magnetic Particle Testing - Part 1: General Principles, ISO International Organisation for Standardisation, 2002.

[4] ISO 9934-2: Non-destructive Testing - Magnetic Particle Testing - Part 2: Detection Media, ISO International Organisation for Standardisation, 2003.