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ABSTRACT

The report is an evaluation of the effectiveness of the 12 instructional units developed around the use of the Briggs-Stratton Model 80302, 3HP, 8 cu. in. displacement engine having a fuel induction system similar in construction to farm tractor types. The evaluation procedure used was the "one-group Pre-test and Post-test" research method. The evaluation instrument used in the testing program consisted of 45 selected multiple choice questions drawn from the original 60 questions used in the pilot testing program. In general, there was an overall improvement from pretest to posttest in a student's performance indicating that instructional material was effective. Lists of student reference literature, basic tool sets, secondary tool sets, special laboratory equipment, the evaluation instrument, and a nine-item bibliography conclude the document. (Author/BP)

Effectiveness of Prepared Instructional Units In Teaching the Principles of Internal Combustion Engine Operation and Maintenance

Technical Bulletin 192

Agricultural Experiment Station
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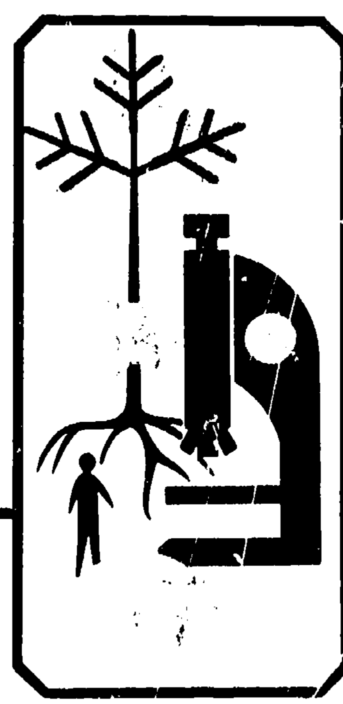

Effectiveness of Prepared Instruction Units In Teaching The Principles of Internal Combustion Engine Operation and Maintenance

A RESEARCH PROJECT
OF THE
DEPARTMENT OF AGRICULTURAL EDUCATION

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Introduction

The economic magnitude which the internal combustion engine contributes to the production of agricultural products and services in the United States is tremendous. Likewise, the emphasis by departments of agriculture in vocational, secondary and technical schools in offering pre-employment training in Agricultural Power probably exceeds any other instructional area in agricultural mechanization.

During the past ten years, the small single-cylinder, air-cooled engine has been universally accepted by departments of agriculture in vocational schools to provide students a "hands-on" opportunity to learn basic principles of internal combustion engine operation, care and maintenance.

The reasons for this acceptance are (1) manufacturers of small engines have provided new engines to schools at an attractive price, hence the cost per student is comparatively low in contrast to making available "hands-on" experiences by other methods; (2) the growth of the small engine manufacturing and utilization industry (an estimated 9.4 million units of less than 15 hp were produced in 1970)[1] has provided occupational opportunities for graduates in sales, service and repair businesses; (3) the subject matter associated with small engine instruction is considered to possess elements which are common and transferable to most types of present day internal combustion engines.

Purpose of the Study

In the past five years, numerous instructional units treating the subject of internal combustion engines have been developed by vocational agricultural educators in various states, some of which have been published for distribution.

Because teachers of vocational agriculture in Arizona ranked in-service training in small gasoline engines as a much needed area, a staff study was initiated to (1) develop an instructional resource unit in the internal combustion engines for Arizona using the small single-cylinder, air-cooled engine as a teaching model and (2) to evaluate the effectiveness of the units by conducting a testing service for cooperating teachers.

A review of literature revealed only one other study which had been conducted to determine the effectiveness of instructional units in small internal combustion engines.[2]

In the study, the following hypotheses were tested:

1. There was no change in the response of students based upon pre-test and post-test scores after having received instruction using the resource unit.
2. Whether teachers have had in-service training in the use of the equipment and resource unit had no effect upon the performance of students involved in the testing program.
3. The time of the school year when the instruction was conducted had no effect upon the change in student response based upon test score information.

Development of Resource Unit

Instructional units published by departments of agricultural education of Pennsylvania[3] and Missouri[4] were utilized to determine content and equipment which might be desirable for a resource unit. In addition, manufacturer's literature was reviewed to determine equipment and materials needed. Also, student reference literature was chosen based upon availability, depth of subject matter, and cost.

The resource unit content was developed around the use of the Briggs-Stratton Model 80302, 3 HP, 8 cu. in. displacement engine having a fuel induction system similar in construction to farm tractor types (Figure 1).

One **new** engine was recommended for each two students.

Twelve units of instruction were identified as necessary to meet the objective of providing sufficient subject matter to teach the principles of internal combustion engine operation, care and maintenance and subsequently provide valuable

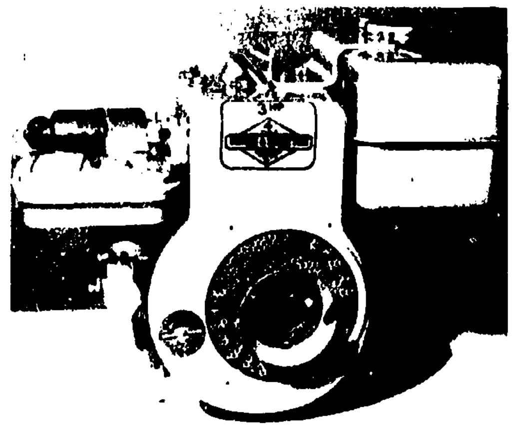


Figure 1 Recommended Engine Briggs-Stratton Model 80302

facts related to tractor engine operating principles. The units developed were as follows:

I. Principles of Internal Combustion Engines
II. Identification and Function of Engine Parts
III. Definition of Terms
IV. Valve and Ignition Timing
V. Fuel Induction — Carburetion
VI. Magneto Ignition
VII. Spark Plugs
VIII. Taking Accurate Measurements
IX. Using the Torque Wrench
X. Maintenance and Repair Techniques
XI. Governors
XII. Daily Service and Operation

From the above units, a teacher's manual was developed which provided unit outlines, teaching techniques and answers to questions.* A student's manual also was provided which identified reference page numbers specific to the listed questions for student study. Reference literature and student's texts which were recommended are illustrated in Appendix I.

It was suggested that teachers provide the recommended refer-

1. George H. Seferovich, Power Outdoor Equipment: **More and More Market**: Lawn/Garden/Outdoor Living, June 1970, p. 12, 13, 32, 33.
2. Lewis C. Ayers. "The Development and Evaluation of a Unit of Instruction on Small Gasoline Engines". Thesis, M.E. 1967, The Pennsylvania State University University Park, Pennsylvania.
3. Lewis C. Ayers, H. J. Hoerner and L. P. Grant, **Small Gasoline Engine**, Student Handbook, Teacher Education Series Vol. 10 No. 4(s). 1969. The Pennsylvania State University, University Park. Pennsylvania, 76 pages.
4. Curtis R. Weston, L. Bays, G. Shinn, and R. Lindhart, **Internal Combustion Engine**, Department of Agricultural Education, University of Missouri, Columbia, February, 1967. 107 pages.

