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Dye Penetration Inspection on Formula Student Car Components

Pooja P. Mohite‡, Rahul R. Angaj‡, Shubham L. Bhujbal‡, Ruturaj D. Tawade‡, Avinash M. Kanake‡

‡ Department of Mechanical Engineering, UG students at MITCOE, SPPU, Pune (INDIA)

Abstract

Most of the engineering component fails from hairline cracks, fatigue cracks, discontinuities etc. when the component with such type of cracks use further in operation it tends to serious big failure which cannot be tolerated. Because of fatigue loading of component it is normal thing to get hairline cracks or discontinuities or any defect on surface of component. Dye penetration inspection (DPI) also known as inspection by liquid penetration and is used to locate the defects on the surface causing breaking of the component. This test is categories in non-destructive test as while testing or inspecting, the component doesn't get damage or distorted, and hence the after the test the interpreted component can be used in application if the result are free from any surface damage.

Keywords: *FSAE (Formula student car competition), Dye penetrant, developer, non-ferrous, cleaner, capillary action*

1. Introduction

Component testing or inspection before use and after some period of use is mandatory to avoid the unnecessary failure in running condition, which will cause the operation to the halt position. Component can be tested or inspected by two types, one is the destructive testing where the mechanical properties of component are find out such as tensile test, compressive test, fatigue test, creep test etc. but the problem with this test is that the tested component cannot used in the operation after the inspection as it is completely distorted.

The second method to inspect the component is NDT i.e. non-destructive testing where components can be used even after the inspection done on it. NDT plays very crucial role in finding out the defects in components which are getting in it due to use for a some period of time where it experience the loading unloading condition, which leads to hairline cracks, discontinuities, fatigue cracks on surface of component, which ultimately leads to failure from this cracks. Their for it is inevitable to do its Dye penetration test which relocate the discontinuities cracks on the surface and avoid further use if any defects are there.

The principle is based on capillary action. Due to which after a particular time period, the excess penetrant which is on the surface is removed. After this the next stage is application of the developer. The fluorescent dye bleeds out from the crack. The developer acts as the 'blotter'. To reveal the cracks or the discontinuities this blotter draws out the penetrant.

There are many ways of applying the penetrant to the test component. Brushing, dipping or even spraying of the penetrant can be done. After the 'dwell time' removal of the extra penetrant is done followed by application of the developer.

Inspection of indications of the visible penetrant can be done in artificial of natural light. According to the florescent or non-fluorescent dye, ultraviolet or white light can be used.

Following are the Stages performed.

1. Stage 1: Preparation of the surface
2. Stage 2: Apply the penetrant
3. Stage 3: Allow dwelling
4. Stage 4: Removal of the excess penetrant
5. Stage 5: Application of the developer
6. Stage 6: Allow developing
7. Stage 7: Reading for cracks
8. Stage 8: Post cleaning of the part.

2. Purpose of using dye penetration

When any new part of any machine or any mechanism is manufactured it is important to insure that it has no defects on surface as well as in core. To insure that inspection of that component has to be done before use. To know that destructive inspection or non-destructive inspection is done. In destructive inspection after testing the component has no use. And hence this type of inspection is done after the failure of components to do the failure analysis of those components. And hence the inspection of new material which are never been used in operation, which are also very costly to manufactured are done by nondestructive inspection where dye penetration inspection is widely used as it is very easy to do, low cost, and after inspection the components can be used in operation.

3. Steps in Dye Penetrant Testing

Depending upon material, size of the component, the environmental conditions under which the testing is been performed and the penetrant system used the procedure can vary. However, the stages are as follows:

Stage 1. Preparation of the surface: The surface is first cleaned to remove impurities like grease, dirt, oil that

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can give wrong results. If the component is machined, it might also require etching.

Stage 2. Apply the penetrant: The process is followed by application of the penetrant on the surface of he component to be tested. Generally the component is allowed to soak for 10 to 30 mins depending upon the factors like type of the material and the size of the crack.

Stage 3:.Allow dwelling: Dwell time is the sufficient time for which the penetrant is allowed to be on the surface so that it seeps into the crack depending upon the factors like system of application, material, etc. the time varies. It ranges typically from 5 to 60 minutes.

Stage 4. Removal of the excess penetrant: depending upon the type of the penetrant used, method of removal is carried out. After sufficient soaking time it is removed. To ensure that all the penetrant from the surface is removed keeping the trapping penetrant in its place, this procedure is performed under controlled conditions.

Stage 5. Application of the developer: A thin layer of developer is applied to the component. Variety of developers are available depending upon the type of the inspection conditions and penetrant compatibility. including the water suspendible, water soluble, non-aqueous wet developer and dry powder.it is necessary to apply thin coating to form a visible indication.

