A STUDY ON OCTANE REQUIREMENT FOR MOTOR VEHICLES IN INDONESIA *)

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Abstract

The knowledge of the exact level of octane number required for the car population in a country is quite important both for the petroleum refiners and the consumers. If the actual gasoline octane number is too high, the use of a superfuous anti-knock represents a loss for the refiners; on the contrary, if the octane level is too low, knock will result and risks of engine damage may occur. Various factors affecting the octane requirement of the car such as engine design, atmospheric conditions, service life of the car are reviewed.

The octane level needed could only be assessed by actual measurements on cars representing the various type of cars in the country.

Two consecutive studies for the requirement of the car population in Indonesia were carried out in 1978 and 1982 respectively, are described, and the results of the measurements of both studies are expressed in octane requirement curves.

1. Introduction.

In Indonesia, the gasoline supplied to the market consist of 2 grade called premium and super grades. These names are but labels used commercially to indicate the quality of the gasolines as indicated by their antiknock quality or Octane number. Premium and Super grades, each has 87 and 98 octane number respectively.

These gasoline grades have been on the market since late 1960's, and their octane numbers were then fixed tentatively by the government.

As the gasoline consumption increased tremendously in the past 15 years, nearly doubled every 5-6 years, a growing concern was felt in the refineries (Pertamina) to know the exact octane level needed for the car population in Indonesia.

It has been realized that no advantage could be attained in using gasoline having an anti knock quality or octane number higher than the engine requires. It would only represent loss for the refiners if the octane level of the gasoline produced is higher than required by the car population. On the other hand, the consumers should receive the correct level of gasoline octane number to satisfy their cars. So, it is to the advantage of both petroleum industry and consumers to know the level of octane number needed for the country.

In this light, the Lemigas Oil and Gas Technology Development Centre carried out the 1st study on the octane requirement of car population in Indonesia in 1978, which was followed by the second study in 1982. The methods and results of both studies are being described and presented in this paper.

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2. Octane number and octane requirement.

2.1. Octane number.

Octane number is a quality of gasoline which relates to its combustion properties. Gasoline of higher octane number has less tendency to produce knocking, which is a form of abnormal combustion, compared to that of lower octane number.

Knocking manifests itself by a characteristic metalic noise and has detrimental consequences, such as loss of power, strong vibrations with local overpressure on mechanical parts, and engine overheating. The actual loss of power and damage to an engine due to knocking may be in significant for a light knock, but heavy and prolonged knocking may have an adverse effect in terms of power loss, the increased rate of engine wear and possible damage to the engine. Hence the potential durability of power and fuel economy of a given engine is realized only when the engine anti-knock quality is adequate.

The octane number of a fuel is defined as the precentage by volume, to the nearest tenth, of ASTM iso-octane (equal to 100) in a blend with n-heptane (equal to 0,0) that exactly matches the knock intensity of the unknown sample when compared according to standard methods.

The standard method to measure the octane number of a fuel is by using a standard single cylinder CFR engine run at well defined conditions.

There are two recognized laboratory engine test methods for evaluating the anti knock quality of motor fuels, namely the Research Method (F1) and the Motor Method (F2).

The Research Method, ASTM D 2699, produces the research octane number (RON) which is a measure of anti knock performance under conditions of relatively low engine speeds. It is indicative of fuel anti-knock performance in a full scale engine operating at wide open throttle and low to medium speed. In practice, these conditions would exist for most passenger cars and light duty commercial vehicles during periods of full throttle operation.

The Motor Method, ASTM D 2700, on the other hand, measures the motor octane number (MON) or the anti knock performance of a gasoline under more severe operating conditions of relatively high inlet mixture temperatures and relatively high engine speeds. In practice, these conditions would exist for many passenger cars and light duty commercial vehicles during periods of power accelerations at higher speeds, such as when passing other vehicles or driving on hills.

2.2. Octane requirement of a car.

While octane number is a quality of fuel, the octane requirement is characteristic of the engine. The octane requirement of a car indicates the octane number of a fuel which would not produce knocking when used in the particular car.

If a car runs on a fuel having an octane number less than its octane requirement, abnormal combustion will occur as indicated by knocking sounds, with the subsequent detrimental effects as described in Section 2.1 above. A loss of power and an increase in fuel consumption will result.

If a higher octane number of fuel is used compared to the octane requirement of the car, no adverse effect may be observed, except that the production of high octane gasoline may involve a higher consumption of crude oil and at a higher cost.

Therefore from the economic point of view it is very important that the octane number of the gasoline supplied and the octane requirement of the car match each other correctly.