*For information on how to obtain a complete copy of the teacher's resource unit, contact the Agricultural Education Department, University of Arizona, Tucson, Arizona 85721.

ences in sufficient numbers to supply one copy for each student in the largest class.

One engine was considered to be a work station. A recommended list of basic tools for each engine was developed in cooperation with Snap-On Tool Corporation and Briggs-Stratton Company representatives (see Appendix II). A secondary list of tools, one set for each three engines, also was recommended (see Appendix III).

Suggested special laboratory equipment for instructor use, which included timing disc, graduated cylinder, torque wrench adapter, and other special equipment, is illustrated in Appendix IV.

A method to control loss of parts and tools as students progressed through the program of engine disassembly and reassembly was considered essential. Thus, a storage box was developed as illustrated in Figure 2 to serve as a work station and a method of permitting students assigned to the station to retain control of hardware by being able to lock the box after each class activity.

In-Service Teacher Training and Pilot Testing

An intensive two-day workshop for 18 teachers of vocational agriculture was conducted by the author during the 1968 Christmas school vacation period using the resource units and recommended equipment.

The Briggs-Stratton Corporation and Snap-On Tools Corporation provided representatives to assist with the practical instruction and donated use of tools and equipment. All twelve instructional units were taught during the training sessions. One engine of the recommended model was provided for each two teachers.

Besides performing the recommended steps of procedure to disassemble, study the working parts, take measurements, reassemble, and operate the engine, the teachers were instructed in operating principles and teaching techniques.

Six teachers from this group agreed to pilot test the resource units for purposes of evaluating the response of students to the subject matter during the 1969 spring term. The pilot testing included the administration of a written examination of 60 selected multiple-choice questions on a pre-test to post-test basis to a total of 86 students.

In addition, teachers were asked to submit recommendations to improve the resource units. As a result, minor changes and corrections were made in both the teacher's and student's manuals.

Method of Procedure

During the summer of 1969, the revised resource unit in Internal Combustion Engines, including teacher's and student's manuals, were published and disseminated to all teachers of vocational agriculture in the State of Arizona.

Prior to the start of the fall semester, 1969, fourteen teachers representing 218 students indicated a willingness to cooperate in a testing program.

Design of the study was based upon the "one-group Pre-test to Post-test" research method.[5] In this process, the dependent variable was measured before the independent variable was applied, after which the amount of change was computed.

The evaluative instrument used in the testing program (see Appendix V) consisted of 45 selected multiple choice questions drawn from the original 60 questions used in the pilot testing program. The reduction in number of questions from 60 to 45 was based upon the teachers' recomendations that the test was too long and that several of the questions did not sufficiently test subject matter drawn from the resource unit.

Test questions and pages were not numbered and the order of collating the five sheets was varied, thus providing a more equal opportunity for retaining the discriminatory power of each question.

From the fourteen cooperating schools, 218 usable students responses to the test were received and manually scored. For purposes of evaluating the strengths and weaknesses in the twelve units of instruction, the responses to individual questions were entered on IBM punch cards according to three subject matter areas. These were (1) Principles of Engine Operation, (2) Fuel Induction and Ignition and (3) Engine Repair.

Profile information on each student regarding age, intelligence quotient number, number of years farming experience and the number of years enrolled in vocational agriculture courses was collected for the purpose of determining whether these data would provide correlative relationships to test responses. Also the number of years of experience in teaching vocational agriculture was identified for each of the fourteen teachers.

Analysis of Data

The primary objective of this study was to determine the amount of change in understanding which students exhibited for the principles of internal combustion engines as a result of having been in-

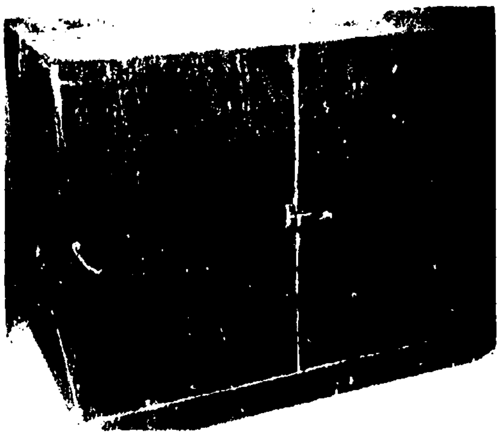
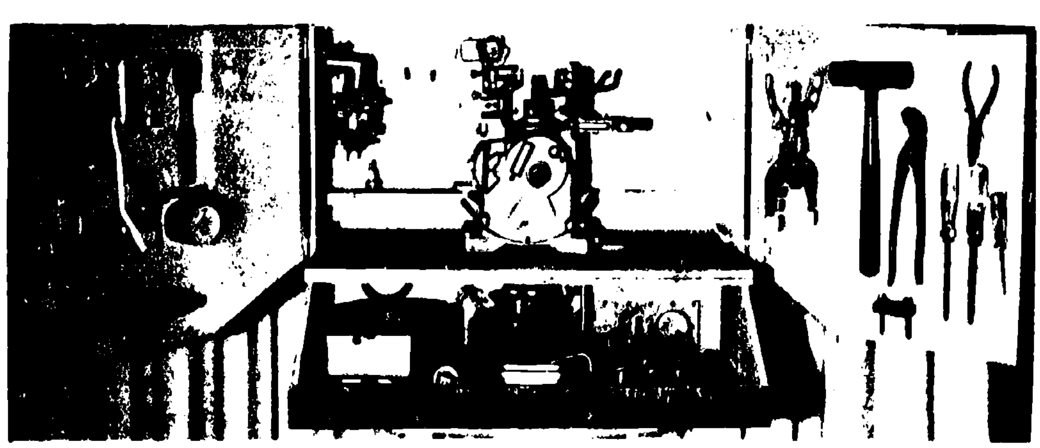


Figure 2. Suggested Work Station and Storage



5. Debold E. Van Dalen and M. J. Meyer. **Understanding Educational Research.** McGraw-Hill, Inc., 1966, pp. 230-232.

volved in instruction using the small engine as a teaching model and the resource unit as an instructional guide.

The principle concern was to determine whether there was a significant change in understanding from pre- to post-test results and whether the observed differences were of such a magnitude that the change could not be attributed to chance factors or sampling variations.

