2. Moped Task Analysis (draft version). National Highway Traffic Safety Administration (in preparation).
3. J. Forester. Effective Cycling. Custom Cycle Fitments, Sunnyvale, CA, 1977.
4. R. DiBrito, B. Reid, and D. Burden. Missoula, Montana, Bicyclist Training Program. Missoula Police Department, Missoula, MN, 1980.
5. Basic Bicycle Repair. Rodale Press, Emmaus, PA, 1979.
6. T. Cuthbertson. Anybody's Bike Book. Ten Speed Press, Berkeley, CA, 1979.
7. Understanding, Maintaining, and Riding the Ten-Speed Bicycle. Rodale Press, Emmaus, PA, 1979.
8. K.D. Cross and G. Fisher. Study of Bicycle/Motor Vehicle Accidents: Identification of Problem Types and Countermeasure Approaches, Volume 1. U.S. Department of Transportation, Sept. 1977.
9. Santa Barbara County Bicycle Safety Project. California Office of Traffic Safety, Sacramento, Oct. 1979.
10. Manual on Classification of Motor Vehicle Traffic Accidents, 3rd ed. National Safety Council, Chicago, IL, n.d.
11. E.N. Cone. Bicycling Education: It Isn't Just for Safety Anymore. Journal of Traffic Safety Education (California edition), July 1980.

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Abridgment

Engine Tune-Ups and Passenger Car Fuel Consumption

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The effect of engine tune-up on passenger car fuel consumption, including criteria for determining when tune-ups are needed for achieving good fuel economy, was investigated as part of a 1975 Federal Highway Administration study. A sample of 22 recent-model family cars was selected for the study. Each car was operated at a series of uniform speeds on a level straight test road, both immediately before and immediately after a major engine tune-up. Road, weather, and speed conditions were identical for the test runs before and after engine tune-up. Fuel consumption data were recorded for all test runs. A table was prepared that shows the percentage of change in fuel consumption that resulted from the tune-up for each of the 22 test cars. This table also lists for each car the age at the time of the study, the accumulated mileage, and the distance traveled since the last tune-up. The principal conclusion of the study is that passenger car tune-ups for cars less than six years old are unlikely to improve on-the-road fuel economy unless there is some evidence of actual fuel loss or waste. Out of the sample of 22 cars, only a third operated with better fuel economy in the normal range of running speeds after tune-up than before. Fourteen percent consumed more fuel per mile of travel after tune-up than they did before.

The improvement in passenger car fuel economy that can be expected from a major engine tune-up for cars in use less than six years was investigated for the Federal Highway Administration in 1974 and 1975. The purpose of the study was to develop on-the-road data on the fuel economy benefits of engine tune-ups for family cars during their first five years of service. Study details on which this paper is based were given in a report by Claffey (1).

Reports of two recent investigations to determine the effect tune-ups have on passenger car fuel economy are available. However, neither study involves the direct measurement of on-the-road passenger car fuel economy before and after full engine tune-ups. Walker and others (2) report that in diagnosing a random selection of 5666 cars in service they found that only about a third needed engine maintenance to improve fuel economy. These researchers also arranged for tune-ups for a small sample of the cars that were found by inspection to need engine maintenance to save fuel. Laboratory fuel economy measurements that used a dynamometer before and after the tune-up of each of these cars indicated that the tune-ups improved fuel economy by about 10 percent. A study by Bayler and Eder (3) found from an extensive review of the records of engine tune-ups to correct emissions deficiencies for 322 cars and of the corresponding fuel economy data that such tune-ups resulted in an average improvement in fuel economy of 4.7 percent. They also arranged for engine tune-ups for a random sample of 26 compact cars and for a random sample of 31 intermediates. In each case fuel economy was determined both before and after the tune-up by using laboratory measurements with the dynamometer. They found that tune-ups improve the average fuel economy of the compacts by 2.7 percent and that of the intermediates by 1.6 percent for a pattern of highway speeds.

The study reported on here involved measuring the fuel consumption rates of a selection of 22 cars from the population of family cars in normal use both before any change was made in the vehicle and again after a complete tune-up. Before and after fuel consumption rates were determined for each car while it was idling and for uniform on-the-road running speeds of 16.1 km/h (10 mph), 32.2 km/h (20 mph), 48.3 km/h (30 mph), 64.4 km/h (40 mph), 80.5 km/h (50 mph), and 96.4 km/h (60 mph) on a section of paved level straight road. All test runs were made when air temperature was between 23.3°C (80°F) and 26.0°C (90°F), humidity was between 60 and 70 percent, there was no wind, and the pavement was dry. All before-and-after test runs for each car were made by the same test-car driver and always in the same manner. Tire-inflation pressures were noted when each car was received from the owner. These were not changed.

