PRODUCTION OF GASOLINE COMPONENTS IN ASEAN REFINERIES AND EFFECTS OF THE STRICTER FUEL QUALITY REQUIREMENT

by

A.S. Nasution, E. Jasjfi and Evita H. Legowo

ABSTRACT

Intensive implementation of the blue sky program in many countries imposed the use of reformulated gasoline with a very sophisticated specification.

Motor gasoline is essentially a complex mixture of hydrocarbons distilled between 40° and 220°C, which consist of distillate fraction of crude oils and the conversion products of crude oil fractions. Small amounts of additives are also used to enhance various aspects of the performance of gasoline.

In ASEAN refineries, over 740 MBPSD of feedstock is processed which produce about 512 MBPSD of gasoline components. About 96 percent of the amount is processed in 39 units of the heterogeneous catalytic processes : i.e. cracking, reforming and isomerization, and the other 4 percent in 4 units of homogeneous catalytic processes: i.e. alkylation and polymerization.

Volatility, octane number, hydrocarbons composition and impurity content are the most determinant criteria of the gasoline. In most spark-ignition internal combustion engines, the fuel is metered in liquid form through the carburettor or fuel injector, and is mixed with air and partially vaporized before entering the cylinders of the engine. Consequently, volatility, is and extremely important characteristic with respect to starting, driveability, vapor lock, dilution of engine oil fuel economy, and carburettor icing.

To increase the octane level of gasoline an anti knock agent such as tetraethyl lead (TEL) or tetramethyl lead (TML) can also be used. Pressures to reduce atmospheric pollution are tending towards the reduction or elimination of lead from gasoline. Lead itself is known to be a poison and its presence in the exhaust gas is undesirable. Lead acts as a catalyst poison of catalytic converter installed to reduce carbon monoxide and hydrocarbon emission. Methyl tertiary butyl ether (MTBE) is one of the alternative to replace lead alkyls, and has been used as antiknock.

Unleaded gasoline (ULG) has been introduced since 1990 in ASEAN Countries: The actual penetration of ULG utilization in the first half of 1998 are as follows : Brunei Darussalam 48.9 %, Indonesia 0.6 %, Malaysia 80 %, Philippines 17.7 %, Singapore 81 %, and Thailand 100%.

The passage of the Clean Air Act Amendment of 1990 in the USA has forced American refiners to install new facilities to comply with stricter specifications for fuels such as gasoline and diesel oil. Various terms in the models address quality of the gasoline blended, sulfur content, and total aromatics and olefins contents, RVP, the T_{90} of distillation range, sulfur content, and oxygenated content. Specifications for the reformulated gasoline and the ASEAN commecial gasoline are presented.

Driveability index (DI) has been standardized by ASTM D-4814-98a and in the near future this DI could be recommended in the specification for the reformulated gasoline. Reformulated gasoline can be blended from the high quality gasoline components.

Volatility (RVP, T_{10}, T_{50}, T_{90} and driveability index), octane number (RON, MON and octane distribution), and hydrocarbon compositions of the gasoline components, as well as the refinery configuration to improve the quality of the gasoline components, and the compositions of these improved gasoline components of reformulated gasoline production are briefly discussed in this paper.

I. INTRODUCTION

Worldwide crude supply is experiencing a modest trend towards heavier gravity and higher sulfur crudes. The Middle East being traditionally the world's major oil exporting region, will continue to be the principal supplier of lower-quality crude in the future [1,2].

For the period of 1992 – 2005, the average annual demand growth rate of light products (gasoline, kerosene and diesel oil) continues to be higher than that for residual fuel oil [2]. The need will thus persist toward the conversion of additional bottoms into light product by both thermal and catalytic conversions.

Octane number is one of the most important criteria of engine the gasoline is connected to the compression ratio of engine and consequently the efficiency of its gasoline consumption. Another important characteristic is volatility, which has a vital influence on the performance of a car. Stability is also important particularly for a long period storage of gasoline, and this is related to olefin component which is prone to undergo oxidation/ polymerization reaction, forming what is known as gum.