Test Instrument Evaluation

The importance of the data reported in this study which concerned the effect of a prepared resource unit on instruction in the internal combustion engines for high school students is directly related to the performance of the instrument used to collect the data. As previously reported, the instrument consisted of 45 multiple-choice items in a written examination which was administered as a pre- and post-test.

The test items used were screened from 60 items used in the pilot testing program.

From the data gathered in this study, it was possible to obtain several descriptive performance criteria relative to the test instrument. As illustrated in Table 1, the test was calculated to have a reliablity coefficient of .86. Reliability refers to the internal consistency of test scores within one measurement.

Using the Kuder-Richardson, Formula 20 method, a reliability coefficient was calculated in order to obtain a stability indicator of the test performance.[1]

A high degree of confidence in reliability is indicated by a large numerical coefficient. Coefficients in the .80's - .90's are commonly reported for standardized tests of aptitude and achievement administered within a fixed time period.

Because the testing program used in this evaluation involved a time spread of 6 to 8 weeks, it is believed that the test instrument used had an acceptable degree of reliability based upon a coefficient calculated to be .86.

A measure of difficulty also is an indication of the reliability of a test. A test should be neither too easy nor too difficult to avoid low reliability of scores. A composite test score which approaches the 50 per cent mark is an indicator of a desirable level of difficulty. The value calculated for this instrument was 56 per cent.

A third measure used to evaluate the effectiveness of the test instrument was to determine the degree to which each test item was capable of discriminating between pupils of high and low achievement. The discriminating power of each test item obtained for this study indicated coefficents ranging from .119 to .729. Table 2 shows the coefficients by number of test items when arranged according to four coefficient range categories.

From this data it can be seen that three of the test items were determined to have discriminatory power of .20 coefficent or less. Twenty-nine items or 64.5 per cent had discriminatory power of .21 - .50, while thirteen items (29 per cent) had a coefficient range of .51- .80. There were no items having very high, (.80-1.00) discriminatory power.

Generally, the range of .21 - .50 coefficient is considered to indicate average acceptability while a .51 - .80 range is ranked very good to outstanding in discriminating power. From this data, it is believed that the evaluative instrument generally had the ability to satisfactorily discriminate between the performance of low and high achievers since 93.5 per cent of the items ranked in the average to outstanding coefficent rating.

The three test items that were found to be low in coefficient were reviewed to determine whether there was a possibility that the items were poorly worded, failed to be answered by instructional information in the resource unit, or were mechanically poor. It was concluded that the items were **not**

TABLE 1

SELECTED FACTORS FOR DETERMINING THE EFFECTIVENESS OF A 45 ITEM EVALUATION INSTRUMENT[1]

EVALUATIVE FACTOR	NUMERICAL DATA
Reliability (Correlation coefficient)	.86
Difficulty (Average Score)	56%
Discriminatory Power Coefficient	.119 to .729
Mean	25.25 items
Standard Deviation	7.6

1 Post-test data analysis used

TABLE 2

DISCRIMINATORY POWER COEFFICIENT CHARACTERISTIC OF THE 45 ITEM TEST INSTRUMENT IN INTERNAL COMBUSTION ENGINES

COEFFICIENT RANGE BY CATEGORIES	NUMBER OF TEST ITEMS	PER CENT ITEMS
.0 — .20	3	6.5
.21 — .50	29	64.5
.51 — .80	13	29.0
.81 — 1.00	0	0.0
Total	45	100.0

TABLE 3

COMPARATIVE DIFFERENCE BETWEEN MEAN CORRECT RESPONSES ON PRE-TEST AND POST-TEST BY AREAS OF SUBJECT MATTER AND COMBINED SCORES (N = 218)

SUBJECT MATTER AREAS OF TEST	NO. QUESTIONS	MEAN CORRECT TEST SCORE RESULTS			
		Pre-test	Post-test	Difference	t*
Principles, Internal Combustion Engine	20	09.138	11.830	02.692	7.851
Fuel Induction and Ignition	16	05.628	08.638	03.010	11.193
Engine Repair	9	03.358	04.780	01.422	8.157
Overall Scores Combined Areas	45	18.124	25.248	07.124	10.612

t* = 1.960 at .05 level
= 2.592 at .01 level
= 3.291 at .001 level
df = 434

1. Norman E. Gronlund, **Measurement and Evaluation In Teaching**, MacMillan Co., New York, pp. 83.

TABLE 4

ANALYSIS OF VARIANCE OF MEAN DIFFERENCE IN PRE-TEST AND POST-TEST PERFORMANCE OF STUDENTS BASED UPON IN-SERVICE TRAINING STATUS OF TEACHERS
(N = 218)

SUBJECT MATTER AREAS OF TEST	MEAN DIFFERENCE - PRE-TEST to POST TEST			
	Students of Teachers Receiving no Training N = 79	Students of Teachers Receiving Training N = 139	Mean Score Difference	F*
Principles of Internal Combustion Engine Operation	2.220	2.957	.729	2.84
Fuel Induction and Ignition	2.291	3.417	1.126	7.43
Engine Repair	0.506	1.942	1.436	24.84
Overall Scores Combined Areas	5.025	8.317	3.292	14.59

F* = 2.74 @ .1 level
= 3.89 @ .05 level
= 6.76 @ .01 level
df = 1 and 216

TABLE 5

ANALYSIS OF VARIANCE BY QUARTERS OF SCHOOL YEAR IN WHICH SUBJECT MATTER WAS TAUGHT
(N = 218)

SUBJECT MATTER AREAS OF TEST	MEAN DIFFERENCE, PER CENT OF QUESTIONS ANSWERED CORRECTLY: PRE-TEST TO POST-TEST				
	SCHOOL YEAR QUARTERS				
	First N = 8	Second N = 22	Third N = 117	Fourth N = 71	F*
Principles of Internal Combustion Engine Operation	24.40	5.95	14.60	11.65	2.40
Fuel Induction and Ignition	22.65	18.50	21.40	14.18	2.49
Engine Repair	26.30	12.20	21.58	6.28	7.29
Overall Scores Combined Areas	24 20	13.42	18.40	11.40	5.15

F* = 2.65 @ .05 level
= 3.88 @ .01 level
df = 3 and 214

inferior in quality and substance and should be retained for future testing programs.

When the reliability value of .86, the degree of difficulty of 56 per cent, and the discriminating power data were interrelated for comparison, the 45-item test was found to possess characteristics descriptive of a desirable evaluative instrument for determining the effectiveness of the instructional resource unit concerning the internal combustion engine.

Change in Understanding Results

When the data for this study were compared on overall test score mean difference in response, there was determined to be an increase of 39.3 per cent in understanding by the 218 students who were involved in the internal combustion engine instructional unit.

