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 overpresssure 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 showed 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.

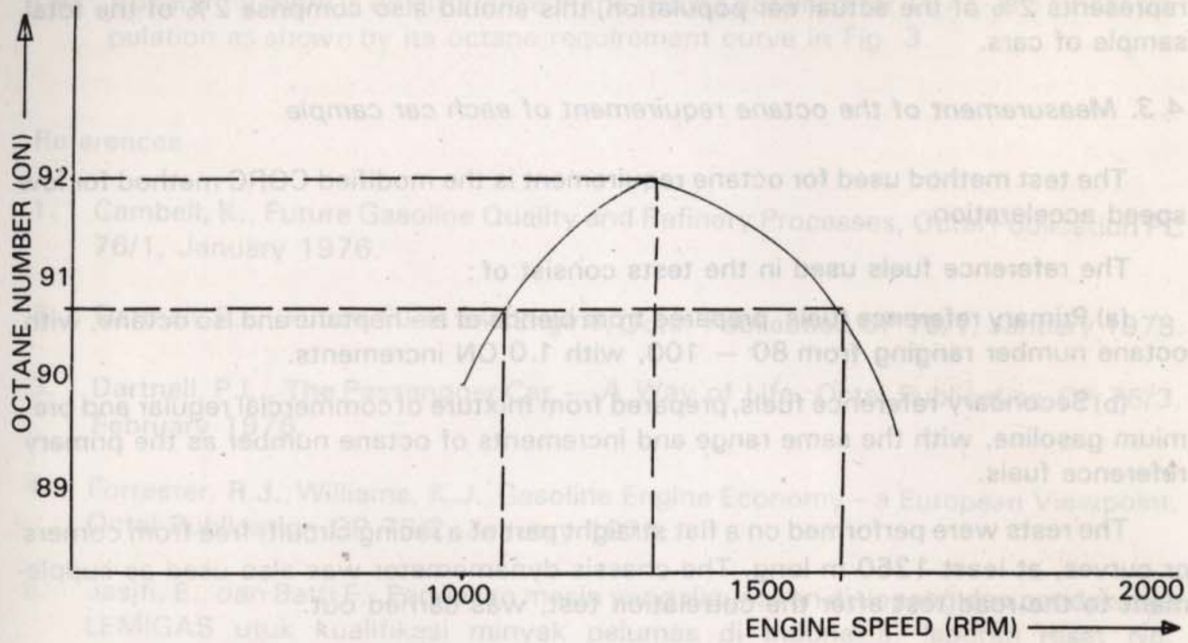

Fig. 1. ***Curve for octane requirement of Mitsubishi Galant, 1600 cc, year 1980.***

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 pcpulation

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 composition 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 whoie 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 number 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

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

No.	Country of origin	Mark	Type	Number of vehicles 1978	1979	1980	1981	1982
1.	JAPAN	DAIHATSU	L–38–FD	122	1	–	–	–
			Charade	85	1.317	2.065	2413	2622
			S.10.P.	7.177	5.141	10.000	13781	15508
		DATSUN	120Y	171	310	–	–	–
			180 B	224	161	–	–	–
			CN 620	6.154	3.461	904	–	–
			Nissan-Patrol	–	306	160	–	–
			Sena	–	–	160	–	–
			Laurel	–	–	–	–	200
		MAZDA	616	245	151	–	243	396
			808	94	70	–	–	–
			929	164	40	–	–	–
			323	130	147	80	360	498
			Pick-up	91	14	28	–	–
		MITSUBISHI	Galant-2000	1.235	754	1.000	1125	1214
			Galant-1600	–	397	500	1123	1172
			Lancer	–	–	–	2411	3706
			Colt T 120	22.462	20.412	33.075	–	–
			Colt Mini Cab.	–	12	2.500	7671	9569
			L–300	–	–	–	10456	15934

Table 1 *(Continued)*

No.	Country of origin	Mark	Type	Number of vehicles 1978	1979	1980	1981	1982
		TOYOTA	Crown	476	482	1.056	801	472
			Corona	2.901	2.186	4.117	3.256	1.879
			Corolla	3.064	2.577	5.473	5.123	4.807
			Hi-Ace	9.206	6.105	9.533	6.425	4.099
			Land-Cruiser	7.065	6.064	8.441	3.041	2.411
			Kijang	4.616	6.277	14.817	15.260	15.427
		SUZUKI	Jimny	–	110	2.094	4.813	5.980
			ST.20	3.621	3.660	5.947	7.218	8.614
		HONDA	Civic	2.484	1.479	2.294	2.431	2.640
			Accord	733	1.801	2.716	3.814	4.126
			Subtotal	72.520	63.435	106.960	91.765	101.274
2.	FRANCE	PEUGEOT	604	80	64	109	91	53
			504	532	229	437	430	435
			304	12	24	45	–	–
			505	–	–	–	–	1.522
		RENAULT	R.12.TI	200	58	140	41	20
			R.5	32	–	–	–	289
			R.18.TI	–	–	–	–	55
		CITROEN	GS.Club	30	–	122	301	538
			Pallas	36	28	30	29	30
			Mehari/FAF	–	–	1.322	942	736
			Subtotal	922	403	2.205	1.834	3.678