Intensive implementation of the blue sky program in many countries imposes the use of reformulated gasoline with a very sophisticated specification. The passage of the clean Air Act Amendment of 1990 in the USA has forced American refineries to install new facilities to comply with stricter specifications for petroleum fuels such as reformulated gasoline and clean diesel oil [3]. Various terms in the models address qualities of the gasoline blended such as benzene, total aromatics and olefin contents, RVP, the T_{90} of distillation range, sulfur content, and oxygenates content. Effects of stricter gasoline specification on exhaust emission are shown in the table 1[3].

Reformulated gasoline can be blended from the high quality gasoline components. Volatility (RVP, T_{10}, T_{50}, T_{90}) and driveability index, octane number (RON, MON and octane distribution), and hydrocarbon composition of the gasoline components, as well as the refinery configuration to improve the quality of the gasoline components, and the compositions of these improved gasoline components of reformulated gasoline production are briefly discussed in this paper.

II. GASOLINE COMPONENTS FROM ASEAN REFINERIES

Surveys on refineries conducted by ASEAN council on Petroleum (ASCOPE) recently revealed the precarious state of current configuration of ASEAN refineries, particularly as regards to catalytic processes, which are indispensable for transforming fuel components to meet the impending stricter quality requirement .

Currently, a total of 3,837.0 MBPSD crude oil is processed in seven ASEAN countries' refineries (Brunei Darussalam, Indonesia, Malaysia, Philippines, Thailand,

Table 1
Effects of stricter gasoline specification on exhaust emission

Properties	Reducing		Exhaust	CO	No_x	Toxic
	From	To	HC			
Reduce Total Aromatics	45%	20%	-6%	-13%		-28%
Reduce Olefins	20%	5%	6%		-6%	
Reduce T_{90} (^{0}F)	360	280	-22%		5%	-16%
Reduce Sulfur (ppm)	450	50	-18%	-19%	-8%	-10%
Reduce RVP (psi)	9	8	-4%	-9%	-8%	
Increase MTBE	0%	15%	-5%	-11%		
Increase ETBE	0%	17%	-5%	-15%		

Table 2
Catalytic processes for the production the gasoline components in ASEAN Refineries
(capacity in MBPSD)

Catalytic process	Brunei D.	Indonesia	Malaysia	Philippines	Singapore	Thailand
Catalytic cracking process	-	103,5	-	44,5	61,0	75,0
Hydrocracking process	-	110,0	18,0	-	109,0	86,0
Catalytic reforming process	4,3	80,80	81,3	49,5	148,2	140,5
Isomerization process	-	-	9,0	-	-	37,5
Alkylation process	-	1,0	-	-	7,5	-
Polymerization process	-	15	-	-	4,1	-

and Vietnam, not including yet Laos, Myanmar and Cambodia). Out of this quaintly around 61 percent is passed through catalytic cracking processes to convert bottoms into light products. The processed crude oils range from sweet crudes, such as Southeast Asian light crudes, to sour crudes from Middle East, Far East, and Persian Gulf [4]

Gasoline, being essentially a complex mixture of hydrocarbons distilling at about 30°C to 220°C designed as fuel for spark ignition engines, can be produced by both distillation of crude oil and further conversion of the crude oil fractions. To burn smoothly and efficiently in modern motor vehicles, gasoline must have enough octane quality which, since 1923, has been achieved by the use of organolead compounds such as tetraethyl lead (TEL) and tetramethyl lead (TML).

In ASEAN refineries currently over 795.0 MBPSD of feedstock is processed in 53 units of catalytic processed, and this produces about 545.0 MBPSD of gasoline components comprising : cat. cracked gasoline 23.7 vol.% on the total gasoline components. Catalytic processes and compositions of gasoline components produced by catalytic processes in ASEAN refineries are shown in Tables 2 and 3 [5] .

