THE EFFECTS OF MTBE BLENDING ON V/L RATIO OF INDONESIAN PREMIUM GASOLINE

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ABSTRACT

In preparation for possible future scarcity of lead alkylate as well as due to environmental considerations in the country, studies are being conducted in Indonesia on the use of oxygenated organic compounds as octane boosting components. Methyl ter'-butyl ether (MTBE) has received a great deal of attention on account of its relatively better characteristics in comparison with other oxygenates.

Since the use of MTBE affects the front-end volatility of gasoline, it is deemed interesting to present in this paper the results of a study on the effects of this compound on the vapour-liquid ratio of typical Indonesian premium gasoline. Although V/L ratio has not been an item in Indonesian gasoline specification, it is nevertheless a good measure of the vapour lock tendency of the fuel.

I. INTRODUCTION

Environmental restriction in many countries of the world has resulted in the general reduction of lead contents in gasolines. World lead alkylates production capacity has subsequently suffered a marked decrease, and the availability is expected to become scarcer in the future.

In place of lead alkylates, more and more countries are now introducing oxygenated organic compounds as octane enhancing components in their gasolines. Indonesia, which presently has relatively high allowable lead contents in its gasolines (15), is taking steps to face the future scarcity in lead alkylates, as well the possible pressure for a cleaner environment.

A number of studies have been made concerning the effects of various oxygenates on different physical and chemical properties as well as octane number of Indonesian gasoline (6, 7, 8, 9, 11, 12, 13).

The present paper outlines the results of a study on the effects of MTBE blending on the vapour-liquid ratio of a typical Indonesian premium gasoline.

II. LITERATURE

A. Indonesian Gasoline Volatility

As a fuel for spark ignition engines, it is important that gasoline has adequate properties with respect to combustion, volatility, and chemical stability. It must give the required performance in the engine, and be safe to handle. Neither it nor its combustion products should give undue problems to the environment (19).

The properties are generally controlled in the official specification of the products. For Indonesia, the present gasoline specifications are established in the regulation decreed by the concerned authority in May 1979 (15).

The volatility property of gasoline is controlled in this specification by its distillation curve as measured according to the ASTM D-86 standard procedure and Reid vapour pressure according to ASTM D-323. These limit the maximum temperatures for 10% evaporation at 74°C, a range of 88-125°C for 50% evaporation, of 180°C and 205°C for 90% evaporation and end point, respectively. Other limits concerned the difference between the temperatures for 20% evaporation and 10% evaporation which is limited to 8°C.

The Reid vapour pressure (RVP) is limited to 9,0 psi, similar to the most volatile (Classification A) gasoline in ASTM D-439 and ASTM D-4814 specifications (1a). The distillation curves limitation on Indonesian gasolines are quite similar to this class of ASTM gasoline, except that Indonesian gasoline use a slightly lower range of cut than the American one. Its initial boiling point and end point being 74°C and 205°C, respectively, compared to 70 and 225°C, respectively, in ASTM D-439 or ASTM D-4814.

B. Vapour Liquid Ratio as Measure of Vapour Lock

The vapour-liquid ratio (V/L ratio) which has been used in ASTM specification to control the front end volatility of gasoline has not been sanctioned in the Indonesian specification. The front end volatility is related to such performance of car engines as cold starting, hot starting, vapour lock, percolation and evaporation loss (18).

In particular for vapour lock, V/L ratio gives better indication for this tendency (1a). Vapour lock is caused by excessive vapour formation in the fuel pump, fuel lines, and carburettor, causing the mixture very lean and insufficient fuel entering the carburettor. This disturbs the smooth running of the engine, in power loss, and in serious loses causes the engine to stall and difficult to start. At V/L = 24, vapour lock begins to appear and at V/L = 36, vapour lock becomes serious (18).

The ASTM gasolines specifications, i.e. ASTM D-439 for automotive gasoline and ASTM D-4814 for automotive spark ignition engine fuel which includes oxygenated fuel blends, specify the limit of V/L= 20 maximum for certain test temperature, depending on the gasoline classification. For the least volatile gasoline, viz. Classification A gasoline, which is quite comparable to the Indonesian gasolines, the test temperature for V/L= 20 is set at 60°C (1a). This limit will be used as the basis for evaluating Indonesian gasolines in this study.

C. MTBE as Gasoline Octane Booster

The use of MTBE (methyl tert-butyl ether) as gasoline blending component influences the volatility behaviour of gasoline (3). MTBE has been much used as octane boosting component of gasoline, since its has better and more desirable properties compared to other oxygenated compounds such as methanol and ethanol. It has a high octane number of 116-118 RON (14, 17) or 115-135 RON in blends with gasoline (14). Its relative density of 0,7405 is within the range of gasoline density which ranges from 0.72 to 0.76 (3). Its Reid vapour pressure is 8.0 psi (2) and is well within the limit of Indonesian gasoline specification of 9.0 psi maximum (15).