The octane requirement of a car is determined by actual measurements on the road. The most commonly used method is the CRC-E-15-62 method by the Coordinating Research Council in the USA. This method was also adopted by the CORC (Cooperative Octane Requirement Committee) in Europe.

This method consists of the determination during acceleration the speed where knocking appears and disappears when using reference fuel mixtures having octane numbers between 80 to 100, with one unit increments.

This measurement is made with the vehicle to be tested so adjusted that spark advance is set at manufacturer's recommendation, and the engine must be first allowed to reach its thermal equilibrium.

Observations are then plotted on a graph such as Fig. 1, where in the abscissa engine rotation speeds are recorded, and in the ordinate, the octane numbers of the reference fuel mixtures are recorded. The maximum value of the curve obtained is called the octane requirement of the car being tasted.

In the CORC method the observations are made for engine speeds between 1000-3500 rpm at highest gear. This corresponds to speeds of 20-80 km/hour, which seem suitable for Indonesia driving conditions, where high way driving does not predominate.

In practice, it is important to know the octane requirement of the car when using commercial gasoline. In this case, the measurements are made using blends of gasolines made if commercial gasoline components having research octane number between, say 80 — 100 ON. This commercial reference fuel should have a chemical composition, specific gravity, and distillation curve similar to the commercially available gasoline in the country. A similar curve relating the octane number and engine speed is produced, and the octane requirement of the car based on average commercial gasoline is determined from the maximum value of this curve.

3. Factory affecting the octane requirement.

Not all engines have the same octane number requirement that would give normal combustion. Each engine under each operating condition has a different octane number requirement.

This is because the octane number that is required by each engine to give normal good combustion depends on many factors such as :

- (1) Engine design
- (2) Atmospheric conditions
- (3) Mileage

Each of these factors is discussed briefly below.

3.1. Engine design.

Within the category of engine design, the following can be considered:

3.1.1 Compression ratio.

Compression ratio, i.e. the ratio of the volume of air and fuel when the piston is at the lower end of the cylinder, to the volume when the mixture is compressed and the piston is in the topmost position, is the most important factor which affects the combustion qualities of fuel.

In general, the higher the compression ratio the higher the tendency of the engine to knock, and the higher the octane number of the gasoline that should be used. In some cases, octane number requirement increases from 75 to 95 as the compression ration of an engine is increased from 6.0 to 9.0. A European study indicates an increase in octane requirements in the range of 4.3 to 6.3 ON per unit increase in compression ratio while the British Technical Council concluded that an average figure of 5.6 increase in octane number requirement per unit increase in compression ratio applies generally to the current engine design.

The reduction of compression ratio, on the other hand, affects the fuel consumption. The British Technical Council (BTC) found that fuel consumption increased by 7.6% for each drop in compression ratio, and the Committee of Common Market Automobile Constructions came up with the figure of 5,6%. Both these figure refer to smaller European engines. For pre-1973 American cars, the figure was 5.9%.

3.1.2. Shape and material of the combustion

The shape and design of the combustion chamber bears an effect on the octane requirement of the engine. Engines with similar compression ratio, but with different design of combustion chambers may require different octane numbers of gasoline to avoid knocking combustion.

The material of construction of the combustion chamber also affects the octane requirement of the engine. This is due to better heat transfer that may occur through certain light alloys.

3.1.3. Ignition system

Spark advance and spark plug types and gaps are known to affect the octane requirement of an engine. One degree variation in spark advance may cause about one point difference in octane requirement.

3.1.4. Carburation system.

The richness of the fuel/air mixture has also a marked effect on the octane requirement. The octane requirement caused by variations on the carburetted mixture can be as high as 1-5 On points.

3.2. Atmospheric condition.

Temperature, pressure and humidity all may affect the octane requirement of a car. Octane requirement of a car in one country may not be the same in another country with a different climate.

3.2.1. Temperature.

Increase in temperature may cause increase in octane requirement. One test show-

ed that the average octane requirement increase is about 0.05 point per °C increase in ambient temperature.

3.2.2. Atmospheric pressure

The atmospheric pressure directly affect the octane requirement of an engine. The varition follows a certain empirical formula, but on the average the octane requirement of a car decreases about 4.4 points as one mounted from sea level to about 1000 m altitude.