III. PERFORMANCE OF GASOLINE COMPONENTS

A. *Volatility*

The primary requirement of a gasoline is that it should burn smoothly without exploding under the existing conditions in the combustion chamber of the spark-ignition, so that the maximum amount of useful energy is liberated.

The volatility of a gasoline has a vital influence on the both performance of a car and its emission. It affects the way car starts, the time it takes to warm-up, the extent to which ice will form in the carburettor, causing stalling and other problems; it influences vapor lock in the fuel system and indirectly determines overall fuel economy.

Volatility is a measure of the ability of a fuel to pass from the liquid to the vapor state under varying conditions. In cold weather, cars can take a very significant time to warm-up, i.e. to be capable of smooth, non-hesitating acceleration without the use of the choke.

The factor which influences vapor lock is the volatility characteristic of the fuel. The degree to which a fuel is liable to give vapor lock depends mainly on its front end volatility. A number of different front-end volatility parameters have been used to define the vapor locking tendency of a fuel, such as RVP, percentage evaporated at 70°C, the 10 and 15 percent slope of the distillation curve, the vapor/ liquid ratio at a given temperature and pressure.

Even after the car has warmed-up, fuel volatility can still have an influence on acceleration time. Low volatility fuels obviously give leaner mixture, and at leaner mixtures acceleration performance can fall of quite rapidly. The fraction of the fuel that influences acceleration behavior to the greatest extent is in the mid and a less extent the higher boiling range. Thus the 50 percent distillation temperature, sometimes together with the 90 percent distillation, must be controlled to ensure optimum acceleration behavior.

Control of the Driveability index (DI) derived from T_{10}, T_{50} and T_{90} can be used to assure good cold start and warm-up performance . ASTM D-4814 volatility standards have typically provided satisfactory driveability in most vehicles. The proposed ASTM specification for DI of gasoline is DI = 597°C. The following DI equation (details in SAE paper 881668) was developed by ASTM Driveability Task Force to relate vehicle cold start driveability to gasoline distillation temperature based on data from several oil companies and the Coordinating Research Council (CRC) programs:

$$DI = (1.5 \times T_{10}) + (3.0 \times T_{50}) + (1.0 \times T_{90})$$

Where :

- T_{10}, T_{50} and T_{90} : distillation temperature °C (F) at 10%, 50% and 90% evaporated by ASTM D-86 test method, respectively.
- Temperature conversion : (DI_F - 176) /1.8. American Automobile Manufactures Association (AAMA), European Automobile Manufactures Association (ACEA), Engine Manufactures Association (EMA) and Japan Automobile Manufactures Association (JAMA) have made an oxygenate correction for driveability index equation, i.e.:

  $$DI = (1.5 \times T_{10}) + (1.0 \times T_{50}) + (3.0 \times T_{90}) + (11.0 \times \text{Oxy wt.\%})$$

Worldwide gasoline harmonization for summer gasoline recommended 569 DI[6] RVP, ASTM Distillation and Driveability Index of gasoline components are given in Table 4.

B. *Octane Number*

Different hydrocarbons show marked variations in their pre-flame and ignition characteristics and so differ in their combustion behavior and knocking tendency in an engine. The anti-knock quality of gasoline is measured using a purely arbitrary scale of octane numbers suggested by Graham Edgar in 1926. To correlate the performance of gasoline in cars on the road three different octane parameters may be considered : research octane number motor octane distribution. The hydrocarbon composition of the gasoline components are given in Table 5.

1. Research Octane Number

The most important of the three octane parameters from the commercial view point is the research octane number (RON) since this is widely used to define octane quality in the market. It is determined by the research or F-1 rating method and related mainly to relatively mild operating conditions such as found during cruising and low-speed driving.