SELECTION OF TEST VEHICLES

Each of the 22 vehicles used in the study was a family car less than six years old at the time of the study. Fifteen were standard or luxury-type cars and seven were small cars or compacts. Twelve were customarily operated in a rural area (the vicinity of Potsdam, New York) and 10 in an urban area (Utica, New York). No attempt was made to select one car model rather than another.

A 22-car sample is, of course, too small to represent adequately the millions of cars registered in this and other countries if each car in the population is unique. However, each car is not unique. Only a few manufacturers produce all the cars and car parts in use. The test sample includes vehicles

Table 1. Change in fuel consumption for 22 passenger cars after major engine tune-up.

Car Model and Year	Age (years)	Odometer Reading (km)	Distance Since Last Tune-Up (km)	Change in Fuel Consumption (%)			
				Idling in Gear	At Uniform Speeds of		
					16.1 km/h	48.3 km/h	80.5 km/h
1970 Chevrolet	4	46 661	11 263	+4.3	-10	-15	-20
1971 Mercury	3	97 713	8 045	+3.5	NC	-10	-14
1973 Nova	1	19 308	11 263	+25.0	NC	NC	-8
1973 Oldsmobile	1	16 090	16 090	+27.4	-9	-11	-12
1973 Plymouth	1	27 353	27 353	-26.0	-10	-4	NC
1973 Chevrolet	1	27 353	27 353	-5.8	+6	-3	-3
1973 Plymouth	1	32 180	27 353	NC	+4	-6	-5
1970 BMW	4	115 848	16 090	-13.6	NC	NC	NC
1970 Pontiac	4	157 682	40 223	NC	NC	NC	NC
1971 Dodge	3	48 270	20 917	-1.7	NC	NC	NC
1971 Ford	3	65 969	32 180	NC	NC	NC	NC
1972 Oldsmobile	2	74 014	8 045	+27.4	NC	NC	NC
1974 Matador	½	8 850	8 850	-40.7	NC	NC	NC
1970 Volvo	4	65 969	16 090	-27.2	NC	NC	NC
1970 Valiant	4	96 540	16 090	+32.3	NC	NC	NC
1971 Vega	3	54 706	25 744	+11.6	NC	NC	NC
1972 Oldsmobile	2	57 924	57 924	+27.4	NC	NC	NC
1973 Buick	1	20 917	20 917	+3.3	NC	NC	NC
1974 Mustang II	½	16 090	16 090	NC	NC	NC	NC
1970 Plymouth	4	54 706	11 263	NC	+14	NC	+10
1973 Ford	1	37 007	37 007	NC	+16	+7	+8
1972 Chevrolet	2	48 270	24 135	-20.1	NC	+4	+4

Note: 1 km = 0.6 mile; NC = no change.

produced by each of the three major motor companies of the United States and by two foreign firms. The tune-up needs of the sample cars reflect the durability and service characteristics of the tune-up parts produced by parts manufacturers from all over the country. Tune-up parts (spark plugs, carburetor kits, distributor caps and points, for example) are standardized mass-produced items that can be adequately represented for the purposes of this study by a small sample of cars.

TEST PROCEDURE

The test procedure for determining the effect of a tune-up on a passenger car's fuel consumption was identical for each of the 22 test cars. Just before the tune-up the fuel consumption while the car idled in gear was recorded. Following this, the fuel consumption for operation at a set of uniform speeds that varied from 16.1 km/h (10 mph) to 96.4 km/h (60 mph) was measured for operation over a 1219-m (4000-ft) section of straight level test road. Then the vehicle was taken to a service station at which a mechanic skilled in tuning the particular model being tested gave the car a complete tune-up. After the tune-up, the fuel consumption of the car was again determined for exactly the same operating conditions and procedures as before the tune-up.

Fuel consumption measurements were made by using the photoelectronic fuelmeter developed for the Transportation Research Board (TRB) in 1964 in connection with fuel consumption studies carried out for TRB from 1964 to 1970. This fuelmeter has been fully described (4). All fuel consumption data were recorded in the field in units of 0.001 gal.

The tune-up performed on each of the 22 cars is commonly called a major tune-up and consists of the following operations:

1. Replacement of all spark plugs;
2. Replacement of breaker points;
3. Replacement of condenser;
4. Replacement of air cleaner;
5. Inspection and replacement, if necessary, of distributor case, distributor cap, distributor rotor, and spark-plug wires;
6. Inspection and adjustment, if necessary, of heat riser, automatic choke, carburetor, and pollution controls; and
7. Performance of compression test.

STUDY RESULTS

The results of the study are summarized in Table 1. In this table each test car is identified by model and year of manufacture. The age of each car is also given, along with the total mileage (odometer reading) and the mileage since the last tune-up. The percentage of change in the rate of fuel consumption as a result of the tune-up is given for each vehicle while it is idling in direct gear and for running speeds of 16.1, 48.3, and 80.5 km/h.

