A STUDY ON SAVING FUEL BY IDLING STOPS WHILE DRIVING VEHICLES

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Abstract: This paper shows the present condition of idling stops and the effect of idling stops while driving vehicles for a field test. A questionnaire survey shows more than 80 % respondents carry out idling stops while their vehicle is parked, but only 4 % use idling stops while driving. The major reason why drivers do not carry out idling stops while driving is to avoid a starting time lag. Therefore, idling stops support system is needed to solve this problem. A field test was carried out with three vehicles that were driven about 3700 km total. One vehicle was normal and other two vehicles were equipped with an idling-stop support system. Compared with the consumption of these vehicles, the fuel saving ratio of idling-stop vehicles was 6 %. On urban roads in particular, the saving ratio was 13 %.

Key words: Idling stops, global warming

1. INTRODUCTION

Reducing carbon dioxide is a crucial problem in protecting our earth from global warming. In 1997, an international agreement to reduce carbon dioxide was proposed in COP3 (Conference of Parties 3) in Kyoto. In this agreement, Japan has to reduce carbon dioxide emissions by 6% by 2010, compared with those of in 1990. However achievement of this goal is not so easy.

In Japan, 20% of total carbon dioxide emissions are from various types of transportation. And 88% of transportation emissions are due to road transportation. Moreover, the amount of carbon dioxide has been increasing. For example carbon dioxide in transportation increased by 16% from 1990 to 1995. Therefore, reducing vehicle gas emissions is an effective way to reduce carbon dioxide. In this connection, Idling stops are one option to save fuel and reduce exhaust gas emissions. In this paper, the present condition of idling stops, a questionnaire survey of people's awareness and driving behavior about idling stops, a field test that measures the effects of idling stops are mentioned. Other related traffic problems were also

researched.

2. IDLING STOPS

An idling stop is when the engine of a car is turned off because the car is parked, is at red light, or is stopped because of traffic congestion. Idling stops are effective for not only saving fuel, but also for protecting environment with less cost and with immediate return. However, the advantage of idling stops has not yet been proven. There are two types of idling:

(1) Idling while parked
Idling does not directly contribute to driving a vehicle. People usually leave the engine running in order to charge battery, keep the air conditioner running, warm up the engine, and to avoid switching the engine on and off frequently.

(2) Idling while driving a vehicle
Idling stops while driving a vehicle occur when a vehicle stops at red light, in congestion, and so on. Such stops also do not contribute to driving the vehicle, but the engine keeps running to prepare for the next run.

Idling stops while parked are common in Japan. Several local governments have regulations concerning idling stops. For example Hyogo prefecture established regulations on idling stops in 1995. In Europe, Netherlands and Switzerland have laws regarding idling stops while driving a vehicle. However, the idling stops while driving a vehicle is not so common in Japan, except for buses. This difference may be caused by the types of vehicles. In Europe, most vehicles have a stick shift. On the other hand, in Japan, most vehicles have an automatic transmission. While driving a car with stick shift, a driver has to operate the transmission whenever a vehicle stops. However, while driving a car with automatic transmission, the driver does not have to touch the transmission whenever the vehicle stops. Therefore, the driver operating a car with a stick shift may accept additional action of turning on and off the engine while driving. On the contrary, some support systems to stop and start the engine may be necessary for the person driving a car with an automatic transmission to encourage idling-stop behavior.
There are several problems about idling stops while driving, as follow:

(1) Effect of the idling stops in reducing fuel consumption
Excess fuel is necessary to start the engine, so short time idling stops might increase fuel consumption. But according to the automobile manufactures, recent vehicles that meet present regulations of exhaust emissions can save fuel by even short time idling stops. According to bus manufactures, 19% fuel saving by buses using idling stops was reported. However, there

are not so many reports about the effect of idling stops for saving fuel. Table 1 shows the effect of idling stops for saving energy and carbon dioxide from other research.