Low RON of gasoline gives knock at low-speed which is, relatively, not considered very serious from the point of view of performance or of possible damage to the engine.

Table 3
Composition of gasoline components produced by Catalytic Process in ASEAN Refineries

Gasoline Components	Brunei. D	Indonesia	Malaysia	Philippines	Singapore	Thailand	Reform Gasoline
Cat.Cracked Gasoline	-	41,54	-	37,14	17,75	28,12	38,0
Reformate	100,0	47,09	87,60	62,86	74,92	59,41	37,0
Isomerate	-	-	12,40	-	4,74	12,47	11,0
Alkylate	-	0,72	-	-	-	-	14,0
Polymer Gasoline	-	10,65	-	-	2,59	-	-
Total	-	100,0	100,0	100,0	100,0	100,0	100,0

Table 4
Volatility of gasoline component

Volatility	Cat. Cracked Gasoline		Reformate				
RVP, kg/cm^2	6,5-9,5	10,0	2,3	4,0	4,3	5,0	5,5
ASTM Distillation °C							
IBP	-	-	54	49	48	46	45
T10	-	46	107	74	68	64	67
T50	56-106	98	149	135	119	118	120
T90	147-180	182	175	171	173	176	178
FBP	-	-	213	213	210	218	225
Driveability Index °C	492-570	545,0	782,5	687,0	632,0	627,0	638,5

Volatility	Alkylate				Polymer gasoline				
	Type of olefin feeds				Type of feedstocks				
		$C_3^=$	$C_4^=$	$C_5^=$	$C_3^= C_4^= C_4^=$	$C_3^=$	$C_4^=$	$C_3^= C_4^=$	$C_3^= C_4^=$
RVP, Kg/cm^2	0.36*	0,30*	0,10*	0,4*	0,28*	2,0*	0,14*	0,65*	3,0
ASTM Distillation °C									
IBP	49	53	51	45	39,5	-	60	36	-
T10	77	81	108	72	109	88	100	65	99
T50	91	104	119	97	139	135	117	109	135
T90	117	127	139	122	192	193	182	176	160
FBP	176	175	182	171	218	-	228	216	-
Drivebility Index °C	505,5	562,5	658,0	521,0	772,5	730,5	683,0	600,5	713,5

Note (X) : RVP in kg/cm^2

Among various hydrocarbon types, paraffins have low octane number, but it increases with the degree of branching. Olefins, iso-olefins and aromatics, as well as highly branched iso-paraffins have octane numbers in the neighbourhood of 100.

Depending upon their hydrocarbon compositions and boiling range, straight-run gasoline are usually of low octane numbers, varying from 40 to 80 clear RON. Light straight-run naphtha with medium branched paraffins give higher octane than heavy straight-run naphtha. The octane number of paraffin naphtha is lower than that of napthenic naphtha.

Thermal cracked gasoline with high olefin content has 70-75 RON. While and thermal reformates containing both high aromatics and olefin give 90-103 RON.

The clear RON of typical catalytic cracked gasoline range from 90 to 93 RON for the C_5 to 130°C boiling range and 93-96 RON for 130-220° C the boiling range, depending on the composition and conversion of feedstock, and the catalyst used. By increasing the olefin and aromatic contents, the clear RON of catalytic cracked gasoline increases.

Clear RON of hydrocracked gasoline can vary between 65 and 90 depending upon type and conversion of feedstcks, and catalyst. Light hidrocracked naphtha with high branched paraffins has higher octane number than the heavy hydrocracked naphtha containing high naphtha.

Reformates have 80 to 107 clear RON depending on the feedstock composition, yield of reformate and catalyst. RON of reformates increase with the aromatic contents.

In a once-through isomerization the clear RON of ligh straight-run naphtha can be increased from 70 to 84. If an additional fractionator is installed to permit recycling of n-C_6, an additional improvement of 4 clear RON can be achieved. The RON of isomerates increases with iso/n paraffins ratio.