Stage 6. Allow developing: To permit the extraction of the penetrant which was trapped in the cracks, the developer is allowed to stand for some time.

Stage 7. Reading for cracks: after the blotting action the inspection is carried out. visible light with adequate intensity is used for viewing the dye penetrant.

Stage 8. Post cleaning of the part: Often the surface under test is cleaned after the inspection and defects are recorded if found.

4. Case study

It became the necessary to go through the dye penetration inspection to check whether the components of FSAE car in good condition or not for second time in a year, as the car experienced a massive impact when the drive train was failed in running condition, it puts a more stress than design stress at the time of failure on component especially on aluminum parts. Also while testing the car it experienced crashed one time which was of high intensity.

And hence it tends to do the dye penetration of following parts,

1. Spool and spool mount
2. Upright
3. Spindle

4.1 Spool and spool mount

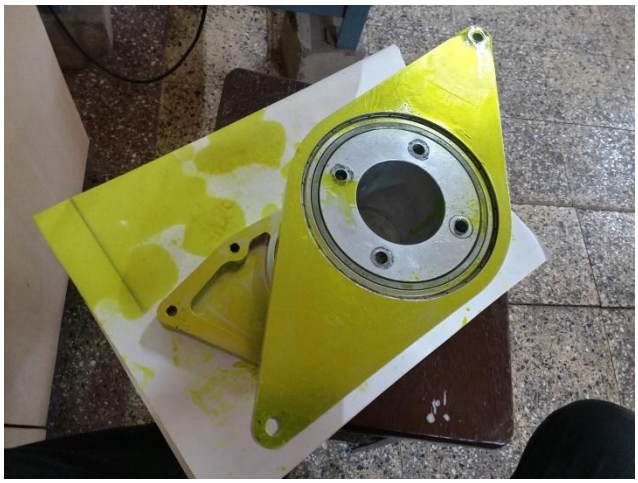

Fig .4.1.1: Spool with spool mount

Removing the grease, oil and dust from spool penetrant is spread on it. In the above fig. it is showing that the florescent penetrant is applied on it. After some dwell the removal of excess penetrant is done followed by application of the developer.

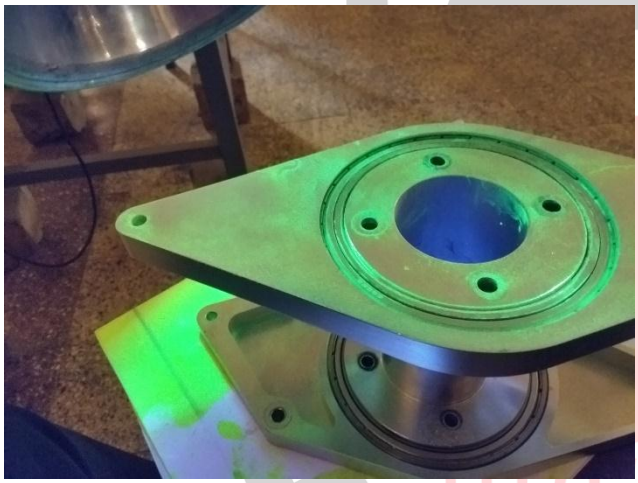

Fig.4.1.2: Under the florescent light

The developer which is the blotter pulls out the penetrant from the discontinuities, even after the cars experienced the impact load when it crashed the spool and spool mounts are in good condition though on the spool mount one little crack is their which is too small and can be neglected.

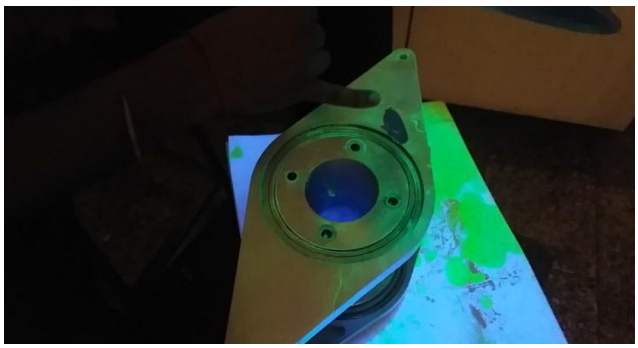

Fig 4.1.3: Spool mount with little crack on surface

4.2 Upright

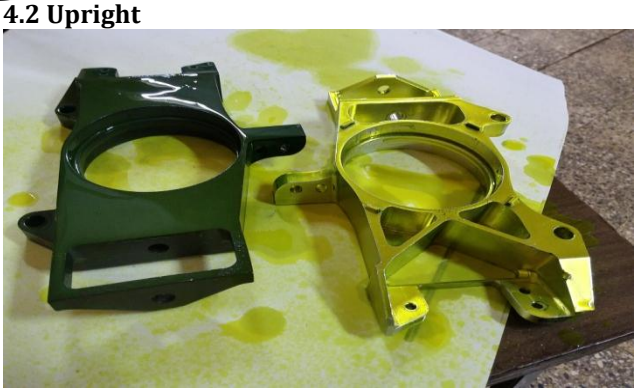

Fig 4.2.1: Upright of car

Figure showing the application of dye penetration after the proper cleaning of upright. After the 10 to15 min of settling time the application of developer is done.