Table 1 Effects of idling stop[1)]

Research body		Fuel	Carbon dioxide	Driving mode
Automobile -	A	38.0 – 41.0 %	38.0 – 42.0 %	Tokyo No.1
manufacture	B	25 %	24 – 25 %	Tokyo No.2
	C	2.9 %	8 %	10.15 mode
	D	8.9 %		Automobile manufacture's
Kanagawa Prefecture			32.0 – 38 %	Kanagawa prefecture's
Japan Automobile Federation		6.8%		Field test in Tokyo

(2) Traffic safety problems

There are several traffic safety problems:

- Lack of concentration on driving skills
- Increased fatigue and irritation
- Starting delay

These problems may be caused when an inexperienced driver turning the ignition on and off carries out idling stops.

(3) Durability of parts

Frequent idling stops may shorten durability of engine parts such as the starter and battery.

As for a lineup of vehicles with idling-stop functions, most of the new buses are equipped with idling-stop functions. However, there are a few lineups for passenger vehicles. Most automobile manufactures are examining the car market of this kind of vehicles.

3. QUESTIONNAIRE SURVEY

(1) Methods

In order to know the driver's behavior and awareness of idling stops, a questionnaire survey through the Internet was carried out. "The Internet Marketing Research Service" was used in this survey. Several thousands of respondents are registered in the Internet Marketing Research Service, and they respond a questionnaire survey if they are requested. The questionnaire was asked for those who drive vehicles with an automatic transmission, except for hybrid cars. The survey period was from October the 1st to the 12th in 2001. As a result, 2198 respondents were obtained. 1457 were males and 741 were females.

(2) Results

Figure 1 shows awareness of the effect of vehicle exhaust gas on global warming. About 95% of the respondents know the relationship well. There are differences between respondents from males and females. 70% of the respondents know the meaning of idling stops.

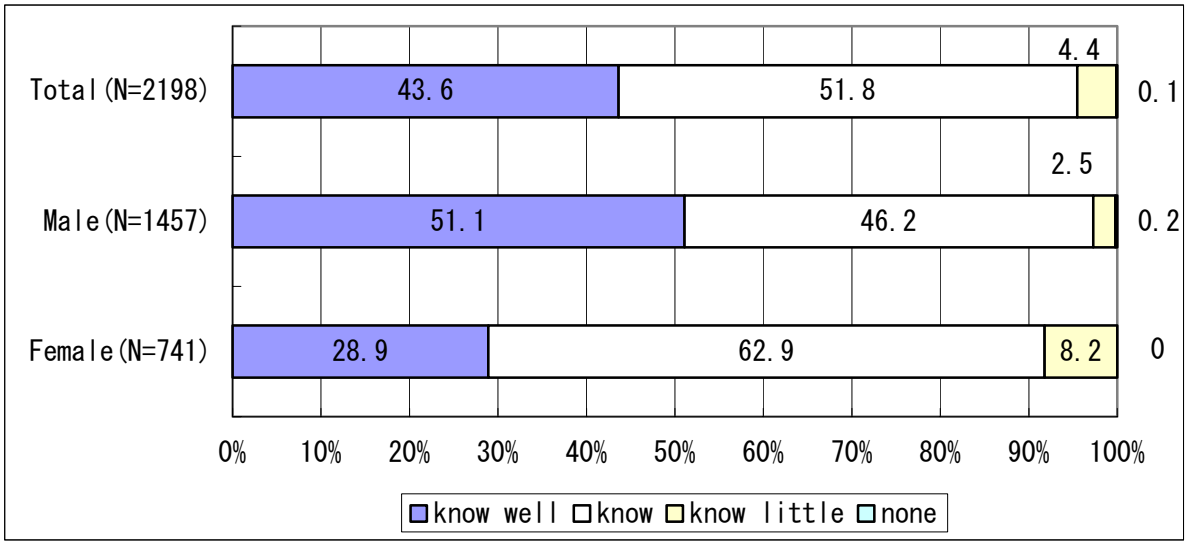

Figure 1. Awareness of the effect of exhaust gas on global warming

Figure 2 shows the behavior of idling stops. More than 80% of the respondents carry out idling stops while parked. However, about 5% of the respondents do not stop the engine while parked. Most of the respondents do not carry out idling stops while driving. But it is remarkable that about 4% of the respondents already carry out idling stops while driving.

