APPLICABILITY OF DIAPHRAGM PUMPS IN SPRAYING MACHINES

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Preface

The Debrecen plant of the Budapest Agricultural Machine Factory (in short BMG) produces a large number of plant protection machines. The factory carries on considerable development work to meet the steadily increasing demands of agriculture.

Invited by BMG, the Department of Agricultural Machinery of the Technical University, Budapest has recently joined the work of research and development, including experiments on 2 and 3 cylinder piston pumps carried on in 1967.

In recent years the Department had the opportunity to examine diaphragm pumps of foreign make (Italian, French). Since the two types of pumps are identically applied on spraying machines, the question arose which of the two was better suited to meet the increasing demand?

1. Previous research results

Since both pump types belong to the same group of reciprocating pumps, with known working principle and operational characteristics, we abstain from quoting the relevant — rather bulky — literature.

WEBER [1] proposes the use of diaphragm pumps to handle contaminated liquids, likely to attack the packings and wear out the components; besides, seepage rapidly reduces the efficiency.

The use of pumps on spraying machines is bound to the following criteria:

— a working pressure of the fluid between 10 and 60 kp/cm^2 (at the given nominal discharge);

— a working rpm permitting the pump to be economically driven by a standard 540 rpm power take-off without gearing;

— small bulk and a degree of safety as specified by the user.

It may be of interest that several factories abroad (Carpi in Italy, Caruelle in France, etc.) have begun the production of diaphragm pumps for plant protecting purposes, but no detailed information (curves etc.) is as yet available on their performance.

2. Theoretical considerations

The pump types and their characteristics being generally known, here the desired pressure of the liquid will be considered. Fig. 1 has been plotted from measurement data on a diaphragm pump with 120 dm³/min rated

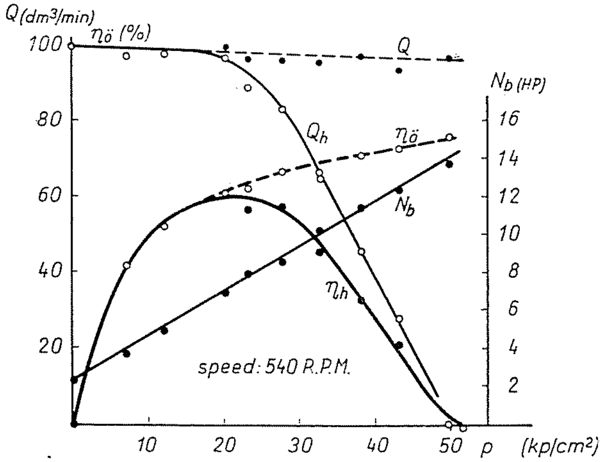

Fig. 1. Characteristic curves for a 120 dm³/min-capacity diaphragm pump

discharge operated in its original setting, as supplied by the manufacturer.

The indispensable safety valve is seen to be active at pressures increasing from approximately 20 kp/cm², to return a steadily increasing amount of liquid into the tank, until at about 51 kp/cm², there is no water delivery in the force pipe any more and the entire quantity returns via the safety valve. The manufacturers rated the maximum pump pressure at 60 kp/cm².

The requirements for the pump operation are clearly defined: to maintain the set pressure even if the needed discharge varies. This, however, is feasible only with a steep cut-off curve (slope of the water volume curve Q_h). Since the slope of the given characteristic curve is in the pressure range of 20 to 50 kp/cm², the pump falls short of the requirement.

Thus, irrespective of the high pump efficiency related to total discharge, the maximum efficiency in spraying operation is not higher than the value corresponding to the pressure releasing the safety valve. (At the represented pressure of 20 kp/cm², there is only 62, instead of 77 per cent overall efficiency.) In the given setting, the pump will operate economically in the pressure range 18 to 25 kp/cm² at an approximately 60 per cent overall efficiency.