The clear RON of alkylates can be as low as 85 but, typically, lies between 93 and 96 depending upon the high branched paraffins content in the alkylate and the olefin in the feed. The $C_3^=$ olefin giving the lower octane number. The latest alkylation process uses ethylene to give C_8 isoparaffins with RON of 99-103. The RON of alkylates increase with three methyl pentane contents.

Polymer gasoline has clear RON from 95 to 99 containing about 90% by volume of high branched olefins depending upon the type of olefins used, the $C_3^=$ olefins giving the lower RON than other olefin feed $C_4^=$and $C_3^=$/$C_4^=$mixed.

2. Motor Octane Number

The motor or F-2 rating method relates to more severe driving conditions such as high-speed, high-load operations. The motor method normally rates a gasoline lower than does the research method, and the difference is defined as sensitivity (S), i.e.:

S=RON-MON

Sensitivity, instead of MON, is often used together with RON to define road octane performance. A fuel having a poor motor octane in relation to its research octane number would have a high sensitivity. RON and MON gasoline components are shown in Table 5. The sensitivity of these gasoline components increases as follows:

Paraffinic < olefinic < aromatic.

A fuel which is satisfactory at low engine speeds (high RON) but performs less well as the speed increases would have a poor motor octane number in relation to its research octane number. In other words, it would have a high sensitivity.

High speed knock (low MON or high sensitivity), on the other hand, cannot readily be possible for engine damage to occur.

3. Octane Distribution

Octane distribution gives a measure of the distribution of octane number through the distillation range of the gasoline. This can be measured by number of different ways in the laboratory. One type of test measures the octane number of lighter fractions. This gives a measure of octane distribution and is designated as ΔR100°C or ΔR75 percent. A poor octane distribution has high Level.

The importance of octane distribution in a fuel is that some cars. Particularly during full throttle accelerations, tend to segregate the high-boiling components from the low-boiling components in the inlet manifold. This has the effect that, for a brief period, only the lower-boiling components that have been fully vaporized go forward to some cylinders while the high-boiling materials still in liquid form hang back in the manifold. Since the lighter fraction normally has a lower octane quality than the heavier components, transient knock occurs which then dies away as the heavier fraction "catch-up".

Reformat has a low-octane paraffin components in the lower boiling and can have quite high-octane aromatic components at higher boiling end. Catalytic cracked gasoline has high octane components of high branched structures of both paraffins and olefins at lower boiling end, and high aromatic at higher boiling end of this catalytic crocked gasoline. Isomerate, alkylate and polymer gasoline have a good octane distribution of reformate is given in Table 6.

Alkylate and polymer gasoline contain high octane of both branched paraffins and olefins throughout their boiling range.

A fuel which gives a poor performance (low RON)