Table 1

Statistics of passenger and light duty cars in Indonesia

(Gasoline engine)

No.	Country of origin	Mark	Type	Number of vehicles				
				1978	1979	1980	1981	1982
1.	JAPAN	DAIHATSU	L—38—FD	122	1	—	—	—
			Charade	85	1.317	2.065	2413	2622
			S.10.P.	7.177	5.141	10.000	13781	15508
		DATSUN	120Y	171	310	—	—	—
			180 B	224	161	—	—	—
			CN 620	6.154	3.461	904	—	—
			Nissan-Patrol	—	306	160	—	—
			Sena	—	—	160	—	—
			Laurel	—	—	—	—	200
		MAZDA	616	245	151	—	243	396
			808	94	70	—	—	—
			929	164	40	—	—	—
			323	130	147	80	360	498
			Pick-up	91	14	28	—	—
		MITSUBISHI	Galant-2000	1.235	754	1.000	1125	1214
			Galant-1600	—	397	500	1123	1172
			Lancer	—	—	—	2411	3706
			Colt T 120	22.462	20.412	33.075	—	—
			Colt Mini Cab.	—	12	2.500	7671	9569
			L—300	—	—	—	10456	15934

Table 1 *(Continued)*

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			Corolla	3.064	2.577	5.473	5.123	4.807
			Hi-Ace	9.206	6.105	9.533	6.425	4.099
			Land-Cruiser	7.065	6.064	8.441	3.041	2.411
			Kijang	4.616	6.277	14.817	15.260	15.427
		SUZUKI	Jimny	–	110	2.094	4.813	5.980
			ST.20	3.621	3.660	5.947	7.218	8.614
		HONDA	Civic	2.484	1.479	2.294	2.431	2.640
			Accord	733	1.801	2.716	3.814	4.126
			Subtotal	72.520	63.435	106.960	91.765	101.274
2.	FRANCE	PEUGEOT	604	80	64	109	91	53
			504	532	229	437	430	435
			304	12	24	45	–	–
			505	–	–	–	–	1.522
		RENAULT	R.12.TI	200	58	140	41	20
			R.5	32	–	–	–	289
			R.18.TI	–	–	–	–	55
		CITROEN	GS.Club	30	–	122	301	538
			Pallas	36	28	30	29	30
			Mehari/FAF	–	–	1.322	942	736
			Subtotal	922	403	2.205	1.834	3.678

Table 1 (Continued)

No.	Country of origin	Mark	Type	Number of vehicles				
				1978	1979	1980	1981	1982
3.	U.S.A	DODGE	Avenger	87	120	44	–	–
		CHRYSLER	180	–	–	–	20	24
		CHEVROLET	Luv (Petrol)	–	–	–	75	83
		FORD	Cortina	–	–	–	92	88
			Laser	–	e 1 –	–	–	799
		A.M.C.	CJ.7 (Jeep)	191	76	2.410	2.105	1.593
			Subtotal	278	196	2.454	2.292	2.587
4.	ITALY	FIAT	131	364	208	180	–	–
5.	GERMANY	MERCEDEZ Benz	200	91	118	202	206	210
			230	158	171	234	–	–
			280	243	223	374	361	332
		VW	Safari	191	487	25	16	8
			Mitra	3	–	–	–	–
			Micro Bus	–	–	–	561	746
		B.M.W.	520	163	111	–	112	115
			Subtotal	849	1.110	835	1.256	1.441
6.	ENGLAND	MORRIS	1000 Salon	2	72	–	–	–
		LAND ROVER	88	172	240	240	1.064	1.837
			Subtotal	129	312	240	1.064	1.837

Table 1 (Continued)

No.	Country of origin	Mark	Type	Number of vehicles				
				1978	1979	1980	1981	1982
7.	AUSTRALIA	HOLDEN	Torana - SL	862	—	—	—	—
			Gemini	—	—	178	271	329
			Sun Bird	—	—	63	—	—
			Commodore	—	—	—	240	316
			Subtotal	862	—	241	511	645
8.	SWEDEN	VOLVO	244	94	152	161	98	74
			264	156	228	190	71	48
			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