A comparison of the mean number of correct responses between pre-test and post-test by areas of subject matter is shown in Table 3. Also included is the computed Fisher's test values of observed difference in mean test score between subject matter areas and combined scores. In all three subject matter areas and combined scores, there was sufficient evidence to refute the hypothesis of no sufficient difference at the .001 level of 3.291 at 434 degrees of freedom.

Effect of In-Service Training

It was anticipated that one of the factors which might contribute to a difference in performance of students on the post-test would be whether the teacher had received in-service training on how to utilize the resource unit prior to his being involved in the testing program. As shown in Table 4, there was sufficient evidence at the .01 level of significance to reject the hypothesis that there was no difference in performance of 79 students whose teachers had not received training, compared to 139 students whose teachers had received training when compared to overall scores of all subject matter areas.

The computed mean score difference of 3.292 represents a 65% greater increase in student understanding when the teacher had received inservice training.

Contributing to the highly significant results on overall test scores for trained teachers were the subject matter areas of Fuel Induction and Ignition and Engine Repairs with F values of 7.43 and 24.84, respectively.

The area of Principles of Internal Combustion Engine Operation showed a mean difference of 7.29 in score increase for the trained teacher, which was significant at the .1 level.

Based upon the performance of students' response to test questions, the data indicates that the greatest effect of inservice training was obtained in the areas of Fuel Induction and Ignition and Engine Repair.

Apparently, all teachers were generally more informed in principles of engine operation, compared to their knowledge in the other subject matter areas based upon student performance.

Effect of Time in School Year

A second variable which was tested for its effect as a factor which might contribute to student performance was the time in the school year when the instructional units were taught. As shown in Table 5, there was a significant difference in the F value at the .01 level to indicate that time in the school year had an influence on the mean difference in correct scores a student would attain, especially in the Engine Repair Area and overall results.

The reasons for this difference may be due to (1) the variation in the number of (N) students involved by quarters and (2) the tendency to run out of time during the second and fourth quarters of a school year, when the conse-

TABLE 6

CORRELATION COEFFICIENCIES FOR SIX VARIABLES WITH OVERALL SCORES ON PRE-TEST AND POST-TEST (N = 82)

VARIABLE	PRE-TEST SCORES (r)	POST-TEST SCORES (r)
Student's Age	.1001	.0312
Student's I.Q.	.4266	.5019
Student's Farm Experience, No. Years	.1411	.0284
Student's Vocational Agriculture Experience, No. Years	.2202	.2822
Experienced Teacher	.0015	.1824
Teacher Received In-Service Training	.03578	.1767

quence that students may have been rushed through the instructional information without complete understanding. The latter may attribute to the generally lower mean difference in per cent of questions answered correctly, (see Table 5) in the second and fourth quarters.

Correlation Factor Relations

Product-moment correlation coefficient (r) relationship were computed for six variables and are shown in Table 6. The variables tested for relationship to performance on pre- and post-test scores were (1) age of student, (2) I.Q. of student, (3) number of years which the student had farm experience, (4) number of years vocational agriculture schooling, (5) whether the teacher was experienced, and (6) whether the teacher had received inservice training.

The evaluation was made using 82 observations because sufficient data was not available to use the remaining 136.

All correlation coefficient relationships (r) were found to be very low with the exception of "student I.Q." which indicated low to moderate relation in both pre- and post-test performance.

The relationship between I.Q. and verbal performance is associated closely with what is expected since r's usually run .40 - .60 in these areas.[6] It also is believed that the positive r relationships which were computed for all six factors have significance even if the numerical value is low. The tendency for r to have a high value in post-test scores in the variables of students having had "more experience in Vocational Agriculture", a more "experienced teacher", and "teachers having received inservice training", follows what generally could be expected.

Summary and Conclusions

It was generally observed that teachers and students have enthusiastically received the small single-cylinder, four-cycle, air-cooled gasoline engine as a model for teaching the operation, care, and maintenance of internal combustion engines.

The change of 39.3 per cent increase in understanding from pre- to post-test scores on a written examination of 45 multiple-choice questions was considered to be an encouraging insight related to the performance of the resource unit

When the mean difference in number of correct responses between pre- and post-test scores was compared, the computed t value indicated that the difference in score was significant at the .001 level. When compared by area of subject matter, namely Principles of Internal Combustion Engines. Fuel Induction and Ignition and Engine Repair, each area was determined to have a significant difference in mean correct responses from pre- to post-test when evaluated by t at the .001 level.

Whether the students of teachers who had received inservice training in the use of small engine equipment and resource units had more correct responses in mean pre- to post-test score difference was determined to be not significantly different when F was compared at the .05 level.

There were indications that students of trained teachers did better in the units of instruction related to principles of internal combustion engines when F was compared at the .1 level of significance.

Time of the year in which the units were taught had a significant effect upon the overall test score performance when F was compared at the .01 level. Generally, students had a greater per cent of mean correct responses in the first and third quarter of the school year than in the second and fourth quarters.

Very low but positive product-moment correlation (r) relationship existed between six factors compared upon pre- and post-test scores. The greatest change between pre- and post-test relationships (although low) were for the following variables: (1) Teacher had received inservice training, (2) Teacher was experienced, and (3) Student had previous experience in Vocational Agriculture.

Intelligence quotient of the student had low to moderate relation ship to performance.

The evaluation instrument used in this study had high level of reliability and discriminatory power when used as an instrument to measure performance of students when taught principles of internal combustion engine operation and maintenance using the prepared resource unit.

Recommendations

The high motivational factor which instruction in the subject of internal combustion engines model apparently possesses for both students and teachers using the small engine as an instructional model should be exploited and perfected to the greatest possible degree of refinement. Continued research in new methods and techniques should be explored continually to determine the effectiveness of the various processes.