Table 5
Hydrocarbon composition of gasoline components

Type of Gasoline Component	Paraffin		Naphthene	Olefin		Aromatic		RON
	Total	Iso		Total	Iso	Total	Benzene	
Straight Run Naphtha								
- Light Naphtha	91,7	45,2	6,8	-	-	1,5	1,5	72,0
	90,0	54,8	7,9	-	-	1,0	1,0	69,9
- Heavy Naphtha	63,5	-	24,5	-	-	11,8	-	-
	44,1	-	44,5	-	-	10,9	-	-
- Total Naphtha	66,0	-	29,0	-	-	5,0	-	54,0
	69,0	-	21,0	-	-	10,0	-	50,0
	62,0	-	24,0	-	-	15,0	-	60,0
Thermal Reformate	5,3*	-	*	34,0	-	34,0	16,8	90,0
Thermal Cracked Naphtha	30,0	-	25,0	30,0	-	15,0	-	-
	44,0	-	23,0	14,0	-	14,0	-	-
	30,0	-	25,0	28,0	-	17,0	-	-
	35,0	-	30,0	22,0	-	13,0	-	-
Reformate	14,8	-	0,95	-	-	84,87	3,0	97,8
	45,0	-	2,0	1,0	-	52,0	1,0	86,6
	38,0	-	2,0	-	-	60,0	9,0	93,1
	31,0	-	1,0	-	-	68,0	-	98,3
Hydrocracked Naphtha								
- Light Naphtha	82,0	-	15,0	-	-	3,0	-	86,0
	63,0	-	36,0	-	-	1,0	-	79,0
	37,0	-	54,0	-	-	9,0	1,5	70,0
- Heavy Naphtha	48,0	-	47,0	-	-	5,0	1,7	52,0
	46,0	-	44,0	-	-	5,0	-	53,0
	47,0	-	55,0	-	-	3,0	-	51,0
Total Napththa	33,0	-	55,0	-	-	12,0	-	68,0
Isomerate	89,5	53,0	5,3	-	-	1,5	-	89,0
	69,0	26,0	3,0	-	-	1,7	-	83,0
	67,5	29,8	2,7	-	-	-	-	80,0
Alkylate	100	100	-	-	-	-	-	94,0
	100	100	-	-	-	-	-	95,5
	100	100	-	-	-	-	-	93,3
Polygasoline	-	-	-	100	100	-	-	96,0
	-	-	-	100	100	-	-	101,0
	-	-	*	100	100	-	-	99,0
Cat.Cracked Gasoline	37*	-	*	38,0	-	25,0	-	-
	23*	-	*	43,0	-	34,0	-	93,3
	34*	-	*	31,0	-	31,0	-	91,0
	45*	-	*	25,0	-	31,0	-	90,6
	27*	-	*	45,0	-	5,0	-	-

Note : (*) Paraffin and Naphthene

at low speeds can be quite satisfactory at higher speeds (high MON); such fuel has a poor octane distributions, I.e. a high DR level. RON and MON of gasoline components are shown in Table 7.

IV. PRODUCTION OF REFORMULATED GASOLINE

Volatility, octane number, hydrocarbon composition and impurity content are the most determinant criteria of the gasoline. In most spark-ingition internal combustion engines, the fuel is metered in liquid from through the sarburettor or fuel injector, and is mixed with air and partially vaporized before entering the cylinder of the engine. Consequently, volatility is an extremely important characteristic with respect to starting, driveability, vapor lock, dilution of the engine oil, fuel economy, and carburetor icing.

The hydrocarbon which make up the bulk of the gasoline components fall broadly into three general types: paraffins, olefin and aromatics, each of which has particular influence in the quality of the gasoline.

The clear research octane number (RON) of gasoline components are as follows: straight-run gasoline 60-80, thermal cracked gasoline 70-75, thermal reformate 90-103, catalytic cracked gasoline 90-96, hydrocracked gasoline 60-90, reformate 85-107, isomerate 70-88, alkylates 93-96, and polygasoline 95-99.

To increase the octane level of gasoline an antiknock agent such as tetraethyl lead (TEL) or tetraethyl lead (TML) can also be used. Pressures to reduce atmospheric pollution are tending towards the reduction or elimination of lead from gasoline. Lead itself is known to be a poison and its presence is undesirable in the exhaust gas. Lead acts as a catalyst poison of catalytic converter installed to reduce carbon monoxide and hydrocarbon emission. Methyl tertiary butyl ether (MTBE) is of the alternative to replace lead alkyls, and has been used as antiknock agent. The lead alkyl content of 0.5 g pb/L gasoline has been replaced by 11 vol. % of MTBE.

