Automated Dye Penetrant Systems with Process Control and Documentation in the Aerospace Industry

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Abstract

Due to the fact that the non destructive testing method of dye penetrant is becoming more and more important in the aerospace industry more and more parts are tested by this method. In recent years ITW TIEDE GmbH has developed automated dye penetrant systems that meets the exacting specifications and requirements of aircraft manufacturers. The complete process is controlled and documented in accordance with the customers programmed requirements. These functions are carried out by the condition monitoring system QAP-FE.

Keywords: Non-destructive testing, Dye Penetrant, Aerospace Industry

1. The Dye Penetrant Method

The principles of the dye penetrant method is shown in the following pictures.

\begin{figure}[h]
\centering
\includegraphics[width=0.6\textwidth]{figures.png}
\caption{Fig. No. 1: Application of the penetrant \hspace{1cm} Fig. No. 2: Start of the dwell time}
\end{figure}

The first stage of the process is the application of the penetrant onto the surface of the part to be inspected. This can be carried out by spraying or by immersing. During the dwell time the dye penetrates into any material defect open to the surface of the specimen due to adhesion and capillary attraction. The dwell time is followed by a washing process which in most specifications is very well defined in duration, water pressure and temperature to prevent over washing and as a result a loss of indication. In case of the use of oily penetrants an emulsifier has to be used before washing. The emulsifier combines with the oil and makes the penetrant water washable.
In the next step the clean surface will be dried by warm air. After the surface is dried, a process starts that is called bleedout. During the bleedout the penetrant liquid, contained inside pores and cracks starts to crawl back to the surface of the part to be inspected.

To enhance the penetrant bleedout to form indications in most of the cases a developer is applied to the surface of the test piece. The developer may be a fine powder, a solution that dries to form a dry powder, or a suspension in solvent or water that dries leaving an absorptive thin coating on the surface of the specimen. After the application of the developer the penetrant starts to diffuse into it. After a certain period of time which is normally also defined in process specifications, the surface defects can be inspected by using a UV light source.

2. Automated Systems for Dye Penetrant Inspection
Due to the fact that light weight materials and components became more and more important over the last couple of years, the process of dye penetrant inspection became more and more automated. The following picture shows an installation for a major fasteners manufacturer.

![Fig. No. 9: Penetration system for fasteners](image)

The equipment consists of five tanks for penetration, emulsification, washing, drying and developing. Inspection is carried out manually inside a darkening booth. The part handling is done by an overhead conveyor.

Figure No. 10 shows an automated penetrant line for aircraft parts. The system is designed for the processing of different materials.

![Fig. No. 10: Automated dye penetrant system for AIRBUS](image)
It consists of 15 process stages in three independent lines. The system has the capability to handle up to 15 part carriers at the same time. Fig. 11 shows the penetrant tank with one carrier taken out for dripping.

Fig. No. 11: Penetrant tank with overhead conveyor and carrier

Fig. No. 12: Automated dye penetrant system for AIRBUS(overview)
The system is fully controlled by QAP. The process status is displayed on the screen of the QAP-FE system, so that the operator is able to locate every lot at any time during the process. Fig. No. 13 shows the operator desk with PLC touch screen and QAP display.

![Operator Desk](image1.png)

Fig. No. 13: Operator desk

The QAP system is connected to the penetrant line via CAN bus. All sensors necessary to control the process parameters like temperatures, pressures and process times are attached to this interface. Furthermore the QAP communicates to the operator via this interface by displaying some important time measures to count-down and count-up clocks as shown in Fig. No. 14. Figure No. 15 shows a UV light intensity sensor mounted to a UV light source. The use of these sensors enables the user to ensure and document that the inspection of the parts is always carried out under the conditions specified in the standards.

![Count-down Displays](image2.png)

Fig. No. 14: Cout-down displays for developing time for two individual carriers
Fig. No. 15: UV light sensor mounted to light source in the inspection cabin