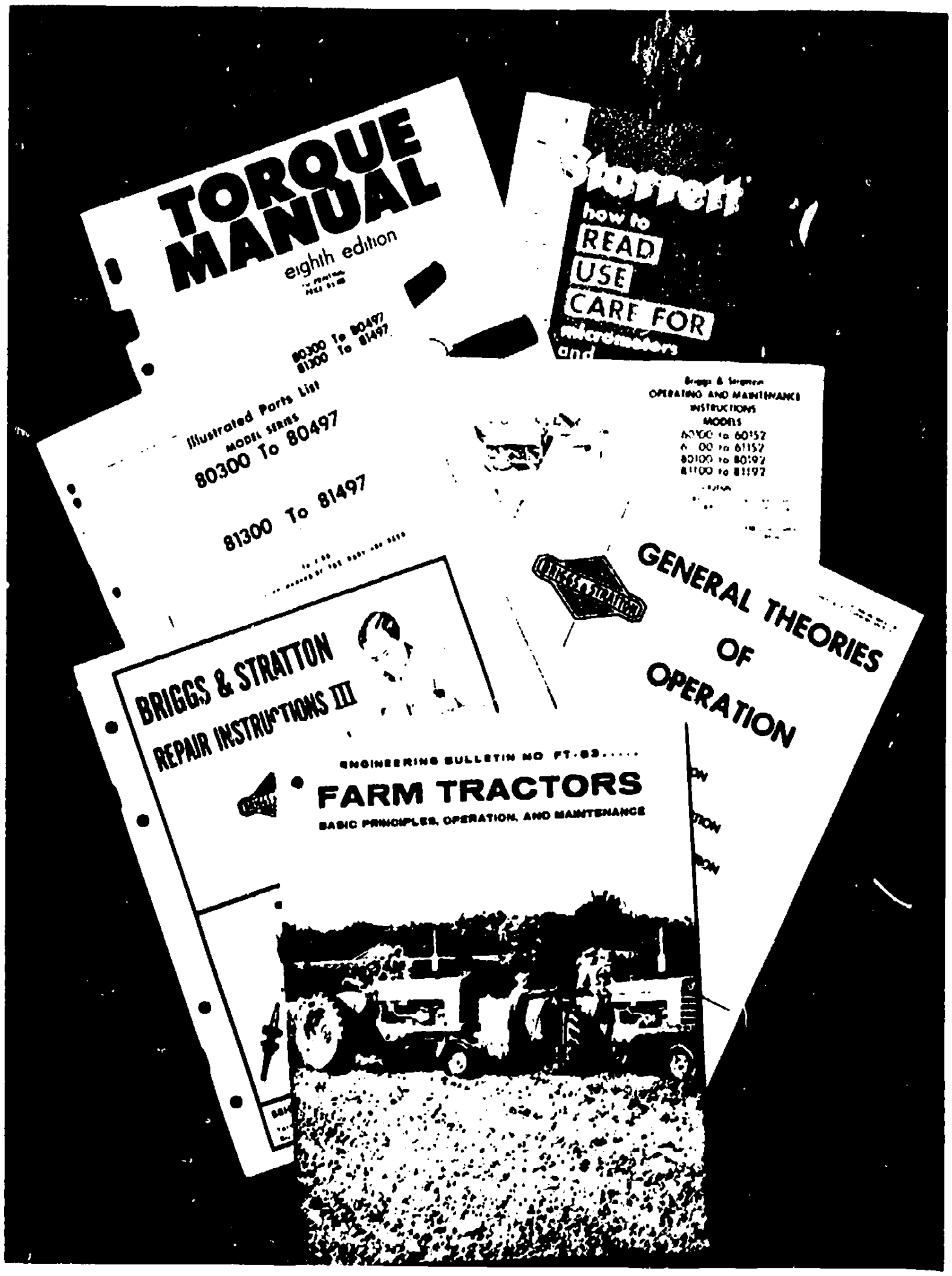
Use of the "One-Group Pre-test —Post-test" technique as a research tool to determine the effectiveness of the instructional process to measure change in understanding is recommended for teachers as a self-evaluation technique.

Additional studies should be conducted to design instructional material in small engines which will determine how effectively students are able to transfer knowledge of subject matter in the small engines to farm tractor engine operation, care, and maintenance.

6. Henry E. Garrett, **Statistics in Psychology and Education,** Longmans, Green and Company, New York, 5th Edition, 1958, pp.175-177.

Appendix I

Student Reference Literature

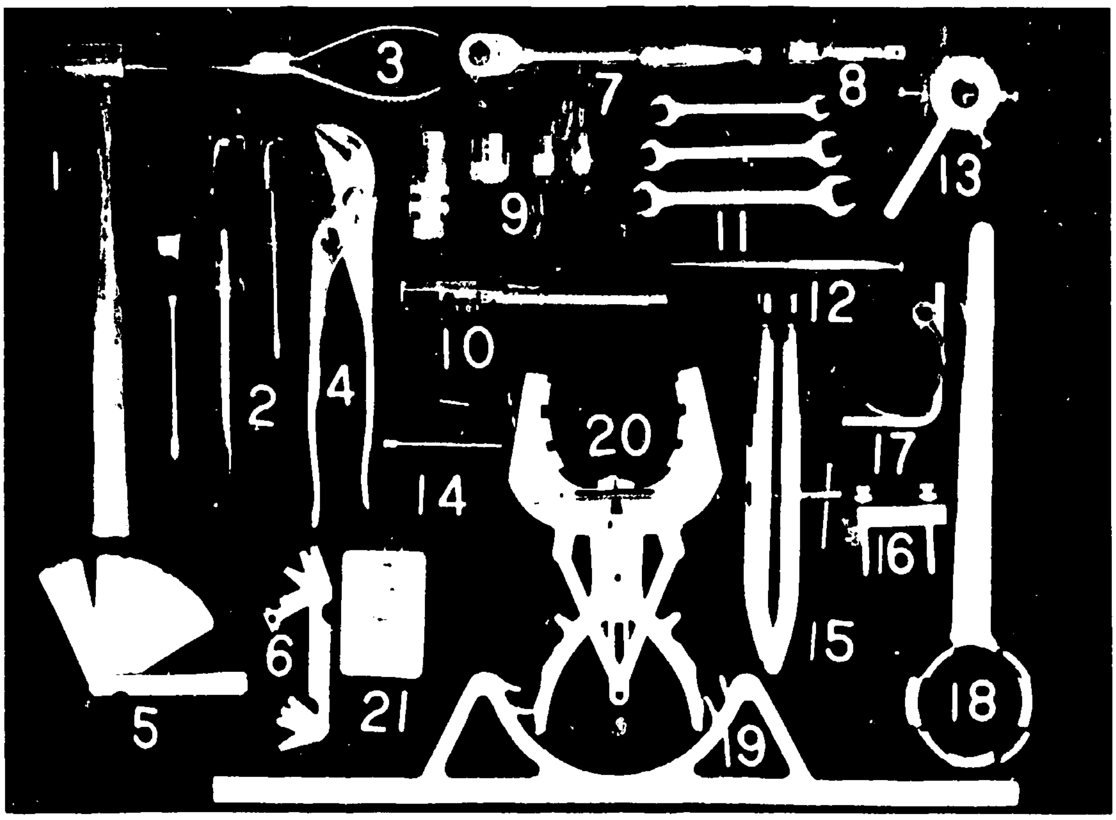


Literature

	Cost per Copy
Farm Tractors, Engineering Bulletin FT53-A. National 4-H Supply Service, 1968.	$1.00
Repair Instructions III, MS 4750-48. Briggs-Stratton Corporation.	*
General Theories of Operation, MS-3553-24 Briggs-Stratton Corporation.	*
Illustrated Parts List, MS-4255-108. Briggs-Stratton Corporation.	*
Operating & Maintenance Instructions, Form No. 27842-108, Briggs-Stratton Corporation.	*
Torque Manual, P. A. Sturtevant Co.	*
How to Read, Use, and Care for Micrometers, L.S. Starrett Co.	*
	$1.00

* No cost in quantities for largest class.