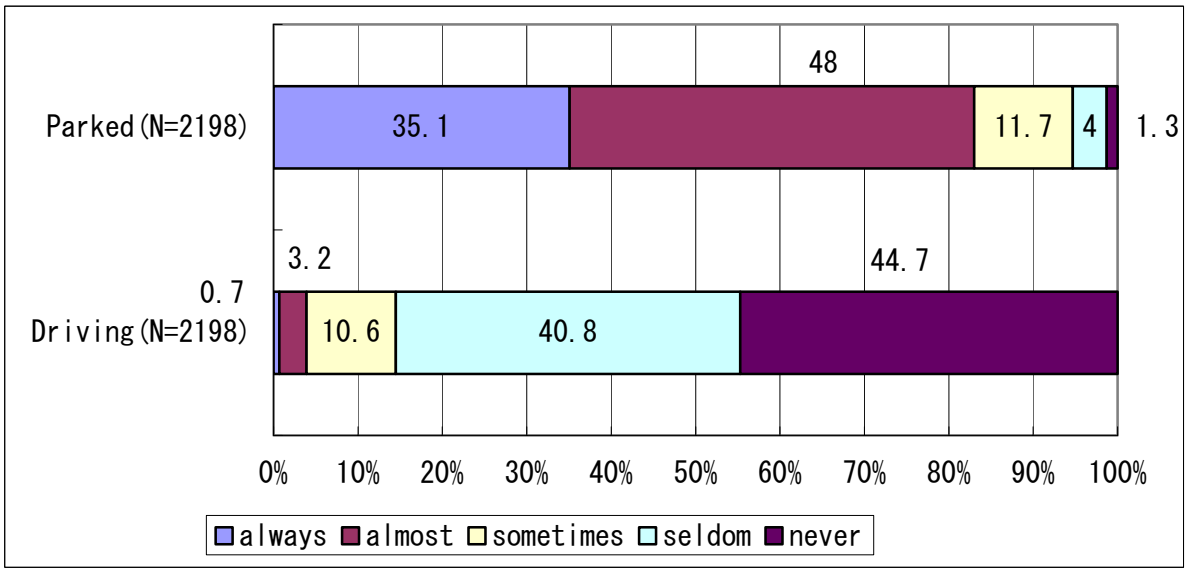

Figure 2. Behavior of idling stops

Figure 3 shows the reasons why a driver doesn't carry out idling stops while driving. The question allows the respondents multiple choices of answers. The major reasons are to avoid a

starting time lag (48%), short lifetime of starters (41%), suspicious effect (40%), suspicious safety (39%), and troublesome ignition key actions (38%). As for avoiding a starting time lag, females have 14 points more than males and about durability of the starter or suspicious effect, males have 17 points bigger than females. Therefore, providing information such as the effect of idling stops and other related matters is necessary to encourage idling stops more effectively.