The curve slope due to the safety valve can be varied by varying the characteristics of the valve spring. The pretensioning of the spring may also be useful. In the pump tested, the pretensioning of the spring with a 3 mm washer made the safety valve not to be released below a pressure of 32 kp/cm^2, hence the overall efficiency in the given pressure range increased to approximately 70 per cent.

According to the above, the users' *requirements* for the pressure may be formulated as follows:

— facilities should be provided to adjust and fix the pressure on the safety valve in steps of 5 kp/cm^2 in the 20 to 40 kp/cm^2 range;

— the pump should be structuraly safe in operation up to 60 kp/cm^2 pressure;

— the safety valve should be so constructed that a 20 kp/cm^2 pressure rise causes full opening, return of the entire liquid quantity.

3. Test Methods

In conformity with the pertient regulations, tests were carried out on an electric test bench. The following characteristics were measured:

Q_h the useful water discharge in dm^3/min
Q total discharge (including the volume returned via the safety valve) in dm^3/min
p the total lift, i.e. the pressure behind the pump, in kp/cm^2
n_s the pump rate in l/min
n_m the rate of the balance dynamo in l/min
G the equilibrium mass on the balance dynamo in kgs.

Characteristics calculated from the measured data (using common formulae):

N_b the horse power required to drive the pump in HP
N_h the useful water horse power of the pump (on the basis of Q_h) in HP
$N_ö$ the overall water horsepower of the pump (on the basis of Q) in HP
η_h the useful overall efficiency of the pump (based on N_h) in %
$\eta_ö$ the overall pump efficiency (based on $N_ö$) in %

From the obtained characteristics the curves already shown in Fig. 1 can be plotted (for a $n_s = 540$/min = const.).

4. Results and evaluation

Since this articles does not aim at selecting actual pump types, we shall not present the findings of tests on each type of pump.

As an example, Fig. 2 illustrates the curves for 2 and 3-cylinder piston pumps based on our measurements in 1967, according to GERENCSÉR [2].

For nominal pump rates of $n_s = 325$, and 335/min, pressures of 25 to 35 kp/cm² and an overall efficiency of about 70 per cent resulted.

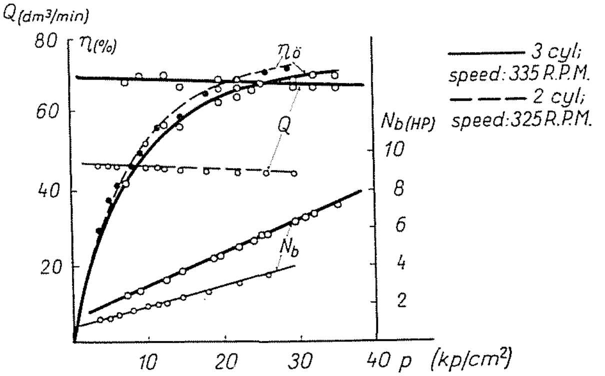

Fig. 2. Characteristic curves for piston pumps

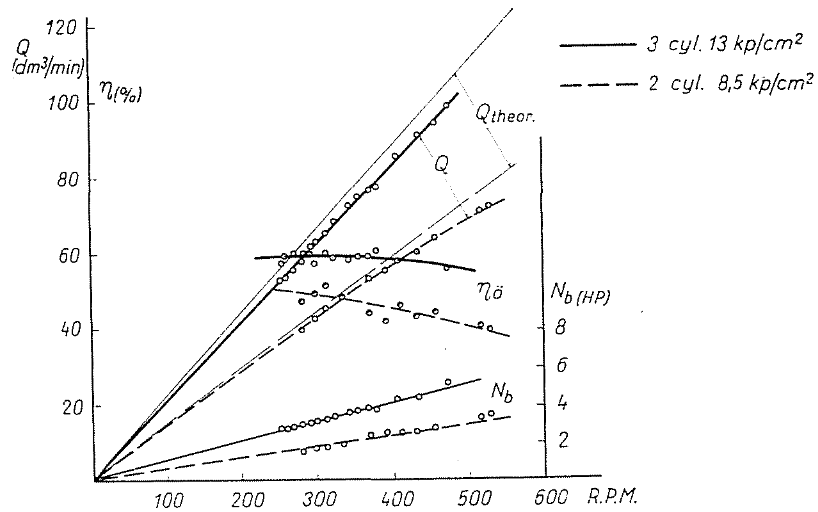

Fig. 3. Variation of characteristics of piston pumps vs. rpm.

