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Yugoslavia.

Final Report on Project of Provision of Services Relating
to the Technical Assistance to the Industry of Engine Part
and Allied Components in the Socialist Federal Republic of
Yugoslavia

UNIDO Contract No. 83/81

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SUMMARY

In the one year of technical assistance to the Institut za Mehanizaciju (IZM) and the company "27. Mart" AVL advised on

- equipment for testing of internal combustion engines
- test bed installation of engines
- training of project area personnel in test bed routines (operation of engines, measurement of performance and other data, interpretation of results, assessment of engine wear, etc.)

The test bed equipment currently available to IZM is still incomplete or too inaccurate for performing the required homologation tests of engine components. Therefore, it is recommended to install in the future instrumentation for the measurement of

- exhaust smoke
- fuel consumption
- exhaust gas temperature
- oil and water temperature
- oil consumption
- vibration

Besides this additional equipment the Institut za Mehanizaciju will also require further consultation in order to improve their knowledge in today's sophisticated measurement techniques and to train and advise the personnel in test bed work.

According to the contract between UNIDO and AVL executed on May 23, 1984, contract no. 33/81 the work in the project area was started already by end of November 1983. The present report summarizes the work performed for Institut za Mehanizaciju (IZM), Novi Sad by AVL for the contract period from November 1983 to December 1984 in a chronological order. The content of the interim report as submitted to UNIDO on Sept. 24, 1984 is repeated.

1. Nov. 15, 1983: Visit of Mr. Albert Fussi to IZM/Novi Sad

The purpose of this visit was to advise on the installation of an engine test bed by use of existing equipment (Schenk W 230 dynamometer) and of the equipment which was delivered by AVL (high pressure indicating system, HP 306/N and blow-by measuring system, needle lift probe 424).

Main topic of discussion was the installation of the needle lift probe and the quartz transducer of the high pressure indicating system on the engine which will be used for the tests of piston and liners (4-cylinder swirl-chamber diesel engine IMR M34/V, bore 91.4mm, stroke 127mm, 64 hp at 2600 rpm).

The installation of the quartz transducer 8 QP 500 ca in the main combustion chamber together with the adaptor 8ZP30 is difficult because the cylinderhead has to be machined for a sleeve through the water jacket. The feasibility of the installation of such a sleeve has to be studied in advance on a detail drawing of the cylinderhead.

However, since drawings were not available, it was agreed that IZM would provide the required cylinderhead drawings to AVL. Then, AVL would be in the position to sketch the necessary machining and advise on the installation of the sleeve.

In case that the manufacturing of a bore through the water-jacket turns out to be impossible, the installation of a quartz transducer in the swirl chamber should be considered. However, then a transducer of 8QP500 c will be required.

The installation of the needle lift probe in the injector by use of a special adaptor piece was explained in detail.

Further items of discussion were the measurement techniques for intake air flow by rotary piston meters and temperature by Pt 100 probes as supplied by AVL. It was agreed that AVL will provide written information on these systems.

Finally, the homologation tests for pistons, rings and liners manufactured by the Yugoslavian company "27. Mart" to be performed by IZM were discussed. The Yugoslavian company IMR (Industrija Motora Rakovica) as potential users of these components have already prepared directions for such tests. IZM handed over a copy of these directions (written in Serbian). AVL is expected to comment. If necessary, AVL should provide information, how the procedure can be further improved.

2. Analysis of homologation test procedure as established by IMR/IZM, including translation of manual

The manual for the homologation test procedure had to be translated by AVL into German for further analysis by AVL experts. In essence, AVL agreed with the homologation procedure as described in the manual. However, several recommendations were made by AVL and discussed on the occasion of the visit of "project area" personnel to AVL on Dec. 2, 1983 (cf. item 3).

3. Dec. 2, 1983: Visit of "Project Area" personnel, Mr. H. Ličen (IZM), Mr. S. Radišić, Mr. B. Mirkić (27. Mart)

- a) Discussion of homologation test procedure for piston and piston rings: The procedure as issued by IMR was discussed and in essence approved by AVL. However, AVL would recommend a very thorough check of piston ring dimensions and tangential forces before start of tests. For the control of ring shape sometimes a simple light-gap method is applied. For wear measurement a very sophisticated equipment is required, which in general is too expensive for test laboratories. Therefore, wear measurements are in most cases performed by piston ring manufactureres.

