AUTOMOTIVE ENGINE HEATERS*

E.H. Wiens
Member CSAE
Department of Agricultural Engineering
University of Saskatchewan
Saskatoon, Saskatchewan

INTRODUCTION

Virtually all automobiles in the prairie region of Western Canada are equipped with automotive engine heaters. Engine heaters are essential for trouble-free starting in the severe winter temperatures. Outdoor temperatures well below 0°F (-18°C) are not uncommon during the months of January and February. Data collected at the Saskatoon Weather Station (1) over a period of 38 years shows the maximum average temperature for the month of January was 9°F (-13°C) and the average daily minimum temperature was -18°F (-28°C). The minimum extreme temperature recorded during this 38 year period was -55°F (-48°C).

The most common type of automotive engine heater in use is the block-type heater which is installed in the frost plug of the engine block and heats the coolant contained in the engine block. Most six cylinder engines are equipped with only one such heater, while V-8 engines often have a block-type heater on each side of the engine block.

Other coolant heaters commercially available are: 1. Headbolt-type engine heaters, where the heater is installed in place of one of the headbolts, 2. A circulating-type engine heater, installed in-line with the heater hose, which circulates the coolant through a thermostatically controlled heating chamber by means of a small circulating pump, 3. A hose heater installed in-line with the bottom radiator hose. As coolant is heated, it rises and circulates throughout the engine block via the water pump by-pass, 4. A dipstick-type heater that heats the crankcase oil in which it is immersed, and 5. An exterior heater, installed on the bottom of some air-cooled engine crankcases, that heats the oil.

The above types of automotive engine heaters vary in output from 100 watts for some exterior crankcase oil heaters to 1500 watts for certain circulating-type engine coolant heaters.

OBJECTIVE

This study was conducted using the block-type coolant heater which is installed in the frost plug of the engine block. The study included tests with 400, 600, 750 and 1000 watt heater elements installed in a six and an eight cylinder engine.

The objective of the tests was to determine the rate of rise of coolant temperature as well as the extent of the temperature rise for the various block heater elements. In addition, crankcase oil temperatures and combustion chamber air temperatures were obtained.

EQUIPMENT

Six Cylinder Engine

The six cylinder engine used for the tests was a 1939, G.M. 48 engine, model no. 3836327. Although this was an old engine, the basic G.M. block design had changed very little and was also typical of other six cylinder engines.

The engine was instrumented with iron-constantan thermocouples at various strategic locations throughout the block coolant passages to obtain coolant temperature variations within the block (Figure 1) The thermocouples were installed by drilling small holes in either the frost plugs or pipe plugs and inserted so that they were immersed in the coolant. The holes were then sealed with "epoxy resin" cement. A thermocouple was also immersed in the crankcase oil, the dipstick opening. The room temperature was measured by a thermocouple placed adjacent to the engine.

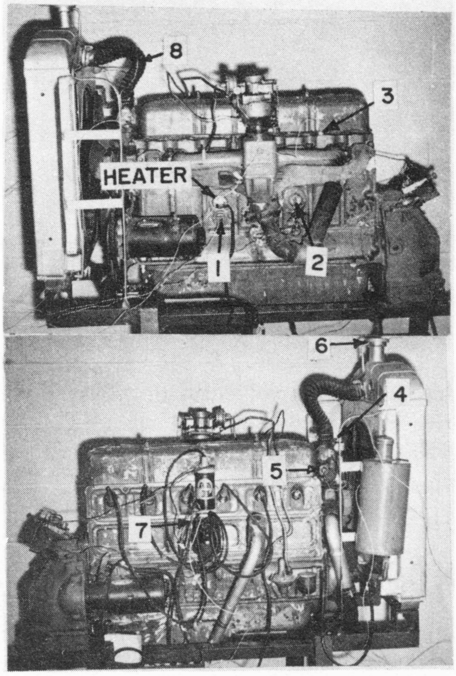

Figure 1. Location of thermocouples and block heater — six cylinder engine.

The heater, (Figure 1), located in the left front frost plug was installed with the heater element pointed up into the block. Tests were performed with 400, 600, 750 and 1000 watt block heater elements.

Eight Cylinder Engine

The eight cylinder engine used for the tests was a 1956, 272 cubic inch, V-8 Ford engine. This engine was instrumented in a similar manner to the six cylinder engine with thermocouples located on either side of the engine block to measure coolant temperatures. In addition, a thermocouple was located in one combustion chamber on either side of the engine block to determine air temperature in the combustion chambers due to heater operation. A thermocouple was also immersed in the crankcase oil to measure oil temperature. Room

* Paper presented at the American Society of Agricultural Engineers Pacific Northwest Regional Meeting, 1970. ASAE relinquished right to first publication at author's request.