No.	Country of origin	Mark	Type	The Number of car samples 1978	1979	1980	1981	1982	Total
1.	JAPAN	MITSUBISHI	T.120	4	3	4	–	–	11
			Galant 1600	–	–	–	–	1	1
			L. 300	–	–	–	2	2	4
		TOYOTA	Corolla	–	–	1	1	1	3
			Corona	1	–	1	1	1	4
			Hi–Ace	1	1	1	1	1	5
			Land Cruiser	1	1	1	1	–	4
			Kijang	1	1	2	3	3	10
		DATSUN	1500	–	1	–	–	–	1
		HONDA	Civic	–	–	–	1	–	1
			Accord	–	–	1	1	1	3
2.	FRANCE	PEUGEOT	505	–	–	–	–	1	1
3.	U.S.A.	A.M.C.	CJ–7	–	–	1	–	–	1
4.	GERMANY	V.W.	Micro Bus	–	–	–	–	1	1
				8	7	12	11	12	50

Fig. 2 ***Octane requirement curve of 1978 – 1982 car population in Indonesia***

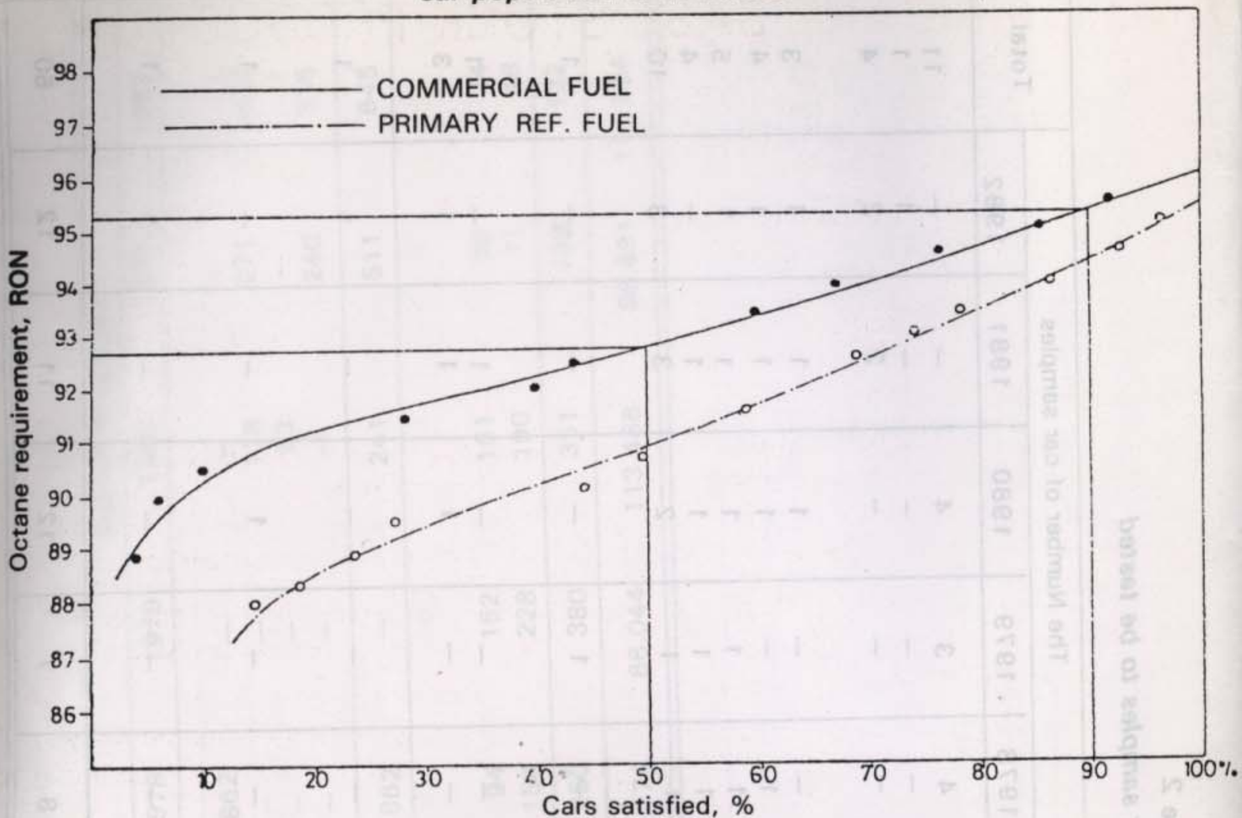

Fig. 3 ***Octane requirement curve of 1973 – 1977 car population in Indonesia***