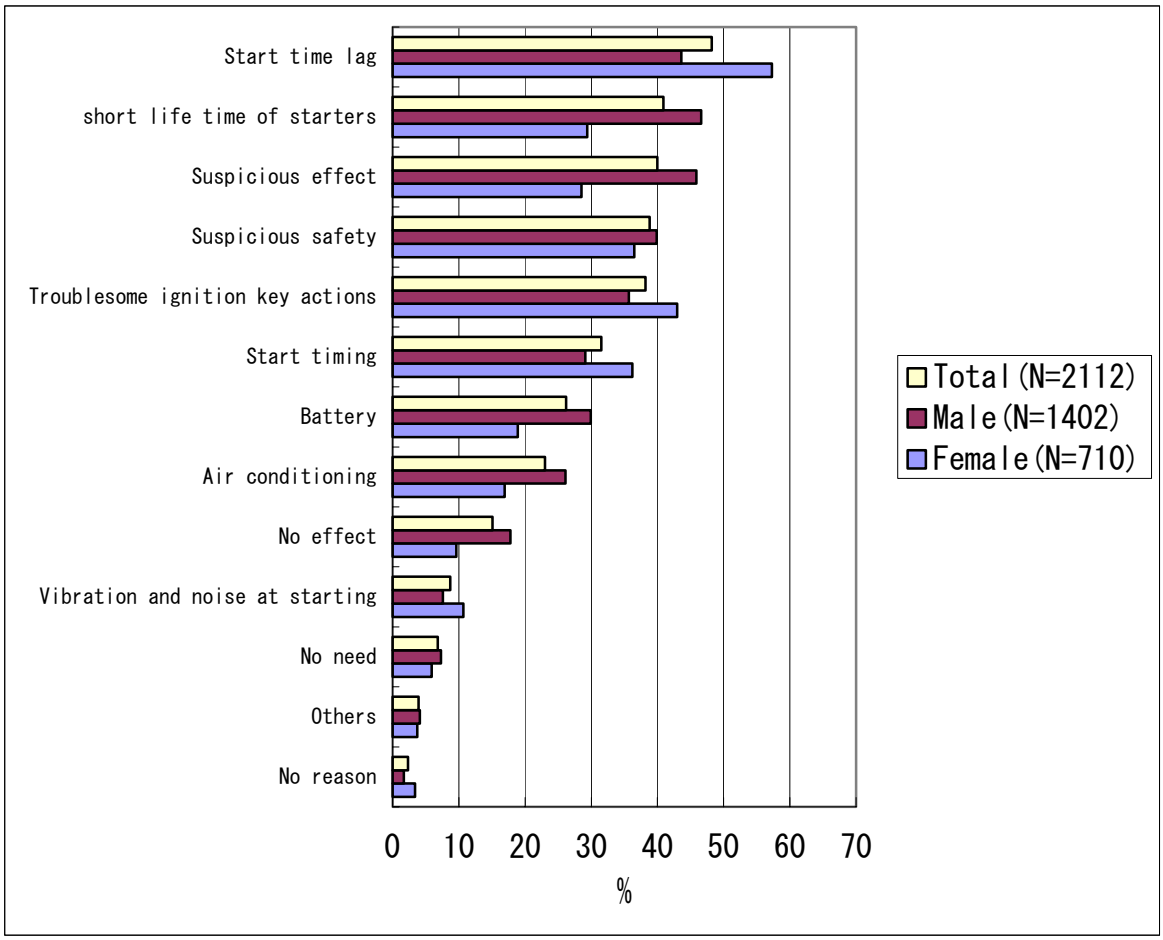

Figure 3. The reasons of avoidance of idling stops while driving

Figure 4 shows drivers carrying out idling stops with their will while driving if some idling stops support systems were provided. As mentioned above, only 4% of respondents carry out idling stops while driving. But if some support systems that enables the driver to carry out idling stops easily while driving was provided, more than 80% of respondents show the drivers carrying out idling stops with their own will.

Figure 5 shows the requirements of the support system mentioned above. The question allows respondents choices of three answers at maximum. The major answers are, safety (66%), ease of handling (56%), fast starter (46%), low emissions (36%), good for the batteries (29%), and so on. The points of countermeasures for the air conditioning are relatively low (7%). This may be due to the period of the survey. Because the air conditioning is not always necessary in October.

Considering the relationship between investments in the support system and saving fuel, “Do not expect a return” and “Expect a little return” occupy 72%. It shows that most of respondents do not expect much of a return.

