Pembangunan bahan penetrant dari minyak terpakai

Development of penetrant materials from used oil

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Abstrak

Kertas kerja ini menerangkan keputusan ujikaji bagi menghasilkan bahan penetrant untuk ujian tidak merosakkan dari minyak terpakai. Minyak hitam terpakai yang diperolehi kenderaan telah digunakan sebagai bahan kajian untuk menghasilkan bahan penetrant. Minyak hitam terpakai yang agak likat dicairkan dengan minyak tanah. Ujian penembusan (penetrability) dilakukan ke atas minyak hitam dengan beberapa darjah kecairan. Kadar penembusan minyak hitam ini dibandingkan dengan penetrant yang terdapat di pasaran. Keputusan ujian diterangkan dan dibincangkan.

Abstract

This paper described the results of experiment to produce penetrant for nondestructive testing using used engine oil. The used engine oil were obtained from motor vehicle. It was mixed with kerosene at several mix proportion. The penetrability of these mixing were measured and compared with the penetrant available on the market. The results of measurement were explained and discussed.

Keywords: penetrant, NDT, penetrability, engine oil

INTRODUCTION

Basically any liquid could be considered a penetrant. The 'penetrating ability' is gained from a force in nature called capillary action. This force is available in any liquid. Capillary action is the force that caused sap to rise in trees. It is the force that causes oil to rise in a lampwick, a towel to soak up water, and a blotter to clean up spilled ink. The penetrant in each case is the liquid, the force is capillary action.

A liquid penetrant placed on a surface does not merely seep into discontinuities. It is pulled into them by capillary action. A penetrant does not depend on gravity to enter discontinuities. Due to capillary forces are much higher than the gravity forces, there is no different in penetration of liquid for discontinuities placed under or upper of the surface (Fig. 1).

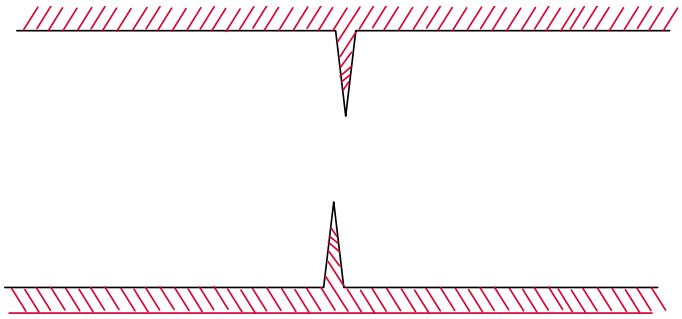


Fig. 1: Capillary force is not affected by gravity

Surface Tension

Surface tension is a surface phenomenon that makes the surface of a liquid behaves as a flexible membrane (Fig. 2). It is one of the two important properties, which determine the penetrating ability of a liquid.

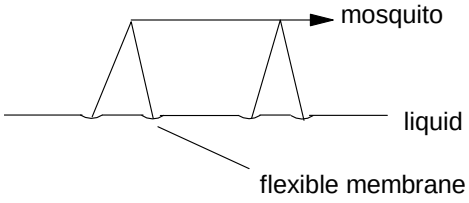


Fig 2: Surface tension of liquid caused mosquito or flies to stay on the surface.

Wetting Ability

The second important property that is required in a liquid if it is to have good penetrating power is the ability to wet the surface of the metal or other solid material to be tested. Ability to wet a surface is measured by the contact angle i.e. the angle between the liquid and the surface at the point of contact as the liquid advances along the surface (Fig. 3). The smaller this angles the better the wetting ability. Good penetrants have a very small contact angle.

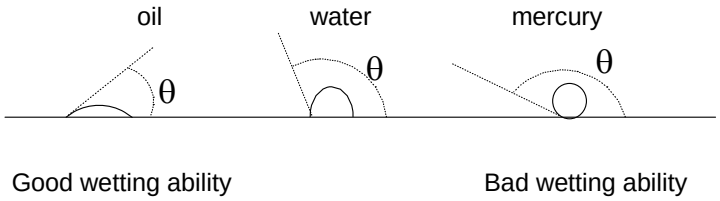


Fig. 3: Contact angle for different liquid

There are two forces involved in wetting ability i.e. cohesion forces and adhesion forces. Cohesion force is only a property of liquid while adhesion force is a combination of liquid and solid properties. Therefore wetting ability is not only depending upon the liquid but also depend on the type of the material and surface condition of the part.