In this context, several publications were handed over to IZM such as: "Allgemeine Abnahmebedingungen für Kolbenringe" (General acceptance specifications for piston rings), "Neue Methoden zur Bestimmung der Genauigkeit von Kolbenringen" (New methods for the determination of the accuracy of piston rings), "Auslegung von Kolbenringen" (Lay-out of piston rings).

- b) Test bed installation and test routine

Various methods of air flow measurement were discussed. In any case it is recommendable to install a surge tank between the measurement equipment and the engine in order to avoid the influence of flow fluctuations on the measurements. The most reliable measurements of intake air flow can be performed by a rotary piston meter. As a provisional device a Venturi or an orifice can be used. It is also recommendable to operate the engine at constant intake temperature. This would require the use of an air cooler.

The coolant system of the engine should be operated with a water softener in order to avoid deposits in the system which would deteriorate the heat transfer. For the determination of the heat balance in the engine the water flow has to be measured by a water flow meter and the inlet and outlet temperatures by resistance probes. Also (air) intake and exhaust temperatures have to be recorded.

Measurement of cylinder pressure:

Once again it was stressed by AVL that the measurement of cylinder pressure in the main combustion chamber is advantageous, since the force of the combustion exerted on the piston can be determined (indicated mean effective pressure = IMEP). The measurement in the swirl chamber should be used only provisionally. The cylinderhead drawings by which it would have been possible to determine the possible position of a sleeve for the quartz transducer was not yet available.

c) Comment on piston design as performed by "27. mart" - factory

For a small stationary single cylinder gasoline engine of 200 cc the factory "27. mart" has provided a newly designed piston, which was presented to AVL for comment. AVL approved the general concept but recommended some minor design changes.

4. Telephone consultation in the time frame January to June 1984

In this time frame various consultation subjects were treated by telephone conversations. Some of these conversations resulted also in written statements (letter). Since these letters were all written in German their content will be summarized below.

a) Measurement of ignition energy

A literature research was made and several pamphlets were submitted concerning the inductive measurement of ignition current and capacitive measurement of ignition voltage.

b) Assessment of performance of spark plugs

The required ignition voltage is dependent on

- distance of electrodes
- electrode material
- electrode shape
- mixture conditions (charge motion)
- temperature

By this an assessment of performance of spark plugs is feasible (same order as above):

- electrode burning-off
- aging of electrode material
- access of air-fuel mixture to electrode gap
- lean mixtures have higher ignition voltage required and hence increased electrode burning
- The temperature of the spark-plug is dependent on the heat rating

Most of the manufacturers apply empirical methods for the evaluation of spark plug performance, this means that spark plugs have to be tested under various conditions like cold start, full-load-rated speed, etc. Also with respect to this topic, a literature research was made and several publications of spark-plug manufacturers were collected and submitted to IZM.

c) As far as available AVL will submit drawings of pistons of gasoline engines currently under production

d) Consultation on computer software:

AVL presents their own computer programs and informs on programs available on the market.

5. Consultation visit of Dr. R. Rankl (AVL) in "Project Area" on June 27, 1984

The installation of the swirl chamber engine IMR M34/V, 64 hp, 2600 rpm on the test bed at IZM/Novi Sad was completed. This engine will be equipped with pistons, piston rings and cylinder liners produced by the company "27. Mart" for performing homologation tests. The visit of AVL personnel was intended for the check of the test bed set up, to consult on test bed routine and to supervise the first test runs.

The air-flow will be measured by an orifice and the fuel flow by a simple flow meter. Already installed were also the pressure probe for the measurement of transient pressure in the combustion chamber and a probe for the measurement of needle lift in the injector.

For recording the most important performance characteristics the following measurement equipment is still missing:

- smoke meter
- thermo-couples for exhaust temperature measurement
- probes for measurement of oil and water temperature.

It was further recommended to measure the intake-manifold-pressure in order to take account of the pressure loss caused by the orifice used for the air flow measurement and also the exhaust back pressure which could be rather high because of long exhaust system, designed without plenum.

The pressure drop over the orifice for the air flow measurements should be rather performed by a water gauge. The pressure pick-up currently used is very sensitive and follows every pressure pulse so that a reliable reading of the mean value is impossible.