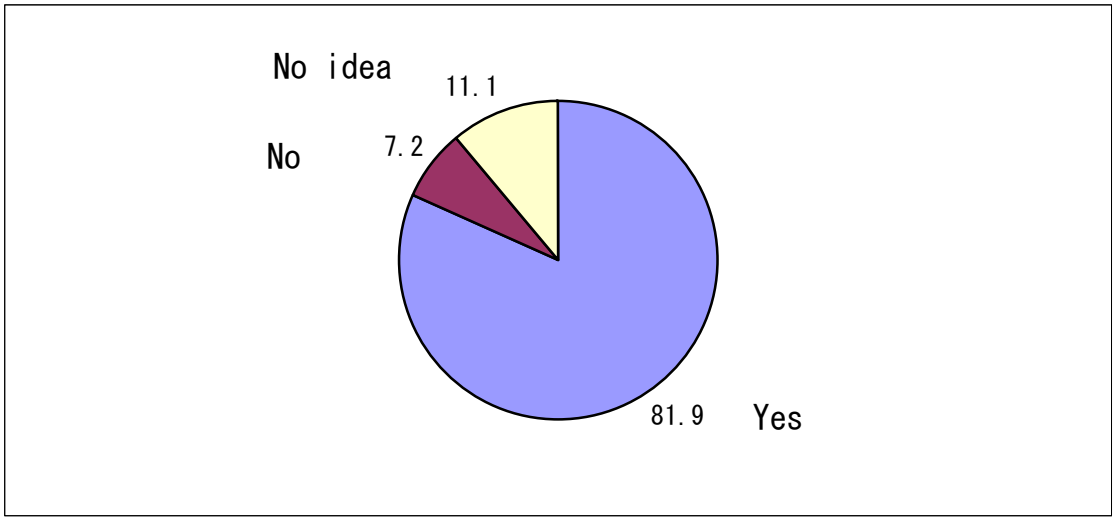

Figure 4. Driver’s will to carry out idling stops if any support system provided (N=2198)

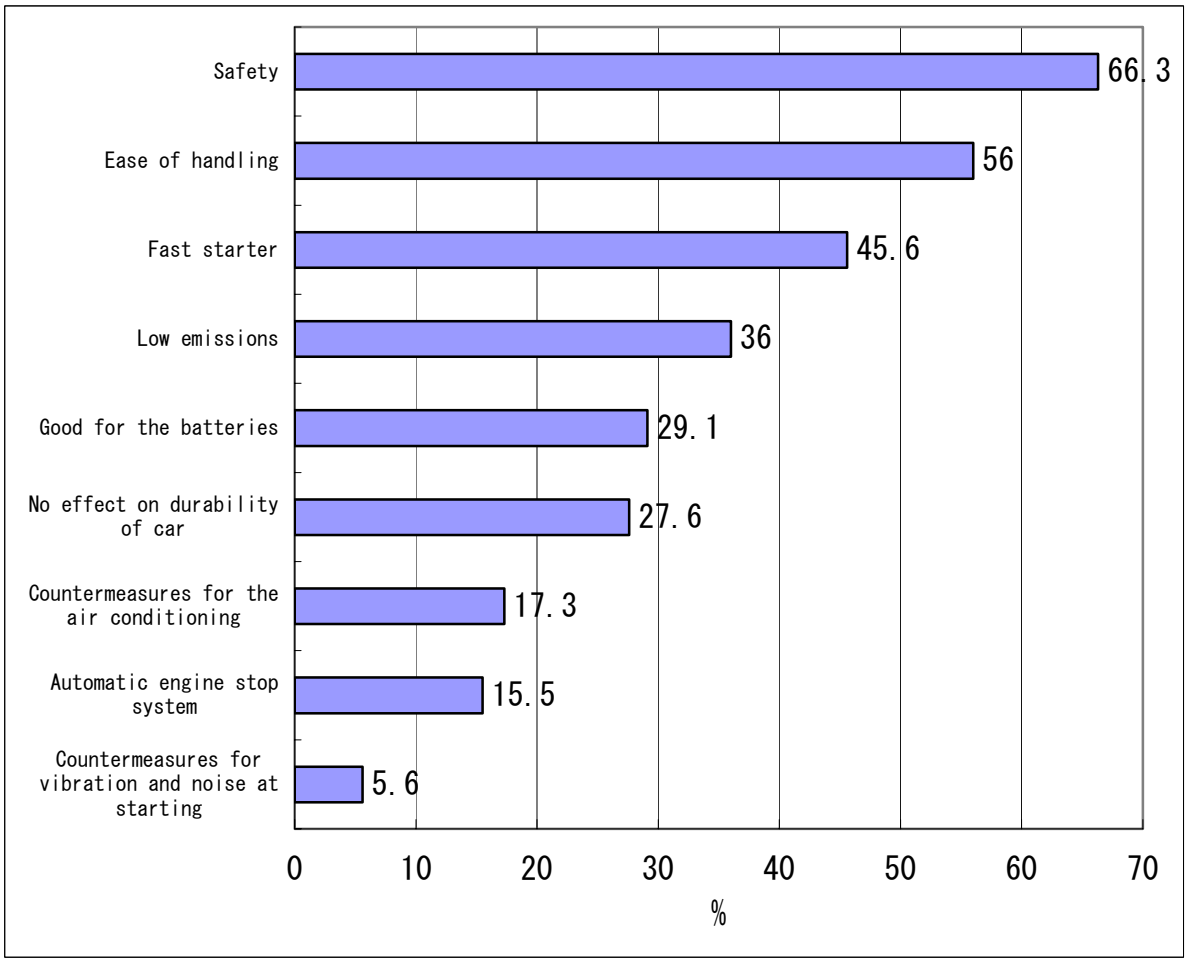

Figure 5. The requirements of support system

4. FIELD TEST

(1) Methods

In order to quantitatively measure the effect of idling stops for saving fuel, a field test using test vehicles was carried out from the 3rd to the 23rd of August in 2002.