Fig. 3 shows the characteristics of the same two pumps vs. rate pointing out the rising trend of volume losses and the effect of higher pressures upon the overall efficiency.

From the results of the tests carried out on diaphragm pumps in 1970, the following deserve interest:

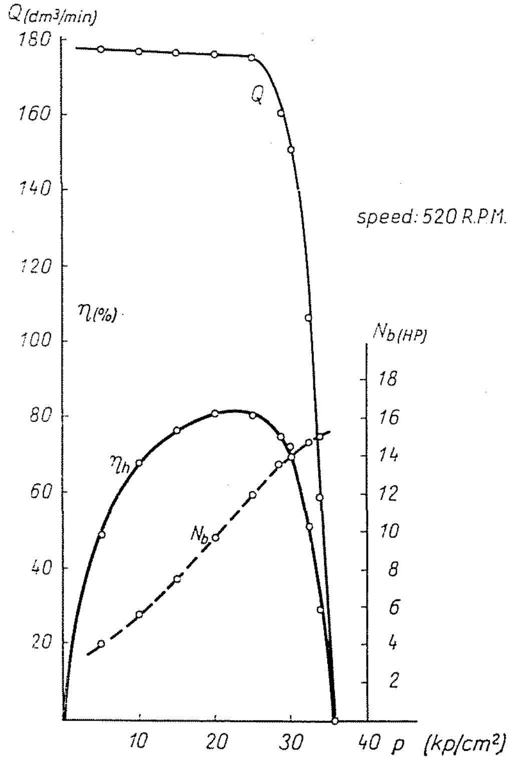

Fig. 4. Characteristic curves for a 180 dm³/min-capacity diaphragm pump of French make

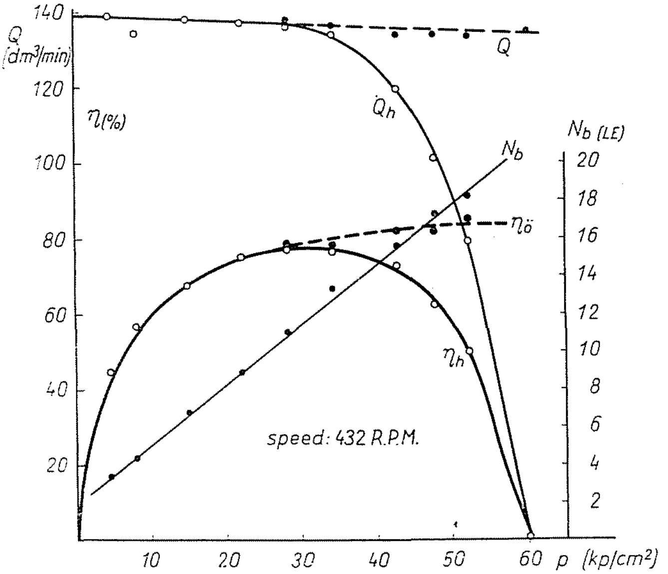

Fig. 5. Characteristic curves for a 180 dm³/min-capacity diaphragm pump of Italian make

