New Concept of Thixotropic Dye Penetrant in Weld Checks

By R. DAS*

The recent concept of quality evaluation, plant maintenance and production engineering is art and science of feed back information on design, performance, inspection awareness and finally cost consciousness. Appropriate non destructive testing evaluation and merit rating can be computed only with the healthy production facilities through properly trained personnel not only in operational control but also in quality control.

In a nutshell, the concept creates wider awareness among managements, executives & engineers of the dire need of "Inspection Triggered Approach" in all stages of production, maintenance and quality monitoring disciplines.

This inspection triggered approach in a sense means getting reliability and quality assurance through non-destructive testing, evaluation and measurements (called T-E-M).

A good management practice is to be alert to the complete spectrum of production right from the development of quality control of vendor's supply to the finished product maintaining the spirit of reliability through non destructive evaluation. It holds the opinion that economical and efficient operation of plants & machinery depend on NDT checking of fabrications and weld to avoid frequent plant breakdown which causes maximum production losses. Undoubtedly this NDT check will help in the conservation of materials, spares and tools whose prices are escalating by leaps and bounds.

* The Oriental Chemical Works (P) Ltd
Calcutta-700 027

The choice of NDT method depends on knowledge of the material's size, shapes, the metallurgical quality of components and the type of location of surface defects like voids, cracks, folds, porosity, shrinkage cold shuts, inclusions, leaks etc. in the manufacturing process such as casting, stamping, welding, drawing, forging and pressing etc.

The well standardised NDT methods can be classified broadly as follows :

1. Magnetic Particle Inspection.
2. Dye Penetrant Inspection—Liquid or Thixotropic.
3. Eddy Current Inspection & Acoustic Emission.
4. Ultrasonic Inspection.
5. Radiographic Inspection.

In this paper, the author will emphasise on the liquid Dye Penetrant Inspection technique as well as on the new technique of Thixotropic technology—the method which is now recently developed in advanced countries.

So long, the method of liquid penetrant inspection involved flooding the surface under inspection with liquid dye penetrant which is drawn into the surface discontinuity by capillary action. After removal of the excess dye liquid from the surface, a thin coat of 'Developer' is applied to dry and blot out the penetrant from the defects of the surface for observation. Conventional red dye or fluorescent dye is added to the especially formulated penetrant solution to make the trace of defects more visible.

There are mainly two types of liquid penetrants in use. One is the visual red dye penetrant where parts can be inspected after the process, in normal bright light in which the colour of the red dye will appear against the white back ground of the developer if the discontinuities are present. The other is the liquid fluorescent dye penetrant where the parts can be inspected after the process by exposing it to ultraviolet 'black' light. Any discontinuity on the part will exhibit a bright greenish yellow when exposed to ultraviolet black light.

The salient features of liquid red dye and fluorescent dye penetrant methods are well known and briefly described in the preceding paras.

For local inspection purposes, such processes are fairly sensitive and relatively convenient. They suffer, however from various disadvantages, one being less sensitivity while the other major disadvantage is that the penetrant and penetrant remover being mobile liquids, tend to flow off the area being treated and may find their way into regions where they are not required and where their subsequent removal may be difficult ; similarly, application to overhead and near-horizontal surfaces is also particularly difficult.

Introduction

THIXOTROPHY is the property of the material which becomes temporarily liquefied when the material is shaken, stirred or brushed but as soon as the above action stops, the material returns to jel state i.e. 'stay put' condition.

The difficulties associated with the use of conventional liquid penetrant formulations may be overcome by the use of postemulsified Thixotropic versions. Till recently, Post Emulsified liquid Fluorescent Dye Penetrants were the only known high sensitive penetrants but the Thixotropic versions, High sensitive post emulsified Red Dye Penetrant (T) and Fluorescent Dye Penetrant (T) together with Lipophilic Emulsifier are now avaliable in this modified Thixotropic form identified by the suffix 'T'.

The materials are applied only by mechanical or manual brushing and will remain in place without running, even on vertical or overhead locations, they are, therefore, particularly suitable for the insitu inspection of local area of large components and structural welds. Thixotropic form can not be used in spray cans or in immersion tank ; this is the limitation in Thixotropic technique.

Operational Technique

1. Clean the area to be inspected in the manner required for conventional liquid penetrant inspection processes. This surface cleaning is the prime factor for the success of Dye Penetrant Technique—both liquid and Thixotropic. Dry with hot air.

2. Cover the hot area to be checked with a generous coating of Red or Fluorescent Dye Penetrant 'T' by brushing application only with occasional repeat action during the contact time of 10 to 15 minutes. It works out best on the surface having temperature upto 160°C max. Liquid penetrant cannot work out on hot surfaces. This property of thermal stability in case of Thixotropic dye penetrant is advantageous over liquid penetrant. However, a longer time of contact i.e. 20 to 30 minutes is usually preferred in case of very tight cracks.