The flow meter used for the measurement of fuel flow seems to be rather inaccurate. AVL recommend the use of a simple Seppeler-meter.

The needle lift probe used by IZM was delivered by AVL. It showed only weak signals. The reason for this defect could not be found. It was therefore decided to check the probe by AVL.

IZM will complete and revise the test bed equipment as recommended by AVL and start already the first test runs. It was decided that a staff member of IZM will visit AVL in the next future for advice on the operation of the measurement equipment as used on engine test beds and information on the test routine.

The next (third visit) of AVL personnel to the project area will be made when the first 50 hours-test run of the homologation test will be completed.

6. Consultation visit of Mr. B. Schukoff (AVL) in "Project Area" on Nov. 19 and 20, 1984 (third and last visit)

As agreed, this visit was payed after the first 50-hours test run of the IMR M 34/V engine equipped with pistons, piston rings and cylinder liners manufactured by the "27. Mart" factory was completet (see point 5.) Although only one-day visits were forseen in the contract, the last visit to the project area was extended to two days because of the many items to be discussed. The additional time spent was

deducted from the commitment of man-hours of home office services.

IZM has performed the test runs according to the following test cycle:

- 1 hour of full load at the rated speed of 2400 rpm
- 5 minutes of low idle at 900 rpm
- this cycle is repeated 4 times
- 10 minutes low idle
- full-load curve over speed
- measurement of lube-oil consumption.

This scheme is repeated until 50 operation hours are accumulated.

The ring pack consisted of

- 1st groove: 2.4 mm keystone ring chrome plated
- 2nd groove: 2.4 mm rectangular ring
- 3rd groove: 3.1 mm ring with scraper edge
- 4th groove: 6.3 mm spring loaded oil ring
- 5th groove: standard oil ring

The blow-by at full load and rated speed was measured as 0.83 percent of the intake air. At an engine speed of 1800 rpm 1.5 percent and at 1000 rpm 1.3 percent were measured. These values are normal.

For the visit the engine was already dismantled and a complete visual inspection of all engine components with respect to wear was performed and commented by Mr. Schukoff. In essence the inspection of the pistons and liners as the most important parts for the homologation showed the following results:

piston # 1 - piston (rod) alignment apparently not adequate
- ring grooves only slightly coked
- no bearing trace at ends of chrome plated key-
stone ring (about 1.5 mm) because of chamfer
- all other piston rings in order
- lower surface of piston crown not colored
- cylinder liner in order

piston # 2 - piston alignment fairly good
- ring grooves only slightly coked
- chrome plated ring does not bear at ring ends
(as cyl. # 1)
- all other piston rings in order
- cylinder liner in order

piston # 3 - piston alignment not adequate
- ring grooves only slightly coked
- all piston rings in order
- cylinder liner in order

piston # 4 - piston alignment fairly good
- ring grooves only slightly coked
- all piston rings in order
- cylinder liner in order

It was proposed to measure the gap between ring ends before the engine is assembled in order to obtain information on wear.

**7. Visit of Mr. H. Ličen, Mr. M. Dozet and Mr. S. Radišić to
Graz on Dec. 3, 1984**

This last visit was used to discuss further problems of instrumentation (test bed equipment) and measurement routine.

The needle lift transducer as delivered by AVL to IZM which seemed to work not satisfactorily was completely checked and found o.k. IZM was advised in detail on the use of this equipment.

Mr. Raliscic stayed at AVL for 4 days for a special test bed training. All necessary equipment for test bed measurement of fuel consumption, smoke, power, temperature, gaseous emissions, pressures, air flow, engine speed, etc. were explained and demonstrated. A description of the test bed procedure was handed over.

CONCLUSION

Today, IZM is in the position to perform testing of engines. However, there is still some important measurement equipment missing or is too unreliable for accurate measurements imperative for homologation procedures of engine components. This missing equipment consists in essence of instrumentation for the measurement of

- exhaust smoke
- fuel consumption
- exhaust gas temperature
- oil and water temperature
- oil consumption
- vibration

However, besides the provision of measurement equipment AVL also recommends to continue the consultation of the Institute of Mechanization in Novi Sad in the future. The problem is that engine testing, development work of engines or engine components and finally homologation of engine components require a very extensive experience, which can be provided by a consultant.