Specification for reformulated gasoline proposed in the USA and Europe are much stricter than those for commercial gasoline in ASEAN (Table 8)[8]. The actual

Tabel 6
Octane distribution and hydrocarbon composition of reformate

Boiling Range, °C	Vol.%	Hydrocarbon Composition, vol.%			Clear RON
		Paraffin	Naphtha	Aromatic	
25-45	13,6	100	0	0	82
45-63	7,6	98	2	0	80
63-75	6,9	86	5	9	62
75-85	6,9	60	5	35	81
85-95	6,3	89	7	4	64
95-107	3,9	71	9	20	70
107-120	15,3	19	3	78	96
120-130	0,8	43	0	57	88
130-140	12,3	7	0	93	104
140-150	5,6	2	0	98	115
150-170	11,6	0	0	100	111
170-195	9,0	0	0	100	113
25-185	100	43	2	55	96

Table 7
Octane distribution and hydrocarbon composition of reformate

Straight-run light naphtha			Cat. Cracked Gasoline			Reformate		
RON	MON	Sensitivity	RON	MON	Sensitivity	RON	MON	Sensitivity
71,0	67,0	4,0	95,0	81,6	14,4	95,2	85,0	10,2
60,0	58,6	1,4	93,6	79,8	13,8	95,0	85,0	10,0
56,8	55,0	1,8	91,5	79,2	12,3	90,0	81,0	11,0
72,0	69,0	3,0	93,7	81,0	12,7	89,0	80,0	9,0
71,0	67,0	4,0	90,3	78,6	11,7	87,0	81,0	6,0
RON	66. ,6	3,3	89,9	79,2	10,7	85,0	77,0	8,0
72,3	69,7	3,5	92,8	80,5	12,3	-	-	-
63,0	62,4	0,6	93,5	81,5	13,0	-	-	-
60,0	58,6	1,4	98,5	81,5	17,0	-	-	-
56,8	55,0	1,8	-	-	-	-	-	-

Isomerate			Alkylate			Polymer Gasoline		
RON	MON	Sensitivity	RON	MON	Sensitivity	RON	MON	Sensitivity
83,0	81,0	2,0	89,0	87,0	2,0	96,0	86,3	9,7
80,0	79,0	1,0	92,0	90,0	2,0	101,0	86,0	15,0
91,0	92,0	1,0	95,0	93,0	2,0	99,0	81,0	18,0
83,6	81,8	1,8	94,0	92,0	2,0	99,0	85,0	14,0
80,9	80,4	0,5	93,0	92,0	1,0	95,0	83,0	12,0
89,0	88,0	1,0	96,0	93,0	3,0	94,0	82,0	12,0
89,0	87,0	2,0	94,0	91,0	3,0	97,5	82,5	15,0
88,5	86,0	2,5	93,3	91,7	1,6	-	-	-
83,5	81,4	2,1	95,5	93,5	2,0	-	-	-
85,1	84,2	1,9	95,0	93,0	2,0	-	-	-
-	-	-	93,0	91,0	2,0	-	-	-
-	-	-	99,0	96,0	3,0	-	-	-
-	-	-	97,0	94,0	3,0	-	-	-

penetration of ULG utilization in the first half 1998 are as follows: Darussalam 48.9%, Indonesia <0.6%, Malaysia 80%, Philippines 17.7%, Singapore 81% and Thailand 100%[9]

Driveability Index (DI) of commercial gasoline in ASEAN countries is as follows: Brunei Darussalam 556-572, Indonesia 555-660, Malaysia 555-636, Philippines 521-653, Singapore 556-636, Thailand 485-605, and Vietnam 655[9].

ASEAN gasoline pool has too much reformate with

Tabel 8
Current Indonesia, ASEAN and Reformulated Gasoline

		Indonesia	ASEAN	USA	Europe
T50	^{0}C	88-125	70-125	98	-
T90	^{0}C	180	170-190	148	-
RVP	kpa	62	62-83	49	-
Oxygen	wt%	2,0	2,0-2,7	2,0	2,0-2,7
Aromatics	vol.%	-	50-55	25,0	30,0
Benzene	vol.%	-	3,5-5,0	1,0	1,0
Olefin	vol.%	-	-	6,0	11,0
$C_4^=/C_5^=$	vol.%	-	-	1,0	-
Sulphur	ppm	1000	1,000-2,000	40	30

high benzene and aromatic content, T_{90} distillation and lack in alkylate and isomerate having low sensitivity and good octane distribution. The gasoline stream consists on average of the following constituents: reformate 30 vol.%, light naphtha 2 vol.%, cat. Cracked gasoline 39 vol.%, alkylate 15 vol.%, dimate 11 vol.% and MTBE 7 vol.% for 92-94 RON[7].