RECEIVED FOR PUBLICATION NOV. 29, 1972

temperature was obtained by a thermocouple located adjacent to the engine. The thermocouple locations were numbered from 1 to 12 (Figure 2).

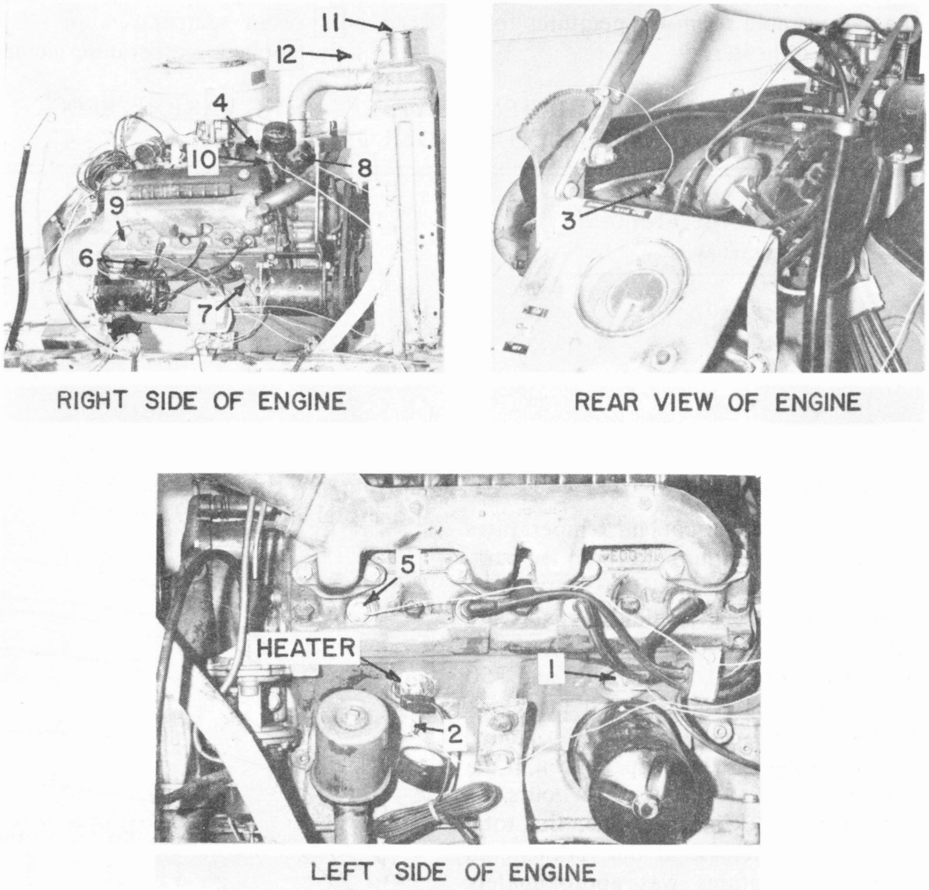

Figure 2. Location of thermocouples and block heaters – eight cylinder engine.

Block heaters were located on either side of the engine block in the front frost plugs with the heater element pointed down into the coolant passages of the block (Figure 2). Tests were performed with 400, 600, 750, and 1000 watt heater elements.

Cold Room

It was usually possible to maintain the cold room temperature to within ±2°F (1.1°C) of the desired temperature. Slightly higher variations were experienced at the lower cold room temperatures, especially when using two block heaters in the eight cylinder engine.

Two fans were in continuous operation within the cold room resulting in an average air velocity around the engine of 2-1/2 mph (4.0 km/hr.). This was considered to adequately simulate the conditions encountered by a car parked outdoors. Average wind velocity measured under the hood of a car standing outside in a 12-1/2 mph (20.1 km/hr) wind was 1-1/2 mph (2.4 km/hr.) (2)

Instrumentation

The thermocouple temperature readings were indicated by a 12 point indicating potentiometer (A, Figure 3). A chart recorder (B) was used to constantly monitor the cold room temperature.

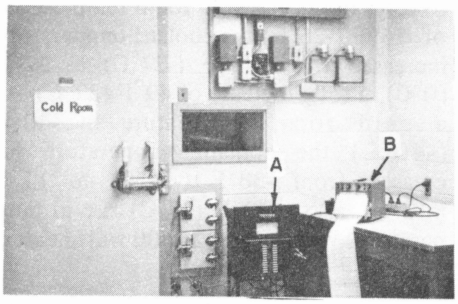

Figure 3. Cold room and instrumentation.