Appendix II
Basic Tool Set BS118
(One set recommended per engine)



Item No.	Tool	Size	Cost
1	Hammer, plastic tip	½ lb.	$5.26
2	Screw driver, Phillips	No. 2 x 4	2.32
2	Screw driver, standard tip	¼ x 4	1.89
2	Screw driver, cabinet	3/16 x 3	1.47
3	Pliers, needle nose	6 inch	4.21
4	Pliers, pump	6 inch	3.01
5	Gauge, feeler	.0015-.025, 25 leaf	2.63
6	Gauge, spark plug		1.37
7	Ratchet	⅜" drive	6.53
8	Extension	3" x ⅜" drive	1.92
9	Socket	7/16" x ⅜" drive	1.05
9	Socket	½" x ⅜" drive	1.05
9	Socket	⅝" x ⅜" drive	1.47
9	Socket	¾" x ⅜" drive	2.06
10	Hex Nut Driver	¼"	1.9[illegible]
11	Wrench	5/16" - ⅜"	1.83
11	Wrench	⅜" - 7/16"	1.96
11	Wrench	7/16" - ½"	2.06
12	Punch, starting	⅛"	1.68
13	Spark tester		1.65
14	Plug gauge, breaker point plunger		.45
14	Plug gauge, valve guide		2.15
15	Valve spring compressor		2.25
16	Puller, flywheel		.50
17	Compressor, piston ring		.95
18	Clutch wrench		1.85
19	Holder, flywheel		3.35
20	Piston ring expander		2.80
21	Piston land wear gauge		.50
		Total Basic Tool Kit, each	$43.88

Appendix III

Secondary Tool Set BS108

(One set recommended for each three engines)

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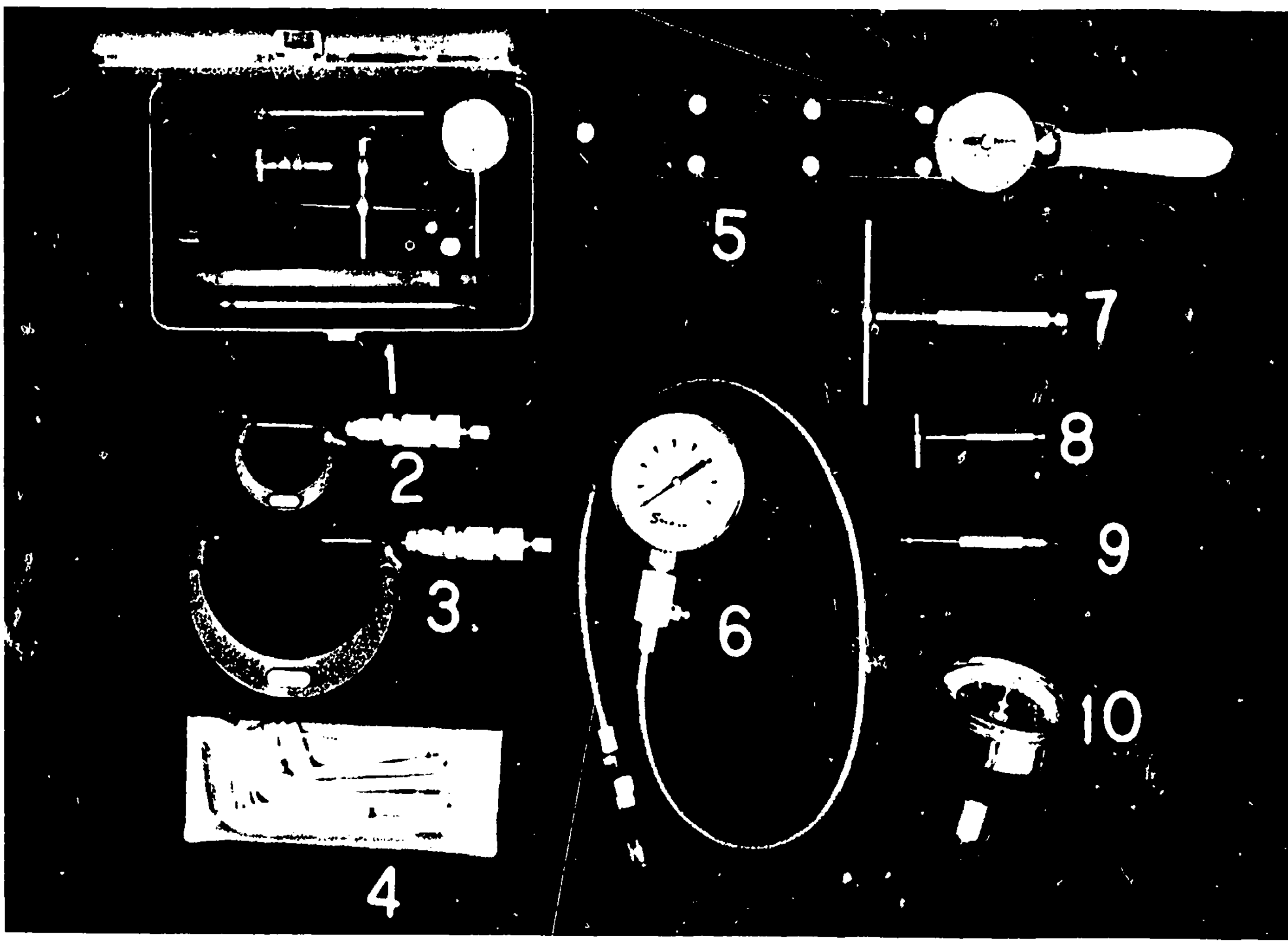
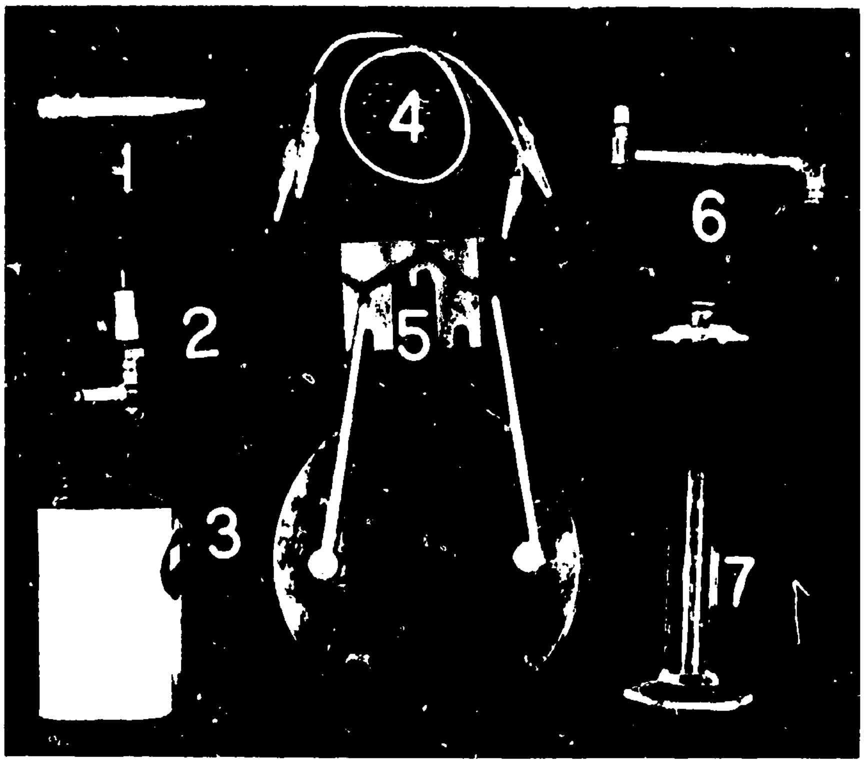