Exhaust emission in gasoline engines can be reduced by decreasing the RVP, T_{50}, T_{90}, distillatioan range, and sulfur, benzene and total aromatic content of gasoline.

Production of reformulated gasoline can be realized by increasing the capacity and performance of prefactionation, fractionation of reformate and cat. Cracked gasoline, and FCC units in the existing refineries.

Prefractionation and splitter can reduce reformate benzene to less than 1 vol.% from about 5 vol.% The existing naphtha hydrotreater can be used to saturate the olefins cat. cracked gasoline.

Between the splitter and reformer unit, a rerun tower can be added to split out the heavy portion of the reformer naphtha feed. This tower will help reduce the 90% distillation point (T_{90}) of reformate and cat. Gasoline to 310-320^0 F from about 380^0 F. The improved fractionation by debutanzer enables control of the cat. cracked gasoline RVP.

Dobottlenecking the LPG-to alkylate process will increase alkylate production. Key factors in achieving this increase are addition of a deisobutanizer and increase of FCC conversion by optimizing the FCC catalyst.

V. CONCLUSION

Intensive implementation of the blue sky program in many countries imposed the use of reformulated gasoline with a very sophisticated specification.

Specification of reformulated gasoline proposed in the USA and Europe are much stricter than those for commercial gasoline in ASEAN.

ASEAN gasoline pools have too much reformat with high benzene and aromatic content, T_{90} distillation and lack in alkylate and isomerate having low sensitivity and good octane distribution.

Production of reformulated gasoline can be realized by increasing the capacity and performance of prefractionation, fractionation of reformate and cat. Cracked gasoline, and FCC units in the existing refineries.

REFERENCE

1. Robert, J. Beck, 1996, *Oil Supply Increase Due in 1996's Second Half*, Oil and Gas Journal, July 29, 1996, pp. 57-76.

2. John R. Dosher, Jack T. Carney, 1994, *Sulfur Increases Seen Mostly in Heavy Fractions of Lower Quality Crudes*, Oil and Gas Journal, May 23, pp. 43-48.

3. Tan Chen, 1994, *Clear Motor Fuels – Implications and Challenges Facing Singapore Refineries*, 2nd ASCOPE Refining Workshop, Manila, Philippines, October 12.

4. A.S. Nasution, and E. Jasjfi. 1996, Production of Gasoline and Impact of More Stringent Specification on Catalyst Performance", 4th ASCOPE Refining Workshop, Thailand. November.

5. A.S. Nasution, and E. Jasjfi, 1994, *Strategic Collaboration Among ASEAN Refineries for the Production of Reformulated Fuels*, 26th IPA, Jakarta, May 19-21.

6. World-Wide Fuel Charter, 1999, 5th *Annual Fuels of Lubes Asia Conference*, Singapore, January 25-28.

7. News, 1994, *California Refiners Face Hurdle in Federal State RFG Rules*, Oil and Gas Journal, October 10, pp. 23-28.

8. Special Report, 1996, *Fuel Quality Standards for Year 2000 Proposed by the European Commission*, Fuels and Lubes International, December 1996, vol. 2 No. 12, pp. 10-11.

9. E. Jasjfi, 1993, *"Trend and Development in the petroleum fuel qualities in ASEAN countries"*, 4th ASCOPE Conference and Exhibition, Bangkok, Thailand. □