Three vehicles of a 2000 cc wagon of the same type with an automatic transmission were used for the test. One vehicle had the normal engine system, the other two vehicles were equipped with a support system to make idling stops easier. One vehicle was equipped with an ignition button. The driver stopped and started the engine with using this button. The other vehicle was equipped with a shift lever system. If the driver shifted the transmission lever to the neutral position when the vehicle stopped, the engine would stop. And if the driver shifted the lever to the driving position while he stepped on the brake pedal, the engine would start. At the test, the normal vehicle was driven without idling stops while the other two vehicles that were equipped with the support system were driven with idling stops. Three male professional drivers participated. Their ages ranged from thirties to forties. When drivers drove a car with the idling-stop support system, they were instructed to carry out idling stops as much as possible with taking care of safety. During the test, they rotated driving vehicles and changed the order of vehicles in the platoon to cancel the differences in driver's characters. Also, air pressure of the tires and the weights of the vehicles were adjusted to be identical.

At a field test, three vehicles started at the Soya peninsula in Hokkaido prefecture, the northernmost point of Japan, and finished at the Sata peninsula in Kagoshima prefecture, the southernmost point of the main Kyusyu island in Japan. Each vehicle ran simultaneously about 3,717 km total and the same route so that driving conditions were identical.

Table 2 shows the outline of the test. In this table, the urban and the rural roads were defined by the test team judging from an array of buildings along the road. The urban road occupied only 13% by length, but 31% by time.

Table 2. The outline of a field test

	Length (km)	Time (min)	Travel speed (km/h)	Length ratio (%)	Time ratio (%)
Total	3,717	6,664	33.3	-	-
Urban	490	2,061	14.1	13.2	30.9
Rural	3,227	4,602	41.9	86.8	69.1

(2) Results

1) Driving characteristics

Figure 6 shows the ratio of total stopping time and total idling-stop time to total driving time. As a result, about 24% of total driving time were for stopping. In the urban roads, about 47% were for stopping. It is remarkable that in the urban road, stopping time share reached almost

half of driving time. As for two vehicles that carried out idling stops, the share of idling-stop time to total driving time was about 13%. In the urban roads, the share was about 25%. Idling-stop time in this figure was an average of two idling-stop vehicles. It is clear that idling-stop time is about half of stopping time.