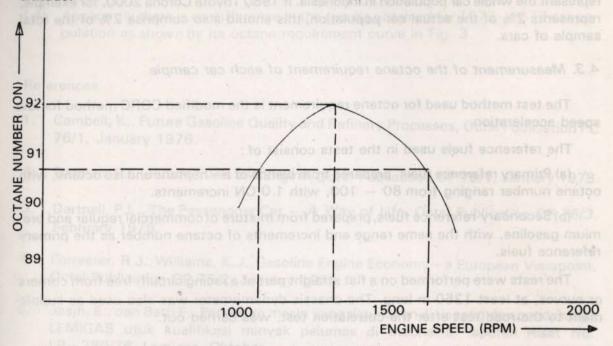


Fig. 1. Curve for octane requirement of Mitsubishi Galant, 1600 cc, year 1980.

3.2.3. Humidity.

Humidity may reduce the octane requirement of a car. It can decrease as far as 3-4 point during rainfall.

Therefore octane requirement of cars of the same make and type may be different in different countries with different climates.

3.3. Mileage of car

The mileage of the car may cause variation on the octane number requirement. Generally, the octane requirement of a car increases up to 4-10 from the running—in period to about 10-20.000km, where it reaches stability and flattens down.

Therefore the age of the car in a car population in a country has also bearing on the octane requirement level.

4. Steps in measurements.

The study of octane requirements of the car population in Indonesia is carried out according to the following main steps:

4.1. Survey of car population

The study of the car population was carried out, to know the number and the composition of the cars existing in the country. The study covers the number and composi-

tion of the car population up to five years old i.e 1978—1982 make. These statistics are shown in detail in Table 1, where the number of each particular make, type and year are indicated.

4.2. Composition of car sample to be tested

Form statistics data on car population, samples of 50 cars were selected so as to represent the whole car population in Indonesia. If 1980 Toyota Corona 2000, for example, represents 2% of the actual car population, this should also comprise 2% of the total sample of cars.

4.3. Measurement of the octane requirement of each car cample

The test method used for octane requirement is the modified CORC method for low speed acceleration.

The reference fuels used in the tests consist of:

- (a) Primary reference fuels, prepared from blends of n—heptane and iso octane, with octane number ranging from 80 100, with 1.0 ON increments.
- (b) Secondary reference fuels, prepared from mixture of commercial regular and premium gasoline, with the same range and increments of octane number as the primary reference fuels.

The rests were performed on a flat straight part of a racing circuit, free from corners or curves, at least 1250 m long. The chassis dynamometer was also used as supplement to the road test after the correlation test, was carried out.

4.4. Result of the measurements

The composition of the car samples is shown in Table 2, and the results of the measurements are plotted in a curve of octane requirement for the car population in Indonesia, where the octane requirement is plotted in the ordinates, and the percentage of the car population satisfied by each octane value on the abscissa (Fig.2) Two curves were obtained, one for each type of reference fuel.

From the commercial reference fuel curve the refinery or the government could determine the exact level of octane number to be incorporated in the gasoline produced in the refinery. If regular grade is made to satisfy 50% of car population, and premium grade to satisfy 90% of the car population in Indonesia, it means that the refinery should produce 92 ON for regular grade (or premium grade) and 95 ON for premium grade (or super grade).

5. Conclusion

- (1) It is to the advantage of both the petroleum industry and the consumers to know the exact level of octane requirement needed for the car population in a country in order.
 - . to avoid extra cost to the refinery in case the gasoline produced has higher anti-knock quality than required by car population and, on the other hand.
 - to ensure that the consumers receive the correct level of gasoline octane num ber to satisfy their cars.

- (2) The octane level needed could only be assessed by actual measurements on cars representing the various types of cars in the country.
 - (3) The results of the measurements for octane requirement of the car population in Indonesia are expressed in a curve, where it is shown that to satisfy 50% and 90% of the car population the required motor fuel is of 92 ON (premium gasoline) and 95 ON (Super gasoline) respectively.
 - (4) Apparently there is no difference in the results obtained for 1973-1977 car population as shown by its octane requirement curve in Fig. 3.

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Table 1
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		Corolla	3.064	2.577	40	5.473	5.123	4.807
		Hi-Ace	9.206	6.105	O)	9.533	6.425	4.099
		Land-						
		Cruiser	7.065	6.064	8	8.441	3.041	2.411
		Kijang	4.616	6.277	14	14.817	15.260	15.427
	ACCOUNT	818		Swe			243	396
	SUZUKI	Jimny	1	110		2.094	4.813	5.980
		ST.20	3.621	3.660	47	5.947	7.218	8.614
		Sense.						
	HONDA	Civic	2.484	1.479	308	2.294	2.431	2.640
		Accord	733	1.801		2.716	3.814	4.126
		Subtotal	72.520	63.435	106	106.960	91.765	101.274
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		Pallas	36	. 28		30	29	30
		Mehari/FAF	1	1		1.322	942	736
		Subtotal	922	403		2.205	1.834	3678