Mechanism of Penetration in a Capillary Tube

The penetrability (Fig. 4), h of the liquid is given by,

$$h = k \tau \cos \theta \qquad (1)$$

where K = constant that depends on the capillary tube, etc.

τ = surface tension of the liquid

$\cos \theta$ = wetting ability of the liquid with respect to the solid

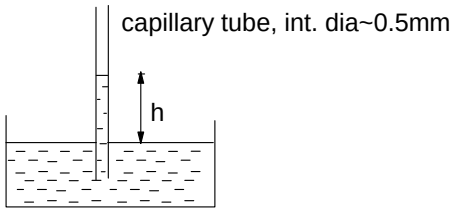


Fig. 4: Capillary tube

To give better penetrability, we need high value of $\tau \cos \theta$. In practise it is quite difficult to have high τ and high $\cos \theta$ because liquid behaves like figure below (Fig. 5).

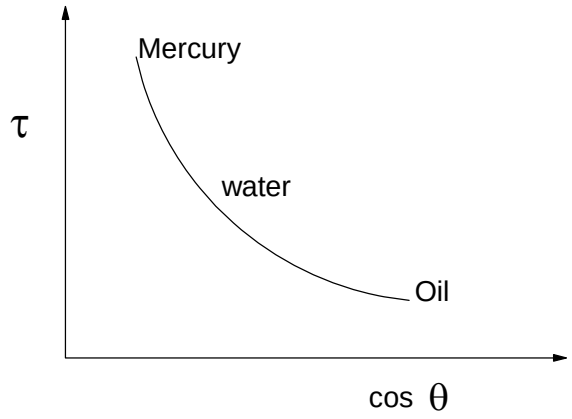


Fig. 5: Surface tension versus wetting ability

The objective of this research is to develop liquid penetrant using used engine oil. The performance of liquid is compared using crack test panel such as TAM panel, aluminum block and Brazil crack panel. The penetrability of liquid is compared using clamped Perspex block.

METHODOLOGY

Sample Preparation

The used engine oil was thinned using kerosene. The ratio is as follows: 1:0, 1:1, 1:2, 1:3, 1:4, 1:5 and 0:1.

Equipment and Materials

Figures 6 to 8 show the crack panel that used in the experiment for checking overall performance of liquid penetrant. Two Perspex plates were clamped for testing of liquid penetrability (Fig. 9).

Fig. 6: TAM panel

Fig. 7: ASME Aluminium cracked block.

Fig. 8: Petrobras (Brazil) crack panel

Fig. 9: Perspex plates clamped for penetrability test

Fig. 10 to 13) shows penetrant materials (penetrant, cleaner/remover and developer) used for comparison test.

Fig. 10: Used engine mixed with kerosene

Fig. 11: Penetrant product from the market

Fig. 12: Developer product from the market

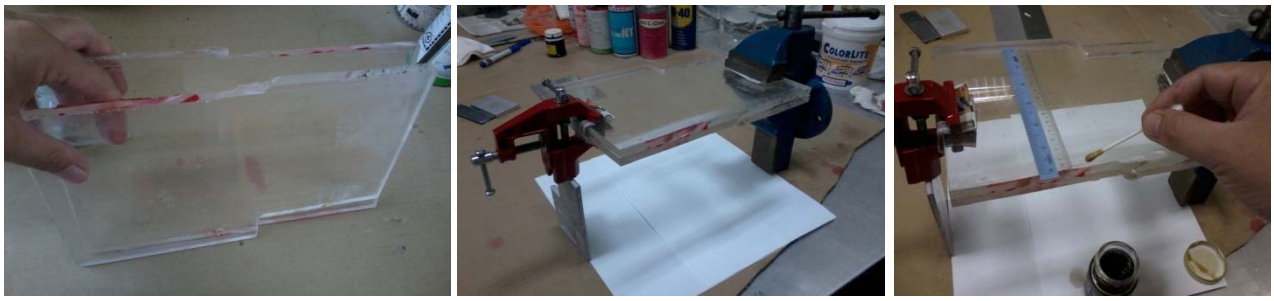
Fig. 13: Cleaner/remover from the market