Coolant

The coolant used was a half and half mixture of permanent type ethylene-glycol base anti-freeze and water. This mixture was adequate to prevent freezing of the coolant at all cold room temperatures encountered.

EXPERIMENTAL PROCEDURE

Tests were conducted at several cold room temperatures, ranging from +10°F (-12°C) to -40°F (-40°C), for each size of heater. The engine under test was placed in the cold room with the thermocouple leads led through the cold room outlet and connected to the 12 point indicating potentiometer. The cold room, engine coolant and crankcase oil were allowed to stabilize at the desired room temperature before commencing a test. Initial readings were taken before "plugging-in" the heater and readings were taken every half hour for a total of seven hours. The room temperature was then changed and subsequent tests were conducted in a similar manner.

In the case of the block heaters in the eight cylinder engine, additional tests were performed at two cold room temperatures for each size of heater to compare the performance when using a block heater on one side of the engine block as opposed to a heater on both sides of the engine block.

DISCUSSION OF RESULTS

The temperatures obtained at the various thermocouple locations throughout the engine block indicated that the coolant reached its highest temperature at the top of the engine block, with decreasing temperatures at the locations lower down on the block. Subsequent discussion of the results will pertain to average temperatures of the coolant in the block, which were obtained by averaging the coolant temperatures at the various locations throughout the engine block.

Six Cylinder Engine

Representative plots of average coolant temperatures versus time, obtained at various cold room temperatures for the 600 and 1000 watt heater elements, are shown in Figures 4 and 5. Similar data were also obtained for the 400 and 750 watt elements. The block heater was operated for a period of seven hours to reach the equilibrium temperature of the coolant. In most cases very little temperature increase was experienced after five hours of heater operation. The total temperature increase for a given size of heater was approximately the same regardless of initial cold room temperature. At a cold room temperature of 0°F (-18°C) the coolant temperature increased from 0°F (-18°C) to 72°F (22°C) in 5 hours. A total increase of 72°F (40°C) was also experienced after 5 hours at a cold room temperature of -25°F (-32°C) when the coolant temperature increased from -23°F (-31°C) to 49°F (+9°C) (Figure 4).

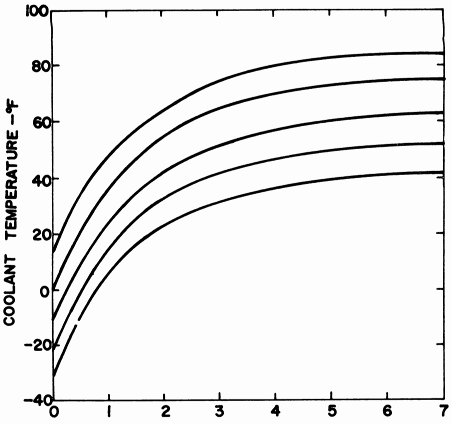

Figure 4. Coolant temperature vs time for a 600 watt block heater in a six cylinder G.M. engine at various cold room temperatures.

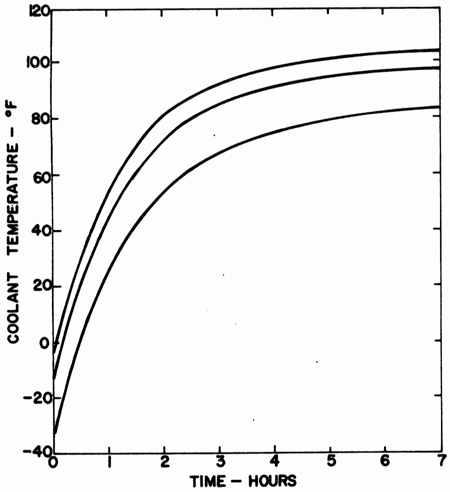

Figure 5. Coolant temperature vs time for a 1000 watt block heater in a six cylinder G.M. engine at various cold room temperatures.

The rate of warmup of the coolant was fairly constant, regardless of initial temperatures, for a given size of block heater. The temperature increase and percent of total increase in each hour for five hours for each of the four sizes of block heater, are shown in Table I.

TABLE I RATE OF ENGINE COOLANT WARMUP USING VARIOUS BLOCK HEATERS IN A SIX CYLINDER G.M. ENGINE

Size of heater element (watts)	Temperature rise per hour (°F) & % of total temperature rise: 1 hour	2 hours	3 hours	4 hours	5 hours	Total	°F/KWH
400	25 56%	11 24%	5 11%	3 7%	1 2%	45	563
600	37 51%	18 25%	9 13%	5 7%	3 4%	72	600
750	47 51%	23 25%	12 13%	7 7%	4 4%	93	620
1000	61 54%	27 24%	13 12%	7 6%	4 4%	112	560

Small increases in crankcase oil temperature, due to block heater operation, were experienced (Table II). Total rise in crankcase oil temperature was similar at the various cold room temperatures for a given size of heater.