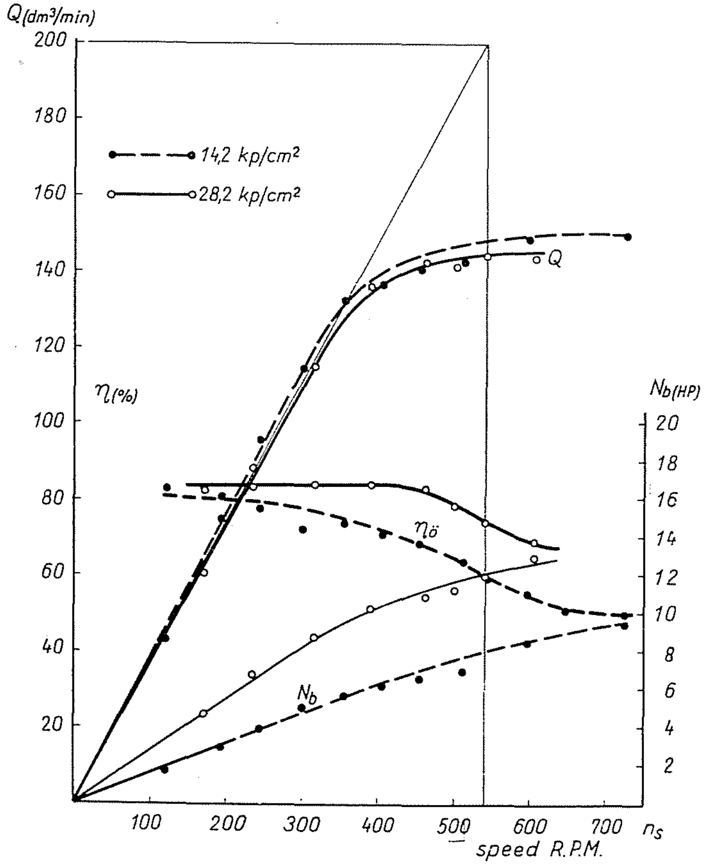

Fig. 6. Characteristics of the 180 dm³/min-capacity Italian diaphragm pump vs. rpm.

From a report by SITKEI and ZALKA [3], the curves recorded at $n_s =$ $= 520$/min of French diaphragm pumps in the original setting are shown in Fig. 4.

According to 1970 tests, characteristic curves for a pump of 180 dm³/min discharge (Italian make) and its characteristics recorded as a function of the pump rate n_s are shown in Figs 5 and 6, respectively, leading to the following conclusions:

— the characteristic curves of the diaphragm pumps are up to expectations, and so are the curves of piston pumps;

— the volume losses of diaphragm pumps abruptly increase onwards from a rate of $n_s = 300$/min;

— while the overall efficiency of the tested piston pumps cannot exceed a maximum of 70 per cent, diaphragm pumps can exhibit efficiencies of 75 to 80 per cent even at 540/min rate and above 20 kp/cm² pressure;

— water discharges are not appreciably increased by rising the rate above 350/min in piston pumps because of volume losses.

Conclusions

On the basis of the examinations, the following facts have been established for the tested pumps:

— optimum efficiencies resulted at 300 to 350/min pump rates (also for diaphragm pumps);

— increasing the rate (up to 540/min) involves considerable volume loses, and impairs the overall efficiency;

— fatigue tests have shown that the safety of diaphragm pumps can be maintained at an acceptable level;

— the efficiency to weight ratios are more favourable with diaphragm than with piston pumps.

Summary

Based on several years' tests on the main structural parts of spraying machines, an account is given of the findings on piston and diaphragm pumps, such as: at about a range 350 rpm diaphragm pumps are more economical to operate than piston pumps; at a rate of 540 rpm the efficiency of diaphragm pumps is not superior to the efficiency of piston pumps operating at a rate of 325 rpm; with a suitable safety valve, diaphragm pumps can yield the desired pressures; and all that at lower weight than that of piston pumps.

Thus, diaphragm pumps can replace piston pumps in every respect (assuming appropriate construction and safety). The optimum efficiency of diaphragm pumps ranges from 300 to 400 rpm, higher than for piston types.

References

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2. GERENCSÉR, A.: Report on Tests on the Working Parts of the RS. Spraying Machine Family Manuscript, Budapest, 1967.
3. SITKEI, G.—ZALKA, A.: Examination of French Diaphragm Pumps* Manuscript, Budapest, 1970.

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* In Hungarian.