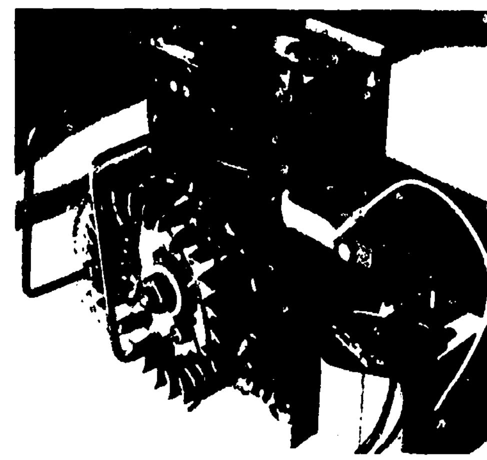
Item No.	Tool	Size	Cost
1	Dial Indicator Set		$15.39
2	Micrometer, outside	0-1	16.40
3	Micrometer, outside	2-3	21.15
4	Allen Wrench Set		3.71
5	Wrench, Torque meter	0-600 in. lb.	49.11
6	Cylinder Compression Gauge	0-300 lbs.	20.53
7	Telescoping Gauge	2⅛" - 3½"	6.35
8	Telescoping Gauge	¾" - 1¼"	4.70
9	Small Hole Gauge	.200-.300	4.00
10	Tachometer, dial type, direct reading Stewart-Warner Model 757-W		12.70
		Total Secondary Tool Kit	$154.04

Appendix IV

Special Laboratory Equipment

(For Instructor)





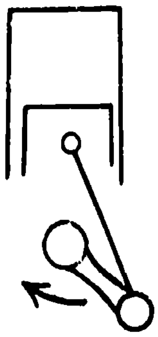
Item No.	No. Each	Item	Cost
1	1 ea.	Sleeve, oil seal installation, shop constructed	—
2	1 ea.	Test Spark Plug, 3/16" gap (substitute for BS 19051 spark tester), shop constructed	.80
3	1 ea.	Battery Dry Cell, 6 volt Lantern	.50
4	2 ea.	Test Leads with Alligator Clips, shop constructed	—
5	1 ea.	Timing Leads, Circle (360°) Protractor, Post No. 1532A-6	1.25
6	1 ea.	Torque Wrench Adapter, 4 inch, Shop Constructed	—
7	1 ea.	Graduated Cylinder, 50 ml plastic base	2.00
		TOTAL COST	$4.55

Appendix V

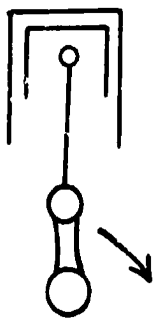
Evaluation Instrument

QUESTION: Which of the following positions of crankshaft rotation is the exhaust valve of a four-cycle engine starting to open?

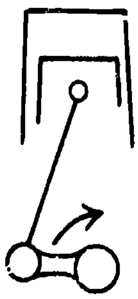
_______a.
_______b.
_______c.
_______d.



a.



b.



c.

d.

QUESTION: How many valves will normally be in the block of a four-cycle, one cylinder gasoline engine?

_______a. 1
_______b. 2
_______c. 3
_______d. 4

QUESTION: What is the name of the device in spark ignition engine that mixes gasoline and air in the proper proportions?

_______a. choke
_______b. cylinder
_______c. carburetor
_______d. governor

QUESTION: Size of an internal combustion engine is usually expressed in

_______a. weight in pounds
_______b. compression pressure
_______c. piston displacement
_______d. torque output

QUESTION: The magneto system of most gasoline engines generates an electric spark by

_______a. the incorporation of a small battery
_______b. the rapid opening & closing of points
_______c. a condenser of the proper capacity
_______d. magnets moving past the armature poles

QUESTION: Which of the following describes the secondary winding of an ignition coil?

_______a. many turns of heavy wire
_______b. a few turns of heavy wire
_______c. a few turns of fine wire
_______d. many turns of fine wire

QUESTION: A governor acting on the principal of centrifugal force is known as the

_______a. vacuum type
_______b. venturi type
_______c. mechanical type
_______d. piston type

QUESTION: Which of the follow- is **not** a part of the ignition coil?

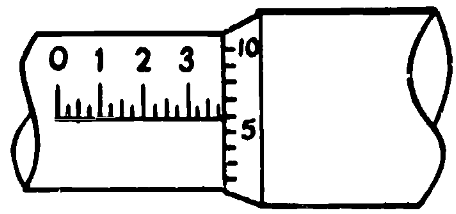
_______a. core
_______b. condenser
_______c. primary winding
_______d. secondary winding

QUESTION: The "compression ratio" in a given size of engine is controlled by the design of the engine. This could be altered by which one of the following?

_______a. advance the spark and clean carbon from the valves
_______b. increase the intake valve in length and diameter
_______c. install a supercharger and use a rich fuel mixture
_______d. change the volume of the combustion chamber by using a thicker cylinder head gasket.

QUESTION: The micrometer pictured below is set to read:

_______a. 2.381
_______b. 2.376
_______c. 2.316
_______d. 3.351



QUESTION: Which would be a reason for honing a cylinder to oversize?

_______a. vertical score
_______b. flat
_______c. .001" taper
_______d. .001" out-of-round

QUESTION: Which of the following is equal to a torque wrench reading of 60 foot-pounds?