TABLE II CRANKCASE OIL TEMPERATURES USING VARIOUS BLOCK HEATERS IN A SIX CYLINDER G.M. ENGINE

Size of heater element (watts)	Total temperature rise in 5 hours (°F)
400	3
600	8
750	8
1000	11

Eight Cylinder Engine

Plots of average coolant temperatures versus time at various cold room temperatures for the 600 and 1000 watt block heaters in the eight cylinder engine are shown in Figures 6 and 7. Similar data were also obtained for the 400 and 750 watt block heaters. Although the block heaters were operated for seven hours, very little increase was experienced in the coolant temperature after five hours. As with the six cylinder engine, the total temperature increase at the various cold room temperatures was approximately the same regardless of the initial cold room temperature for a given size of block heater. For example, when using only one 600 watt block heater (Figure 6) for 5 hours at a cold room temperature of -15°F (-26°C) the coolant temperature increased from -17°F (-27°C) to 32°F (0°C), a total increase of 49°F (27°C). At a cold room temperature of -40°F (-40°C) the coolant temperature increased from -38°F (-39°C) to 11°F (-12°C), also a 49°F (27°C) rise in temperature. When using 2–600 watt heaters for 5 hours at a cold room temperature of -15°F (-26°C), the coolant temperature increased from -16°F (-27°C) to 77°F (25°C), a total increase of 93°F (52°C). At a cold room temperature of -40°F (-40°C) the coolant temperature increased from -37°F (-38°C) to 58°F (14°C), also a total increase of 93°F (52°C).

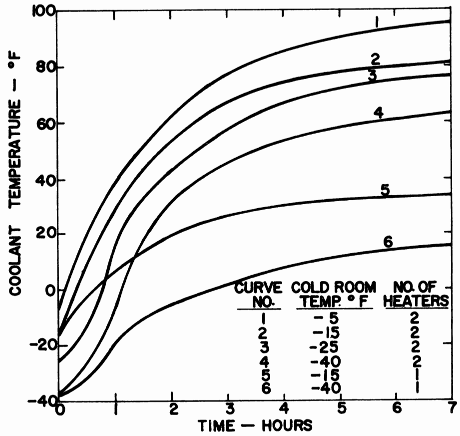

Figure 6. Coolant temperature vs time for the 600 watt block heaters in a Ford eight cylinder engine at various cold room temperatures.

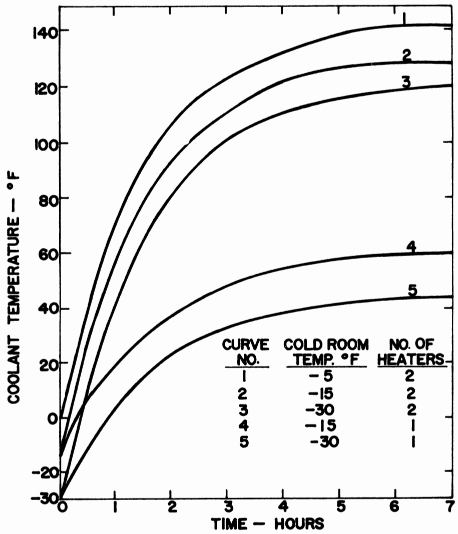

Figure 7. Coolant temperature vs time for the 1000 watt block heaters in a Ford eight cylinder engine at various cold room temperatures.

During the first two hours of block heater operation, 67 to 77 percent of the total coolant temperature increase was experienced (Table III). In the fifth hour only 4 to 8 percent of the total temperature increase was experienced. The total coolant temperature increase was greater as the size of heater was increased and also the coolant temperature obtained when using only one block heater was approximately 1/2 that experienced with two block heaters.

The total average increase in crankcase oil temperature after five hours of heater operation for the various sizes of block heater in the eight cylinder engine is shown in Table IV. The total increase in oil temperature varied from 10°F (-12°C) when using 2–400 watt block heaters to 25°F (-4°C) when using 2–1000 watt heaters. The increase in oil temperature when using only one block heater varied from 6°F (-15°C) for 1–400 watt heater to 9°F (-13°C) for 1–1000 watt heater.

Combustion chamber air temperatures were obtained for two of the combustion chambers on the eight cylinder engine. Air temperatures within the combustion chambers were found to be identical to the coolant temperatures surrounding the combustion chambers.