Table 1
Statistics of passenger and light duty cars in Indonesia (Gasoline engine)

District of the second		Tons	100	Z	Number of vehicles	S	SBA
Country of origin	Mark	l ype	1978	88 1979	9 1980	1981	1982
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		Patrol	1	306	160	2.437	2.840
		Sena	1	1	- 160	1	- 1
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1979	482	482		2.186	2.577	100	6.105	6.105	6.105	6.105	6.064	6.064 6.064 6.277 110 3.660	6.105 6.064 6.277 110 3.660	6.105 6.277 110 3.660	6.105 6.064 6.277 110 3.660 1.479 1.801	6.105 6.064 6.277 1.10 3.660 1.479 1.801	6.105 6.064 6.277 1.479 1.801 63.435	6.105 6.277 1.10 3.660 1.479 1.801 63.435	6.105 6.277 1.10 3.660 1.479 1.801 63.435		6.105 6.277 1.10 3.660 1.479 1.801 64 229 24	6.105 6.064 6.277 1.479 1.801 64 229 24 24 58	6.105 6.064 6.277 1.479 1.801 64 229 24 24 24 58	6.105 6.064 6.277 1.479 1.801 64 229 24 24 24 259	6.105 6.064 6.277 1.479 1.801 64 229 24 24 24 25 63.435	6.105 6.277 1.479 1.801 64 229 24 24 24 58	6.105 6.064 6.277 1.479 1.801 64 229 24 24 24 24 25 64	6.105 6.277 1.479 1.801 64 229 24 24 24 24 24 24 24 27 28
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1978 476 2.901	2.901	2.901	2.901	2004	3.004	9.206		1001	7.065	7.065	7.065	7.065	7.065	7.065 4.616 - 3.621 2.484	7.065 4.616 - 3.621 2.484 733	7.065 4.616 3.621 2.484 733	7.065 4.616 3.621 2.484 733 8	7.065 4.616 3.621 2.484 733 80	7.065 4.616 3.621 2.484 733 72.520	7.065 4.616 3.621 2.484 733 72.520 80 532	7.065 4.616 3.621 2.484 733 72.520 80 532	7.065 4.616 3.621 2.484 733 72.520 80 532 12	7.065 4.616 3.621 2.484 733 72.520 80 532 12	7.065 4.616 3.621 2.484 733 72.520 80 532 12	7.065 4.616 3.621 2.484 733 72.520 80 532 12	7.065 4.616 3.621 2.484 733 72.520 80 532 12 - 30	7.065 4.616 3.621 2.484 733 72.520 80 532 12 - 200 32 36	7.065 4.616 3.621 2.484 733 72.520 532 12 - 200 330 36
tanti 00 00 00 00			2.9	3.0		9.5		0.7		4.6	9.4	3.6	4.6	3.6 3.6 3.6 3.6 3.6 3.6 3.6 3.6 3.6 3.6	8 4.6 8 8.6 9.6 9.6 9.6 9.6 9.6 9.6 9.6 9.6 9.6 9	0x8 -0x8 lon sr len	0 8 6 7 6 8 6 8 8 8 8 8 8 8 8 8 8 8 8 8 8	3, 4, 4, 6, 6, 6, 6, 6, 6, 6, 6, 6, 6, 6, 6, 6,	33. 33. 33. 33. 33. 33. 33. 33. 33. 33.	2. 2. 2. 2. 2. 2. 2. 2. 2. 2. 2. 2. 2. 2	33. 4. 4. 4. 4. 4. 4. 4. 4. 4. 4. 4. 4. 4.	2. 2. 2. 3. 3. 3. 3. 3. 3. 3. 3. 3. 3. 3. 3. 3.	2. 2. 2. 3. 3. 3. 3. 3. 3. 3. 3. 3. 3. 3. 3. 3.	2. 100 2. 100 100 100 100 100 100 100 100 100 10	2. 2. 2. 3. 4. 4. 4. 4. 4. 4. 4. 4. 4. 4. 4. 4. 4.	1 Abs	1016 1016 1016 1016 1016 1016 1016 1016	1 AF T2. 18 AF T
Crown Corona Corolla Hi-Ace	Crown Corona Corolla Hi-Ace	Corona Corolla Hi-Ace	Corona Corolla Hi-Ace	Corolla Hi-Ace	Hi-Ace	200	Criticar	Viiona	Nijang		Jimny	Jimny ST.20	Jimny ST.20	Jimny ST.20 Civic	Jimny ST.20 Civic Accord	Jimny ST.20 Civic Accord	Jimny ST.20 Civic Accord Subtotal	Jimny ST.20 Civic Accord Subtotal	Jimny ST.20 Civic Accord Subtotal 604 504	Jimny ST.20 Civic Accord Subtotal 604 504	Jimny ST.20 Civic Accord Subtotal 604 504 304 505	Jimny ST.20 Civic Accord Subtotal 604 504 304 505 F.12.TI	Jimny ST.20 Civic Accord Subtotal 604 504 304 505 8.12.TI	Jimny ST.20 Civic Accord Subtotal 604 504 304 505 8.12.TI R.12.TI R.5	Jimny ST.20 Civic Accord Subtotal 504 504 304 505 8.12.TI R.12.TI R.5	Jimny ST.20 Civic Accord Subtotal Subtotal 504 504 304 505 R.12.TI R.5 R.18.TI GS.Club	Jimny ST.20 Civic Accord Subtotal 504 504 505 8.12.TI R.5 R.18.TI GS.Club Pallas	Jimny ST.20 Civic Accord Subtotal 604 504 304 505 R.12.TI R.5 R.12.TI GS.Club Pallas Mehari/FAF
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Table 1 (Continued)