3. Remove excess penetrant (T) dye using paper tissues or cloth.

4. Apply a generous coating of "Lipophilic Emulsifier" by brushing and allow this to remain in contact with the surface for one minute max. This is a special caution.

5. Remove excess emulsifier and traces of penetrant using paper tissues or cloth.

6. Wipe the area with a paper tissue moistened with water and dry by wiping with a clean tissue paper or cloth followed by hot air blast to dry the surface.

7. Developer (Aerosol) spray should be used for development of defects in both Red and Fluorescent (T) methods. However, powder developer can only be used with a Flock gun in the case of Post Emulsified Fluorescent Dye Penetrant 'T' application.

Standards in weld checks

At the International level, considerable work was done in the particular field of standards by the Technical Committees ISO/TC 44 Welding on Radiography and Ultrasonic etc. and a number of International standards were formulated by these Committees for the benefit of welding industry. Need was later felt to create a separate technical committee to deal exclusively with the standar dization in the field of various Non Destructive Testing methods and accordingly in 1969, a technical committee ISO/TC 135 Non Destructive Testing was set up. The scope of the Committee has been defined

as standardization covering various Non Destructive Testing Methods as applied to constructional materials' components, welds and assemblies by means of (a) glossary of terms in tests (b) methods of tests and (c) performance specifications for testing equipment and ancillary apparatus. Most of the ISO standards so far are in the field of radiography, ultrasonic, magnetic particle, acoustic emission etc.

International Institute of Welding has also carried out a lot of investigation work in the field of Non Destructive Testing of Welds and published a number of reports as well as recommendations for suitable Non Destructive Testing practices. The Reference Radiographs of Steel Welds published by IIW are used in almost all parts of the world for weld quality assessment.

The inspection practice of welding under International and National Standards of Radiography is well established but very meagre knowledge is available in welding inspection by dye penetrant techniques which is less costly and easy to use without the help of any complicated equipments. It is an operator-intensive method. The established International and National specifications for Dye Penetrants are as follows : DTD 929 & MIL/I/25135C(ASG) & IS-3658-1981.

Sensitivity by visual inspection in the dye penetrant

There is a saying "Videre Credere est"—To see is to believe. Inspite of all modern scientific methods of measurement (NDM) of defects and failures with sophisticated instruments and even if the scientist or engineer is prepared to accept these results, he is happier if he can see too the marking of the defects on the surface.

The high sensitivity of Thixotropic Penetrant (both Red & Fluorescent, is of the same order as that of the standard post emulsified liquid fluorescent dye penetrant when used under similar conditions ; the sensitivity on shallow, open defects is however, of a higher order.

The inspection is carried out with the help of a Black lamp in case of Fluorescent Penetrant 'T' while in the case of Red Dye Penetrant 'T' inspection is carried under normal day light or incandescent light.

An interesting combined method of N. D. Testing by Thixotropic Dye Penetrant followed by Ultrasonic Testing in measuring the depth of cracks in Austenitic Stainless Steel overlays was advocated by a group of Japanese steel technologists given below.

Various reactors with internal stainless steel overlays exposed to hydrogen atmosphere frequently reveal cracks in welds. In such cases, it is necessary to measure the depth of cracks and ascertain by fracture mechanics analysis by using Ultrasonic Testing equipment—Krautkramer USIP-II using longitudinal wave twin crystal angle probe that the reactor is safe for continuous services. A number of refineries operate with direct desulfurization or hydrocracking reactors that are overlaid inside with austenitic stainless steel to cope with high temperature and high pressure hydrogen.

Though this is developed for chemical pressure vessels and welds, the technique could also be applied to nuclear pressure vessels with proper remote manipulating system. Measuring the depth of the crack with the shear wave angle beam technique is acceptable for ferritic steels but not for austenitic stainless steel welds because of the coarse grain.

In the turn around maintenance inspection of these stainless steel reactors, Thixotropic Dye Penetrant Tests (PT) are performed to confirm that the overlay welds are sound. When a crack is detected by PT, it is necessary to measure the depth and length of the crack and ascertain from fracture mechanics analysis whether the reactor is sound or requires repair before being operated again.

Conclusion

Newly developed indigenous Thixotropic Dye Penetrants (both Red and Fluorescent) suffixed with "T" are now available for this high sensitive technique to confirm the surface defects in weld inspection at minimum cost, with properly trained quality control personnel through the available International/National reference standard test pieces for dye penetrant checks and specifications as mentioned in this paper. This will remove ambiguity and confusion arising from individual interpretation.

In view of the fact that Thixotropic technique is operator intensive, welding as well as quality control operators should possess some knowledge of the Thixotropic techniques of dye penetrants.