The test vehicles that benefited most from the tune-up for on-the-road operations are the first two cars listed in Table 1. In the case of each of these vehicles, fuel consumption rates were very erratic and varied widely on the test runs before tune-up. After tune-up, their fuel consumption rates were stable and repeatable. The erratic fuel consumption rates before tune-up indicated a definite breakdown somewhere in the fuel systems or ignition systems of these cars that resulted in random losses of fuel. The first car listed in the table was actually leaking gasoline around the carburetor. One of the findings of this study is that there is often evidence of fuel waste when a vehicle really needs a tune-up to save fuel. Erratic fuel consumption rates usually mean leaking fuel lines or other directly observable phenomena related to fuel loss.

Neither the overall mileage (odometer reading) nor the distance traveled since the last tune-up seem to relate to the fuel economy benefits of an engine tune-up. Neither of the two sample cars that had the highest accumulated mileage (the 1970 BMW and the 1970 Pontiac) gained improved fuel economy as a result of being tuned up. Similarly, neither of the two cars that had traveled the greatest distance since the previous tune-up (the 1970 Pontiac and the 1972 Oldsmobile) had any better fuel economy after the tune-up than before. The implication of this finding is that owners should have some reason for believing that a tune-up will result in improved fuel economy other than accumulated mileage or mileage traveled since the last tune-up before investing in an expensive tune-up to save fuel.

CONCLUSIONS AND RECOMMENDATIONS

The principal conclusion is that passenger car tune-ups for cars less than six years old are unlikely to improve fuel economy unless there is some evidence of actual fuel loss or waste. Out of a random sample of 22 cars, only about a third operated with better on-the-road fuel economy after tune-up than before. Over half of the test cars showed no change in on-the-road fuel economy as a result of the tune-up, whereas three of the 22 test cars actually used more fuel. Two of the cars that operated with improved on-the-road fuel economy as a result of engine tune-up had very erratic fuel consumption patterns before tune-up. The erratic fuel consumption patterns were eliminated by the tune-up. In the case of these two cars, the tune-up corrected a particular engine malfunction that was wasting fuel. One operated with better fuel economy after tune-up than before because a fuel leak around the carburetor was corrected by using a new carburetor kit. The other achieved improved fuel economy through replacement of a spark-plug wire. A third vehicle got better fuel economy through replacement of the distributor rotor. The remaining four test cars that had better on-the-road fuel economy after tune-up than before benefited from carburetor and timing adjustments.

There was no evidence that replacement of spark plugs, points, and condensers improved fuel economy in any of the test cars. This does not mean that it did not help in some of the cars, but fuel economy improvement was due principally to other elements of the tune-up work, especially engine adjustments and replacement of malfunctioning engine parts.

It is suggested that diagnostic service stations be established at convenient locations where car owners can take their cars for analyses of engine fuel economy characteristics. Such stations, by using precise fuelmeters and a dynamometer, could identify cars that had poor fuel economy attributes and suggest tune-up work needed to improve fuel economy. Whether or not such stations are made available to the motoring public, all automobile mechanics should be given specific training on how to spot evidence of engine malfunctioning that results in poor fuel economy. Furthermore, drivers themselves should have available some kind of instruction sheets that explain how to recognize the more easily observable engine conditions associated with poor fuel economy. These include such conditions as fuel-line leaks and erratic overall fuel consumption rates. Fuel economy diagnostic centers, special training for mechanics, and instruction sheets for car owners are all suggested as means of identifying cars that have engines that are wasting fuel and the reasons for the waste so that corrective measures can be taken.

Neither major nor minor tune-ups are recommended for recent-model cars to improve fuel economy unless there is evidence of an engine malfunction of some kind that is causing a waste of fuel. Fifteen of the 22 test cars in the study sample (68 percent) either gained no improvement in on-the-road fuel economy from the tune-up or had poorer economy after the tune-up than before. There is only approximately one chance in three that a recent-model car will gain improved on-the-road fuel economy as a result of the tune-up. Since such tune-ups are expensive, they should be resorted to only when there is evidence that they will produce a fuel economy improvement.

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REFERENCES

1. P.J. Claffey. Passenger Car Fuel Conservation. FHWA, U.S. Department of Transportation, 1977. NTIS: PB 265 369.
2. D.L. Walker, J.O. Boord, J.S. Piggot, and E.R. Sutton. How Passenger Car Maintenance Affects Fuel Economy and Emissions. Presented at SAE International Automobile Engineering Congress and Exposition, Detroit, Feb. 27-March 3, 1978 (SAE paper 780032).
3. T. Bayler and L. Eder. Impact of Diagnostic Inspection on Automotive Fuel Economy and Emissions. Presented at SAE International Automobile Engineering Congress and Exposition, Detroit, Feb. 27-March 3, 1978 (SAE paper 780028).
4. P.J. Claffey. Running Cost of Motor Vehicles as Affected by Highway Design. NCHRP, Rept. 13, 1965.

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