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SUBJECT: HIGH PRESSURE EJECTOR TEST
TO: I. Spiewak
FROM: B. A. Hannaford

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SUMMARY

A commercial jet ejector was operated over a range of pressures up to 1500 psi to determine its characteristics. The purpose of the test was to establish head-capacity and efficiency curves to serve as a guide in sizing much larger jets for high pressure applications. Presumably, larger jets would have similar characteristics except for flow rate.

Water, circulated by a canned-rotor pump, was the motive fluid; the driven fluid was nitrogen gas. All tests were run at room temperature.

It should be emphasized that wherever gas flow rate is mentioned, "cfm" refers to the volume flow rate measured at the stated temperature and pressure.

Both gas head and efficiency varied directly with system pressure up to 1000 psi and dropped slightly at 1500 psi. The optimum operating point was not reached, but efficiencies of approximately 25 per cent were attained at 1000-1500 psi. The ejector appears attractive as a simple and efficient device for pumping gas at high pressure.

TEST DESCRIPTION

Figure 1 is a photograph of the loop built for this experiment. An ORNL 5 gpm pump circulated water through the jet and back into the separator tank. Nitrogen in the separator tank traveled through one or both high pressure rotameters to the jet suction. Resistance in the gas circuit was varied by means of the valves below the rotameters. Water flow was varied by manual setting of the air-operated throttling valve.

Values measured directly were:

1. System pressure
2. System temperature
3. Water flow rate, M
4. Nitrogen flow rate, V_g

5. Pressure differential between jet inlet and outlet, ΔP_1
6. Pressure differential between jet suction and outlet, ΔP_g

Flow rate curves for the gas rotameters were calculated for all test pressures. A limited number of rotameter calibrations were made indicating a pronounced divergence from the calculated values at the lower flow rates. Since the calibrations were questionable, all results are based on the calculated gas flows. This results in conservative efficiencies.

RESULTS

Figure 2 is a plot of gas head, ΔP_g versus capacity for a range of pressures.

Efficiency is defined as: $E = \frac{V_g \Delta P_g}{Z \Delta P_1}$, where "Z" is the compressibility factor for the gas. Other terms are defined above; all terms in consistent units.

Efficiency versus gas flow rate, Figure 3, illustrates the considerable effect of pressure upon jet efficiency.

Figure 4, efficiency versus water flow rate, demonstrates that efficiency changes rapidly with change in water flow rate. It is apparent that the optimum operating point was not reached and that maximum efficiency might have gone to 30 per cent, had a higher water flow rate been possible. The dip in efficiency at approximately 6 gpm is a direct result of lower gas head at this point. The same effect appears in lower parameters; these were not included on this plot because a different rotameter and gas throttling valve position were used in obtaining data. The reason for this behavior has not been determined.

Gas flow rate varied in a straight-line relationship with water flow for a given pressure.

Figure 5, a plot of system pressure versus gas flow rate for two different water flow rates, indicates that gas flow rate varies inversely as P_{log} . The data fit the equation $P = 38,600 \times 10^{-1.653} V_g$ at a water flow rate of 6.9 gpm. However, at pressures much below 250 psia, the data diverge radically from this equation.

APPENDIX

Jet Ejector Description

Manufacturer's Identification	Penberthy 758
Connections	1-in. IPS, all ports
ORNL Specifications	
Water head available	39 feet
Water density	50 lb/ft ³
Water flow	5-10 gpm
Gas density at design conditions	1.5 lb/ft ³
Gas flow	0.5 cfm at operating conditions
Desired head to be developed	288 ft. of gas (3 psi)
Operating pressure	1000 psi
Operating temperature	250°C.

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FIGURE 1. HIGH PRESSURE EJECTOR TEST LOOP

Figure 2. Gas Head vs. Gas Flow Rate

Figure 2. Jet Efficiency vs. Nitrogen Flow Rate.

Figure 4. Jet Efficiency vs. Water Flow Rate

SYSTEM PRESSURE, psia

1,000

10,000

100

20

3

Gas Circuit Constant

Temperature = 80°F

NITROGEN FLOW RATE (V_g), cfm

Figure 5. System Pressure vs. Nitrogen Flow Rate.

Symbol	Water Flow Rate
Δ	5.0 gpm
$\odot$	6.9 gpm