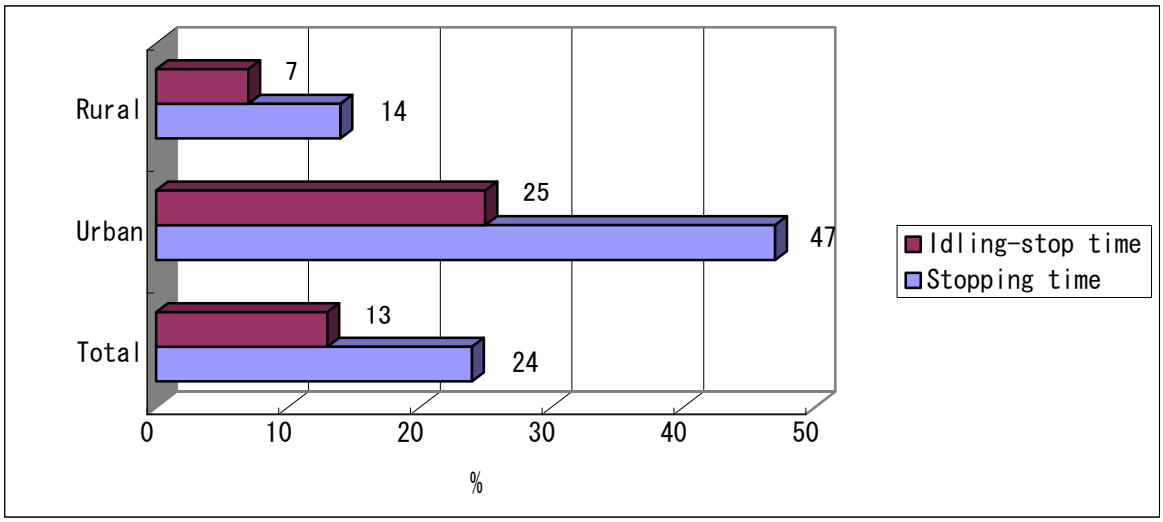

Figure 6. Stopping time and Idling-stop time

Figure 7 shows the relation between travel speed and stopping time ratio and idling-stop time ratio. Travel speed was measured every 10 minutes. These time ratios decrease when travel speed increases. Because when the speed goes up, the opportunities to stop will decrease. The figure shows the idling-stop time ratio is about half of the stopping time ratio. At the test, drivers carried out idling stops with their own accord. If automatic idling-stop system is introduced, this ratio will go up.

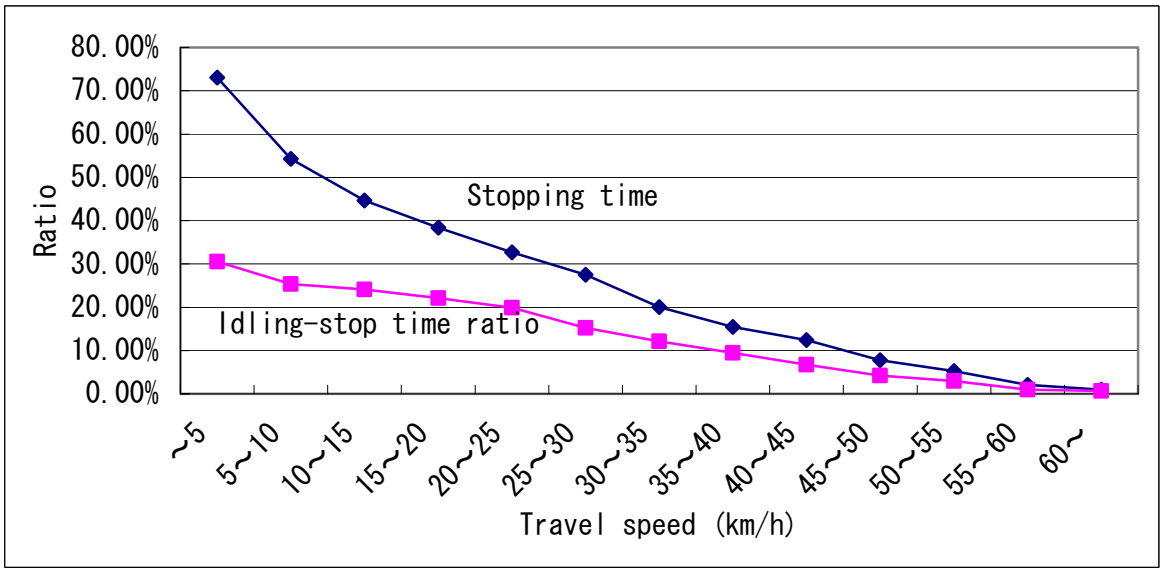

Figure 7. Travel speed and stopping time

Figure 8 shows the relation between stopping time range and frequency of stopping and idling stops. The frequency of stopping time decreases as the stopping time increases. But as for idling stops, there is a peak in 20-25 sec range. It may connect with the split time range of the traffic light.