Its boiling point of 55.2°C is relatively low (17), and when use as a blending component for gasoline it does affect the distillation curve of the latter, particularly in the range of 10% and 50% volume evaporated. This is particularly important from the point of view of vapour lock, which makes it important to measure the V/L ratio of the blends as is done in this study.

Various studies claimed that the use of MTBE up to 15% volume (3) or 20% (14) in gasoline does not create operational problem. In the United States, up to 11% volume of MTBE is permitted to be used as the blending component, corresponding to the maximum of 2% mass of oxygen in gasoline allowed by the country's Environmental Protection Agency (1a, 16).

The limitation of oxygen content is also related to the performance of the car engine and drivability. At 2% mass of oxygen disturbance to the drivability begins to appear and felt by expert drivers, and at 3.5% mass (corresponding to 20% volume of MTBE in gasoline blend) it become serious and felt by the common drivers (16).

Our present study is carried out for MTBE content of 0-15% volume.

D. V/L Ratio Determination

The ASTM gasoline specifications (ASTM D-439 and ASTM D-4814) indicate the standard procedure of ASTM D-2533 to be use for V/L ratio measurement or a modified one for oxygenated blends of gasoline (1a).

In addition to this direct measurement, ASTM allows the use of indirect estimation through the determination of distillation curve (ASTM D-86)

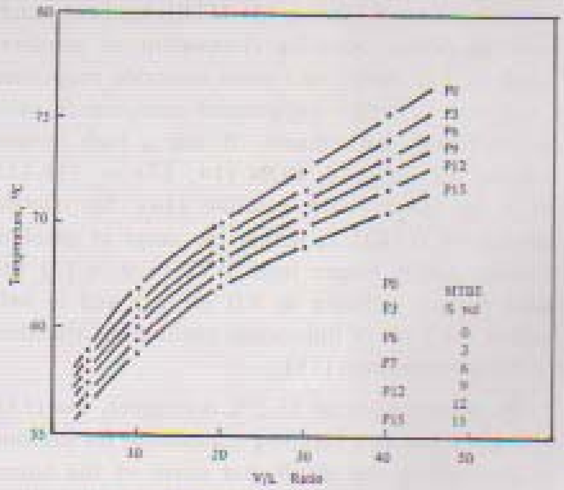

Figure 1. V/L Ratio-Temperature realationship for Premium – MTBE blends

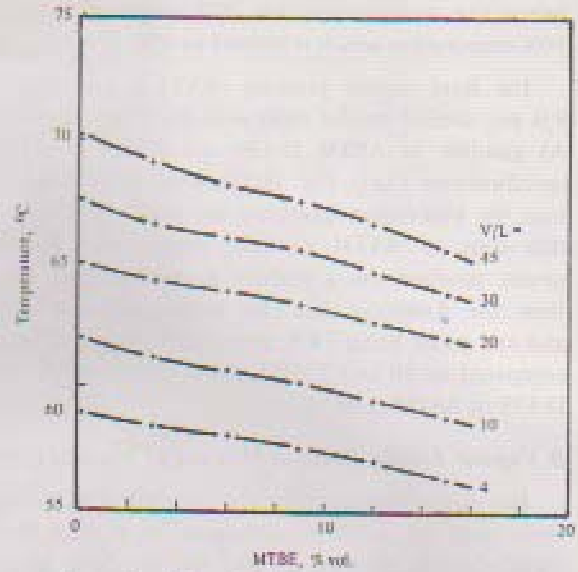

Figure 2. Effect of MTBE blending to V/L Ratio Temperature of Premium gasoline

and RVP (ASTM D-323). Three methods are recommended for calculation of V/L ratios from other data (1a).

The computer method involves the use of 10% and 50% volume evaporated and RVP data in a series of polynomial equations which are best worked out with the aid of a computer. Curve are also provided but these do not allow accurate readings.

The second method involves the use of 10% volume distilled only and RVP data and permit a simpler calculation which can be easily handled manually. The third method involves the use of a nomogram which was prepared from the linear equation.

An intensive study on the relation of distillation and RVP data with V/L ratios of gasoline has been made by Jenkins, who offered some 60 equations which were claimed to give sufficiently accurate estimates of V/L ratio (10). Our study, however was limited to the use of ASTM methods of estimation in addition to direct determination.

ASTM, on the other hand, indicated that the estimation methods should only be used as a guideline when V/L data from direct measurement are not available. The correlation of the direct measurement and indirect estimation methods will also be evaluated in this study (1a).

III. EXPERIMENTAL

A. Samples

The gasoline sample used in this study was a typical premium gasoline obtained from a petrol station in Jakarta. Its quality checked satisfactorily against the current Indonesian gasoline specification (15).

The MTBE used as blending component was an imported sample. It was analysed and found to contain 99.7747% mass MTBE (6). This checked with the published specification which shows that it should contain 98-99% mass, minimum, except its water countent was 0.058% mass compared to 0.005% mass, maximum, in the reference specification (14).