Country	oiois o	Mod				Number of vehicles	Icies	
Country or origin	origin	Mark	lype	1978	1979	1980	1981	1982
U.S.A		DODGE	Avenger	87	120	980 44		1
		-	180	1	1	1	20	24
			Luv (Petrol)	1	1	1	75	83
		FORD	Cortina	i	1	-	92	88
			Laser	I,	e 1 -	1	1	799
		A.M.C.	CJ.7 (Jeep)	191	92 .	2.410	2.105	1.593
			Subtotal	278	196	2.454	2.292	2.587
ITALY		FIAT	131	364	208	180	1	1
GERMANY		MERCEDEZ		00%				
		Benz	200	91	118	202	206	210
			230	158	171	234	- W	ī
		ADEAD	280	243	223	374	361	332
		W	Safari	191	487	25	91	80
			Mitra	က	1	ī	Ē	Í
			Micro Bus	1	ı	1	561	746
		B.M.W.	520	163	111	6 K	112	115
			Subtotal	849	1.110	835	1.256	1.441
ENGLAND		MORRIS	1000 Salon	18\2	72	1880	1981	138
		LAND ROVER	88	172	240	240	1.064	1.837
			Subtotal	129	312	240	1 064	1 837

			able I (commued)		010			
	Country of origin	MANU BONES	88	135,007	240	Number of vehicles	vehicles	1.887
No.	Country of origin	Mark	lype	1978	1979	1980	1981	1982
7.	AUSTRALIA	HOLDEN	Torana SL	862	017.1	4.717 822	3,258,350	748.702
			Gemini	Though a	H	178	271	329
			Sun Bird	01 9 1	1	63	6,426 T	1 000 4
			Commodore	1	1	1	240	316
			Subtotal	862	1 1 8	241	511	645
			hete2	181	YBA	28	01	00
89	SWEDEN	VOLVO	244	94	152	161	86	74
			264	156	228	190	- 71	48
		MONRONS CIVIL	Subtotal	250	380	351	169	122
			TOTAL	76.174	66.044	113.466	98.891	111.554

Table 2
The composition of car samples to be tested

Total	lotal	E-4	3 4 10	AL FUEL	OMMERCI PRIMARY	RO	DUC	1101	90
	1982	1-2	I w	1	1-	-	A.S.	Neautic	12
samples	1981	110		1	rom o eze	1.	1		Se ⁻
The Number of car samples	1980	4		saetila c dopinen se dital racking	of modern p scut specific year to be and other	netrole lic fam netlon retina	illes of africient ag proc	betalves by Ind c	12
The Nur	1979	m	11	tond a	of producted in the production of the production	ing pro	spop du	r aignifid joly jarge	1
	1978	4	1	Cere so	1 100	ac l	n morely		8
Tumo	adkı	T.120 Galant 1600 L. 300	Corolla Corona Hi – Ace Land Cruiser Kijang	1500	Civic	202	C7	Micro Bus	
Mark	Mark	MITSUBISHI	тоуота	DATSUN	HONDA	PEUGEOT	A.M.C.	v.w.	- AP
Country of	origin	JAPAN			1 10	FRANCE	U.S.A.	GERMANY	- 08 - 08 - 08
(No.	÷				2.	e,	4	- 88