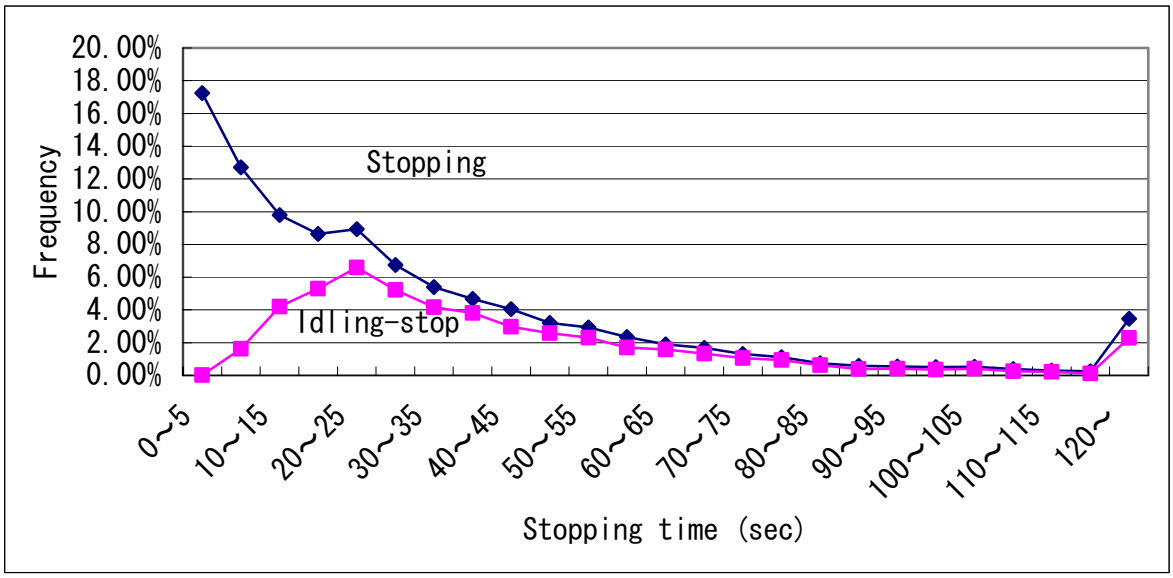

Figure 8. Frequency of stopping and idling-stop by stopping time

2) Saving fuel

Compared with the fuel consumption of the normal vehicle and average of the other two vehicles in this table, the saving ratio of idling stops is calculated. In conclusion, 5.8 % in the total road, 13.4 % in the urban road, 3.4 % in the rural road were obtained. The saving rate in the urban road is higher than that of in rural roads. Because opportunities of vehicles that stop at red light or in congestion in the urban road are more than in the rural roads in general.

Table 3. The comparison of fuel consumption (l)

	Total	Urban	Rural
Vehicle 1	346.5	82.0	264.5
Vehicle 2 *	329.2	70.4	258.5
Vehicle 3 *	324.0	71.6	252.5

* Idling-stop support system equipped

If the result above was used, the effect of idling stops to reduce fuel would be calculated. The total automobile-kilometers of passenger vehicles in Japan in 1999 were about 479 billion. This will be divided into four road categories as shown in Table 4. Using fuel consumption rate data gained in this field test, the total fuel consumption will be calculated by road categories. Then saving amount of idling stops will be calculated. According to this, 3.03

million kilo-litter gasoline will be saved. This amount is equal to 2.75 million kilo-litter of crude oil in terms of energy. It means about 3% of crude oil consumed for all transportation (about 100 million kilo-litter in 1999) will be saved by idling stops of passenger vehicles. This is almost equal to save the same percent of carbon dioxide of transportation.

Table 4. Calculation of saving fuel by passenger vehicles

	Automobile-kilometer[2)] (mil. vehicle km)	Fuel consumption rate (l/km)*	Fuel consumption (mil. kl)*****	Saving rate (%)	Saving fuel (mil. kl)
Expressway	41,279	0.0826	3.99	-	-
Urban**	90,222	0.1684	17.78	13.42	2.39
Rural***	199,813	0.0818	19.14	3.37	0.64
Others****	147,852	0.1088******	18.82	-	-
Total	479,166		59.73		3.03

* From the field test

** DID area

*** Outside of DID area

**** Outside of the traffic census data

***** Adjusted to the total volume: Total fuel consumption by passenger vehicles

****** Fuel consumption rate weighted proportional to the automobile-kilometer in urban and rural

5. CONCLUSION

In conclusion, people's behaviors and awareness of the idling stops, the effect of saving fuel by idling stops were obtained. The effect of idling stops to reduce carbon dioxide is relatively big. For more popularization of idling stops, the development of the idling stop support engine system, traffic safety examinations, an advertisement of idling stops are necessary. Idling stops are not only useful for reducing carbon dioxide, but also for encourage people's awareness about global warming.

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