Test Procedures

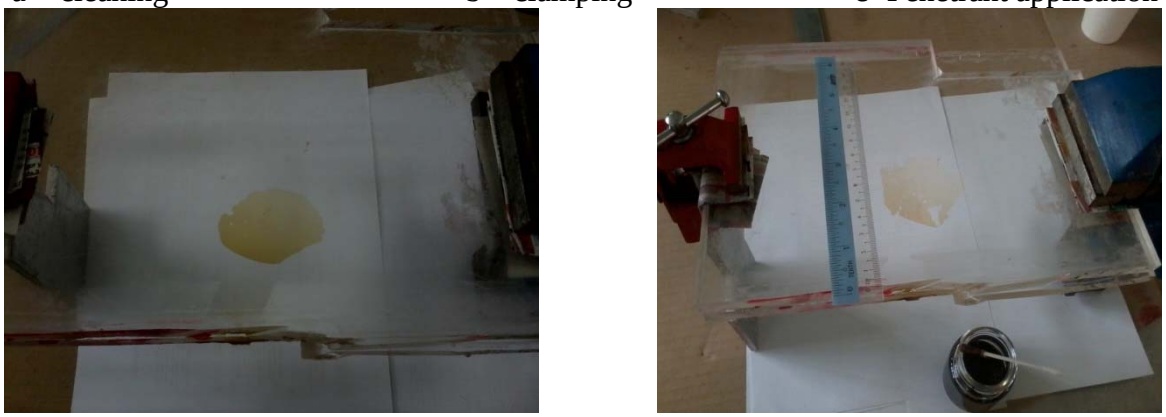
Crack panels from different standard were used to compare the overall performance of the liquid penetrant. The procedure is as follows;

- Surface preparation - clean using solvent remover to remove dust, oil, greases and other contaminant
- Penetrant application - penetrant applied to the surface by brushing
- Dwell time - 10 minutes to allow as much penetrant as possible to be drawn from or to seep into the defects
- Excess penetrant removal - excess penetrant on the surface were removed without removing penetrant from the discontinuity by using cloth dampened with cleaner/remover.
- Developer application - A thin layer of developer is then applied to the sample to draw penetrant trapped in flaws back to the surface where it will be visible.
- Inspection – 7-10 minutes after developer application.

Fig. 14 explained the step for testing penetrability of the liquid.



a- cleaning b- clamping c- Penetrant application



d-Liquid is allowed to penetrate for 2 minutes e- Depth of penetration is measured

Fig. 14: Penetrability test

RESULTS AND DISCUSSION

The result of overall performance test is summarized in Table 1. It shows that most commercial products can detect more than 80% of the cracks in the test panels. For aircraft industries the

requirement is to obtain 4 star cracks in TAM panel. For oil and gas or power generation (in welding construction), the requirement is as per ASME for non-standard temperature.

Used cooking oil produced the result with the least sensitive method. This is may be due to the liquid is too viscous and dilution with kerosene did not give better results.

Used engine oil may be applicable for less critical component and for detection of larger discontinuities.

Table 1: Overall Performance Test

Penetrant	**Number Crack detected**		
	TAM panel (5 star cracks)	Petrobras (5 star cracks)	ASME block (circular cracks)
ARDROX(996PA)	4	5	100% detected
ELY(Checkmor 222)	4	5	100% detected
MAGNAFLUX(SKL-SPI)	4	5	100% detected
Met-L-CHECK(VP-31A)	2	5	80% detected
Used engine oil	0	3	50% detected
Used cooking oil	0	2	N/A

Figure 15 shows the comparison between various liquid based on penetrability. Magnaflux produces highest penetration. WD-40 and kerosene oil are about similar penetrability. However when kerosene is mixed with used engine oil the penetrability dropped.