Comparison of Heater Effectiveness in the Six and Eight Cylinder Engines

The total coolant temperature increase in the six cylinder engine after 5 hours was greater for each size of heater than the increase in coolant temperature using only one heater in the eight cylinder engine. Possible causes for this difference could be the greater amount of coolant which the one block heater must heat and also due to the greater heat loss from a larger surface area exposed in the case of the eight cylinder engine. Although using two block heaters in the eight cylinder engine resulted in higher total temperature increases of the coolant, the amount of temperature rise per kilowatt-hour was less for the eight cylinder engine than for the six cylinder engine. A comparison of the amount of temperature rise per kilowatt-hour input, based on the total temperature rise in 5 hours, for the various sizes of heaters in both the six and eight cylinder engines is shown in Tables I and III.

The difference in crankcase oil temperature when using only one heater in both the six and eight cylinder engines was negligible. Crankcase oil temperatures when using two heaters in the eight cylinder engine were approximately doubled.

TABLE III RATE OF ENGINE COOLANT WARMUP USING VARIOUS BLOCK HEATERS IN AN EIGHT CYLINDER FORD ENGINE

Size of heater element (watts)	No. of heaters used	Temperature rise per hour (°F) & % of total temperature rise 1 hr.	2 hr.	3 hr.	4 hr.	5 hr.	Total	°F/KWH
400	2	26 39%	21 31%	11 17%	6 9%	3 4%	67	418
400	1	14 39%	10 28%	5 14%	4 11%	3 8%	36	450
600	2	40 42%	28 29%	15 16%	8 8%	5 5%	96	400
600	1	21 43%	13 27%	7 14%	5 10%	3 6%	49	408
750	2	54 48%	30 27%	15 13%	9 8%	5 4%	113	377
750	1	28 48%	14 24%	9 15%	5 8%	3 5%	59	393
1000	2	74 50%	39 27%	17 12%	10 7%	6 4%	146	365
1000	1	34 46%	19 25%	11 15%	7 9%	4 5%	75	374

TABLE IV CRANKCASE OIL TEMPERATURES USING VARIOUS BLOCK HEATERS IN AN EIGHT CYLINDER FORD ENGINE

Size of heater element (watts)	No. of heaters used	Total temperature rise in 5 hours (°F)
400	2	10
600	2	12
750	2	19
1000	2	25
400	1	6
600	1	7
750	1	9
1000	1	9

CONCLUSIONS

The rate of increase in coolant temperatures, based on a percentage of the total increase, was slightly higher for the block heaters in the six cylinder engine than for the heaters in the eight cylinder engine. For the six cylinder engine, 76 to 80 percent of the total temperature increase was experienced in the first two hours of operation while an increase of 67 to 77 percent was experienced in the eight cylinder engine.

Equilibrium temperatures of the coolant were reached after five hours of block heater operation. The total rise in coolant temperature, for a given size of heater, was the same regardless of initial cold room temperatures. The total temperature increase of the coolant in the six cylinder engine varied from 45°F (25°C) when using a 400 watt heater to 112°F (62°C) when using a 1000 watt heater. Total temperature rise in the eight cylinder engine varied from 36°F (20°C) when using 1–400 watt heater to 146°F (81°C) when using 2–1000 watt heaters.

The total rise in crankcase oil temperature in the six cylinder engine ranged from 3°F (-16°C) to 11°F (-12°C) depending on the size of block heater. In the eight cylinder engine, the total rise in crankcase oil temperature varied from 6°F (3°C) when using 1–400 watt heater to 25°F (14°C) when using 2–1000 watt heaters.

The temperature of the air inside the engine combustion chambers was found to be identical to the coolant temperature surrounding the combustion chambers.

SUMMARY

Cold weather conditions during the winter months in Western Canada dictate that automobiles be equipped with an engine heater to enhance ease of starting. The rate of coolant temperature rise as well as the total temperature rise, when using 400, 600, 750 and 1000 watt block heater elements in both a six and eight cylinder engine, were investigated at various simulated weather conditions in a cold room.

The rate of coolant temperature increase was most rapid during the first two hours of block heater operation with equilibrium temperature being reached after five hours. The total rise in coolant temperature was dependent upon the size of heater used, but was the same for one size of heater regardless of initial cold room temperature.

REFERENCES

1. Environmental Data Service. 1969. Climates of the world. U.S. Department of Commerce Environmental Science Service Administration. January.

2. Zoerb, G.C., 1967. University tests engine block heaters. Design Engineering 13 (11): 61.