_______a. 720 inch-pounds
_______b. 180 yard-pounds
_______c. 60 millimeters-gram
_______d. 210 meter-grams

QUESTION: Which one of the following spark plug appearances most clearly indicates the possibility of too "rich" a fuel mixture?

_______a. dry or damp black soot on insulator or shell
_______b. burned and badly eroded electrode
_______c. light tan or brown insulator
_______d. black, wet deposits on insulator and shell

QUESTION: Which of these air cleaners can be cleaned with soap and water?

_______a. metallic mesh
_______b. dry-type paper
_______c. oil bath
_______d. polyurethene

QUESTION: Which type of gauge should ordinarily be used to measure magneto air gap?

_______a. inside calipers
_______b. outside calipers
_______c. flat thickness
_______d. round wire

QUESTION: One of the reasons for adjusting valve clearance of an engine is to

_______a. make valves open further
_______b. keep valves cooler
_______c. place valves in time
_______d. increase compression

QUESTION: When a condensor is checked for capacity, the unit of measure is

_______a. ohms
_______b. volts
_______c. resistance
_______d. farads

QUESTION: A condenser is most actively functioning

_______a. when the breaker points open
_______b. when the breaker points close
_______c. after the spark plug fires
_______d. when the primary coil stops functioning

QUESTION: The combustion pressure of a gasoline engine cylinder is greatest when the piston is located

_______a. at bottom dead center
_______b. several degrees past bottom dead center
_______c. at dead center
_______d. a few degrees past top dead center

QUESTION: Secondary voltages in a small gasoline engine may be as high as

_______a. 15 volts
_______b. 150 volts
_______c. 1,500 volts
_______d. 10,000 volts

QUESTION: Diesel engines are distinguished from other types of internal-combustion engines by their use of

_______a. the four-stroke cycle only
_______b. ignition by heat of compression
_______c. very low compression ratio
_______d. air blast fuel injection

QUESTION: Richness or leanness of mixtures burned in an engine is referred to as

_______a. octane of fuel
_______b. volatility of fuel
_______c. air-fuel ratio
_______d. vapor being burned

QUESTION: In a two-cycle engine how many complete revolutions must the crankshaft make to complete one cycle?

_______a. one
_______b. two
_______c. three
_______d. four

QUESTION: What part of the ignition system controls the time current flows to the spark plug?

_______a. induction coil
_______b. ignition coil
_______c. breaker assembly
_______d. lead wire
_______e. core

QUESTION: What is the constricted area of a carburetor that is designed to increase the velocity of the air?

_______a. tunnel
_______b. venturi
_______c. air foil
_______d. valve

QUESTION: In order to operate successfully every engine must have at least three primary functional systems. These are

_______a. magneto, spark plug and condenser
_______b. spark plug, breaker points, and compression
_______c. compression, fuel and magneto
_______d. compression, fuel and ignition

QUESTION: Diesel and gasoline engines differ mainly in their

_______a. fuel systems and ignition methods
_______b. fuel systems and cylinder blocks
_______c. fuel systems and cylinder assemblies
_______d. ignition methods and cylinder assemblies

QUESTION: A two-cycle chain saw engine will be expected to have the following type carburetor

_______a. float
_______b. injection
_______c. diaphram
_______d. rotary

QUESTION: In comparing two-cycle vs. four-cycle engines, which of the following is the **most** accurate statement?

_______a. a four-cycle and two-cycle engine of the same horsepower will be of approximately equal weight.
_______b. a two-cycle engine will start faster and easier.
_______c. a two-cycle engine will normally run smoother than a four-cycle.
_______d. a two-cycle engine is simpler in construction and design

QUESTION: One cylinder gasoline engines operate at a compression ratio of about

_______a. 6 to 1
_______b. 9 to 1
_______c. 12 to 1
_______d. 15 to 1

QUESTION: Which of the following spark plug insulator descriptions best indicates a "hot" spark plug?

_______a. long
_______b. thin
_______c. thick
_______d. short

QUESTION: As breaker points wear, timing of a spark ignition engine will be:

_______a. advanced
_______b. retarded
_______c. no change in timing
_______d. wear only effects RPM

QUESTION: If a piston displaced 6 volumes in the cylinder, the compression ratio of the engine is

_______a. 5:1
_______b. 6:1
_______c. 7:1
_______d. 8:1

QUESTION: When fastening the cylinder head of a small engine to the block, which of the following procedures should be followed?

_______a. rotate each of the head bolts one-quarter turn
_______b. use a socket wrench with a handle 12 inches long
_______c. tighten the bolts evenly following proper order
_______d. tighten down the bolt nearest the muffler port before tightening the others

QUESTION: The angle or surface of the **valve seat** should match what part of the valve?

______a. face
______b. head
______c. margin
______d. dish

QUESTION: The normal wear on most cylinders is greatest near the

______a. valve chamber
______b. top of the cylinder
______c. center of the bore
______d. bottom of the bore

QUESTION: What should be done when crankshaft end-play is insufficient?

______a. use a thicker magneto plate
______b. use special bushings on the crankshaft
______c. use additional end plate gasket
______d. replace the crankshaft

QUESTION: The float level in a small gasoline engine carburetor is set to manual specifications with a

______a. ruler
______b. feeler gauge
______c. micrometer
______d. depth gauge

QUESTION: A machine which converts heat of burning gases into rotating movement is referred to as a:

______a. prime mover
______b. motor
______c. blast furnace
______d. heat engine

QUESTION: Stroke of the piston is expressed in:

______a. inches of movement in the cylinder
______b. degrees of crankshaft rotation
______c. pounds of force exerted on flywheel
______d. torque valve in ounces

QUESTION: Which of the following type engines does not take an air-fuel mixture into the cylinder on the intake stroke.

______a. external combustion
______b. spark - ignition
______c. compression - ignition
______d. vacuum - ignition

QUESTION: When the connecting rod is in exact parallel alignment with the crankshaft throw, the piston is said to be positioned on:

______a. dead center
______b. power stroke
______c. bore sight
______d. 360 degree alignment

QUESTION: The reference to the exact time that ignition spark occurs during engine operation is expressed in:

______a. speed of light
______b. degrees of crankshaft rotation
______c. angle of connecting rod
______d. seconds between electric discharges

QUESTION: The relationship of the crankshaft gear to the camshaft gear is such if the crank gear has 16 teeth the cam gear will have:

______a. 16 teeth
______b. 21 teeth
______c. 26 teeth
______d. 32 teeth

QUESTION: Which of the following mechanisms causes the valve of a four-cycle engine to be lifted from its seat?

______a. wedge
______b. guide
______c. spring
______d. cam

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