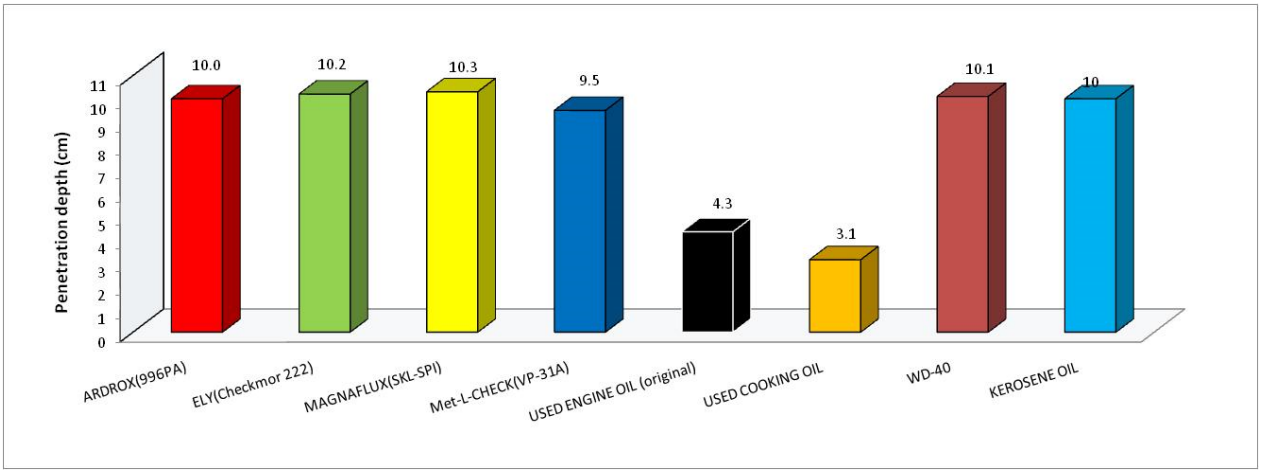


Fig. 15: Penetration depth of different type of liquid

Figure 16 shows the effect of mixing ratio between kerosene and used engine oil on the penetrability.

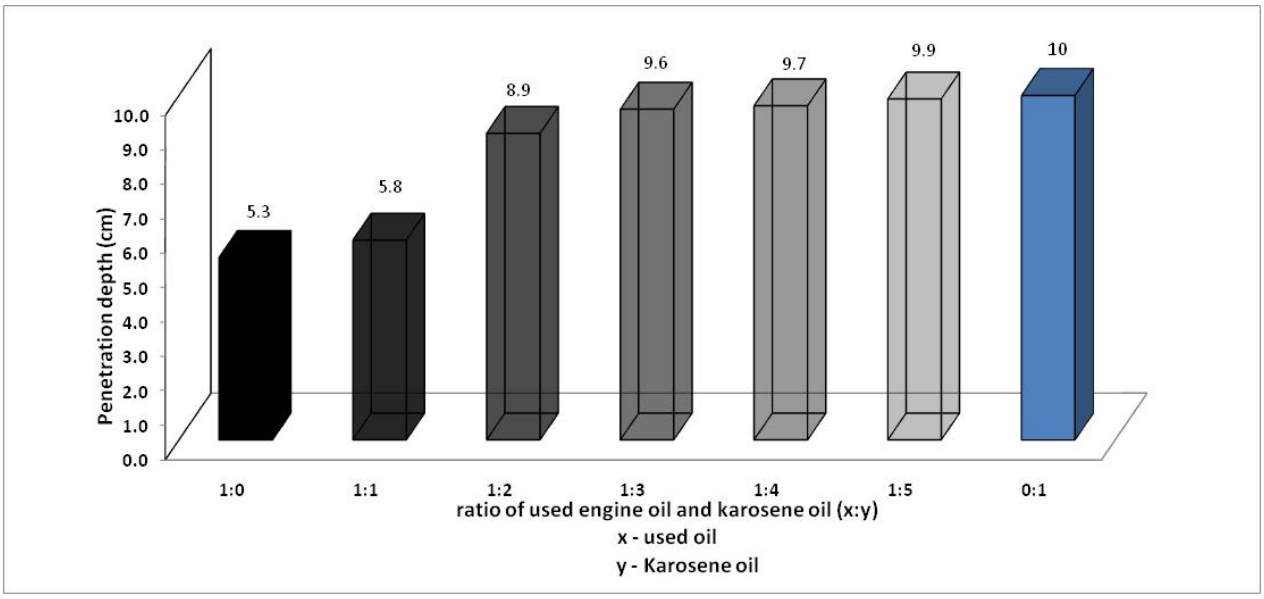


Fig. 16: Penetration depth of different dilution of engine oil/kerosene

CONCLUSION

The higher ratio of kerosene added to used engine oil the higher it's depth penetration but the color contrast is decreased. Ratio 1:3 may be optimum to balance between penetration and colour contrast.

The sensitivity rank of liquid penetrant in capillary action is Magnaflux, ELY, WD-40, ARDROX, kerosene oil, met-L- check, used engine oil and used cooking oil

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