Premium-MTBE blends were prepared for 0%, 3%, 6%, 9%, 12%, and 15% volume of MTBE in the blends. These are designated as P0, P3, P6, P9, P12 and P15 in this study.

B. Test Apparatus and Method

1. Direct Measurement

The V/L ratio was measured following the modified procedure of ASTM D-2533. The apparatus consisted of a special V/L buret and a water bath.

Table 1
V/L ratio and temperature relation
of Premium – MTBE blends
(Indirect determination by computer method)

Sample Composition, % vol :	P0	P9	P6	P3	P12	P15
Premium	100	91	84	97	88	85
MTBE	0	9	6	3	12	15
ASTM D-86 :						
T 10%, °C	55.8	55.6	55.2	55.0	54.9	54.4
T 20%, °C	64.9	64.0	63.2	62.6	62.1	61.5
T 50%, °C	92.5	90.1	87.5	85.3	83.1	81.4
ASTM D-323 :						
RVP, kPa	46.5	47.6	47.9	48.6	49.0	50.3
V/L Ratio	Temperature, °C					
4	61.8	60.8	60.4	59.7	59.3	58.3
10	63.6	62.6	62.1	61.4	60.8	59.9
20	65.5	64.4	63.7	62.9	62.2	61.2
30	66.4	65.3	64.4	63.5	62.7	61.6
45	67.5	66.4	65.1	64.0	63.0	61.8

effects of MTBE blending to the V/L ratio of typical Indonesian Premium gasoline. Consistent with the higher volatility of MTBE, the effects on the front-end volatility have also been evident on the V/L ratio of the blends. The decrease in the V/L= 20 temperature, however, is relatively small, only 3°C for 15% volume of MTBE in Premium

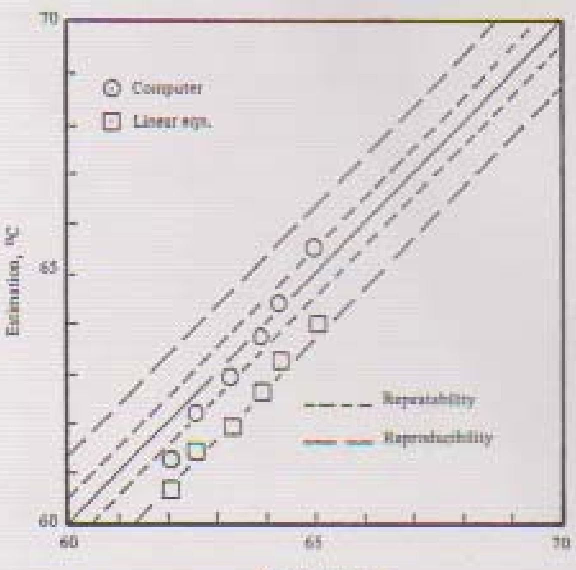

Figure 5. Comparison between estimated T(V/L=20) and experimental values

Table 2
Estimated T (V/L=20) for Premium–MTBE blends
(Indirect determination by linear equation and amogram methods *)

Sample Composition, % vol :	P0	P3	P6	P9	P12	P15
Premium	100	97	94	91	88	85
MTBE	0	3	6	9	12	15
ASTM D-86 :						
T 10%, °C	55.8	55.6	55.2	55.0	54.9	54.4
T 20%, °C	64.9	64.0	63.2	62.6	62.1	61.5
T 50%, °C	92.5	90.1	87.5	85.3	83.1	81.4
ASTM D-323 :						
RVP, kPa	46.5	47.6	47.9	48.6	49.0	50.3
Calculated T(V/L= 20), °C :						
Linear Equation	64.0	63.2	62.6	61.9	61.4	60.6
Nomogram	64.0	63.2	62.4	61.9	61.4	60.4

*) T/V/L= 20) = 52.47 – 0.33(RVP) + 0.20(T 10%) + 0.17(T 50%)

gasoline. This means that in order to have a V/L= 20 temperature for the blends higher than 60°C as for ASTM Classification A gasoline, the original Premiu m gasoline should have a minimum V/L= 20 temperature of 63°C.

The study found that the results of computer methods for estimation of V/L= 20 temperature correlate very well with the experimental resuults, but estimates by linear equation and nomogram methods gave results which are generally lower than the experimental ones. Through more experimentation, it is expected that new linear equation which would give better correlation could be formulated.

Table 3
Comparison of results
V/L=20 temperature of Premium – MTBE blends
by various methods

Sample Composition, % vol :	P0	P3	P6	P9	P12	P15
Premium	100	97	94	91	88	85
MTBE	0	3	6	9	12	15
T(V/L= 20), °C :						
ASTM D-2533 Mod.	65.1	64.3	63.9	63.3	62.6	62.1
Computer Method	65.4	64.4	63.7	63.0	62.2	61.2
Linear Equation	64.0	63.2	62.6	61.9	61.4	60.6
Nomogram	64.0	63.3	62.4	61.9	61.4	60.4

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