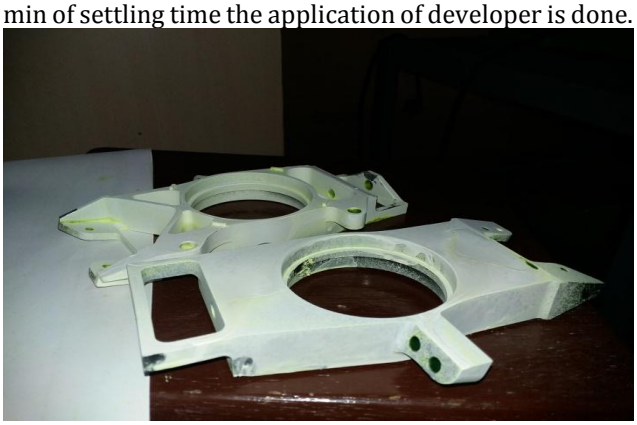

Fig 4.2.2: Upright of the car

Figure showing the uprights under the use of developer, after this under the fluorescent light it was checked whether it is in good condition or not after the car experienced the accident while testing.

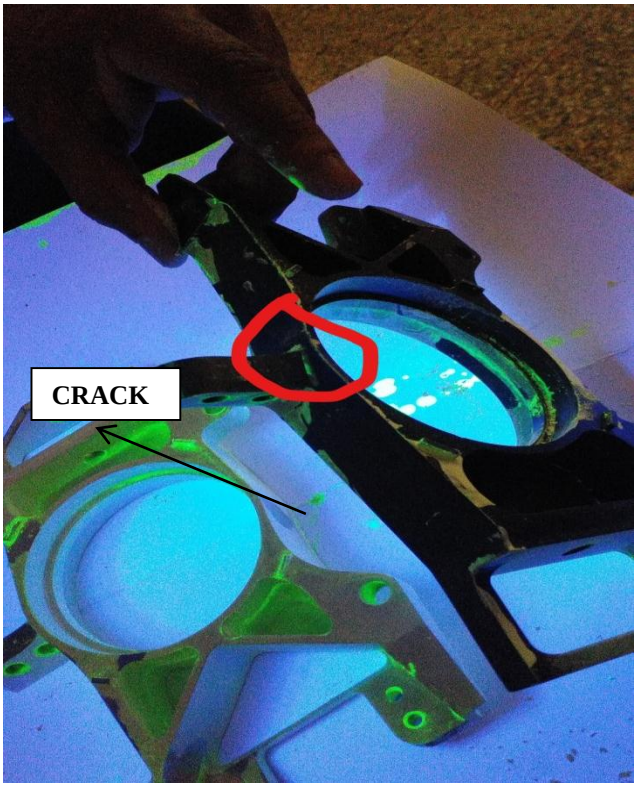

Fig.4.2.3: Upright with crack

When car crashed while testing the wheel assembly was get damage which rebuild within the day time but the real problem occurred when this picture came in frame, the above figure showing upright with the crack.

4.3 spindle

Fig 4.3.1: Spindle of car

Step1: As crack was occurred on the upright it became more important to do the dye penetration of spindle as it is the closest part of upright. The above figure showing the penetrant is sprayed on it, the same procedure is carried out for this also, and the dwell time of 15min gave to it to settle down the penetrant on surface of spindle.

Fig 4.3.2: Spindle of the car

Step2: After removing the penetrant developer applied on it to pull out the penetrant from the cracks if there. But after the inspection it is found that the spindle was free from the defect, no surface cracks or discontinuities occurred.

Fig 4.3.2: Spindle under light

Step3: Figure showing the Spindle under the fluorescent light showing no defect in it.

6. Conclusion

Dye penetration was done on this component when they brought from manufacturing to check whether it is in good condition or free from the surface defects, once we did that it was found that the parts were good and can be use, and then we used that parts on car. But after crashed and drive train failure it became mandatory to do the same on car parts.

And after dye penetration it is found that the uprights got serious crack and hence we decided to manufacture the new one and the upright with the crack used as a backup part. The spindle and the spool found to be free from the defect and hence we used this for further testing of car.

Only because of dye penetration it became possible to avoid the failure in uprights as corrective action was taken at a right time according to the dye penetration result.

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