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NASA TECH BRIEF

Twin-Spool Turbopumps for "Low" Net Positive Suction Pressure Operations

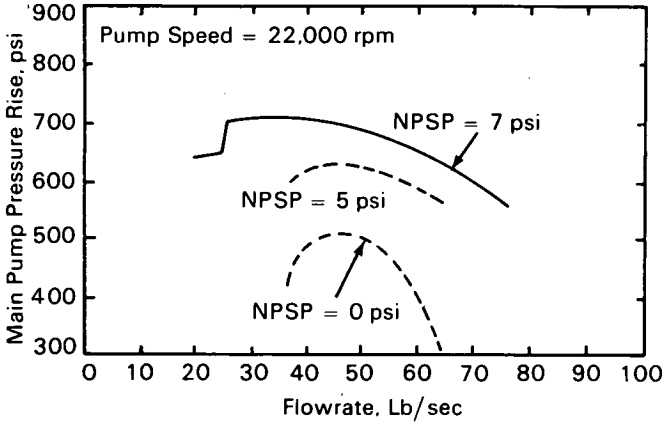

Figure 1. Effect of NPSP on Single-Spool Turbopump Performance

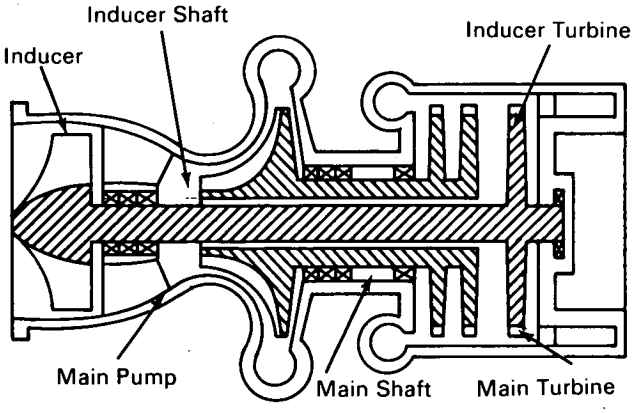

Figure 2. Twin-Spool Turbopump Schematic

The problem:

Rocket engine turbopumps capable of operating at low to zero net positive suction pressure (NPSP) would improve rocket engine performance and reliability. Specifically, the need to pressurize propellant storage tanks could be at least simplified or possibly eliminated. [NPSP is the margin by which total pressure in the pumped fluid exceeds its vapor (saturation) pressure, as measured in the supply tank. Low or zero NPSP is achieved when the absolute pressure in the supply tank approaches or equals the saturation pressure of the fluid.] Figure 1 indicates the reduction in performance of a conventional single-spool turbopump as the NPSP is reduced to zero.

The solution:

A separately driven low-speed inducer, capable of handling the pumped fluid at low NPSP and raising its pressure to an adequate NPSP before it is ingested by the main-pump inlet, is employed. The twin-spool turbopump, Figure 2, incorporates the inducer and a main pump, each separately driven at different speeds through a coaxial-shaft arrangement. The inducer can operate at low speed for low NPSP, and the main pump can operate at high speed to generate high pressure. This arrangement results in a minimal envelope and requires no external control for the inducer.

How it's done:

The twin-spool turbopump is a modification of a single-shaft turbopump in which a centrifugal pump is driven by a two-stage impulse turbine. The single-shaft turbopump is modified to add an in-line, low-speed inducer immediately upstream of the main pump inlet, and an inducer drive turbine immediately downstream of the main turbine, with the inducer drive turbine extracting its power from the main turbine exhaust. The inducer and the inducer drive turbine are mechanically connected by a shaft that is coaxial

(continued overleaf)

with the hollow shaft connecting the main pump and the main turbine. Both the inducer and the main stages are supported by their own rolling-element bearings.

A twin-spool hydrogen turbopump for pumping liquid hydrogen at zero NPSP has been developed and tested. This turbopump operates satisfactorily over its entire operating range with zero NPSP at the inlet of the low speed inducer. The stall margin of the pump does not drop when the pump is operated at low positive suction pressures. The twin-spool turbopump makes the fuel system pressure rise insensitive to variations in tank pressure, thus hydrodynamically decoupling the tank from the engine.

Notes:

1. The twin-spool turbopump can be used in pumping applications where low NPSP is desired.
2. A computer program which accurately predicts both steady-state and transient operating characteristics of the twin-spool hydrogen turbopump has been developed. This computer program is available from: COSMIC, Barrow Hall, University of Georgia, Athens, Georgia 30601. Reference: LEW-11079.
3. The following documentation may be obtained from:

   National Technical Information Service
   Springfield, Virginia 22151
   Single document price $3.00
   (or microfiche $0.65)

   Reference:
   NASA-CR-72540 (N69-36246), Investigation of Twin-Spool Turbopump Performance
4. Technical questions may be directed to:

   Technology Utilization Officer
   Lewis Research Center
   21000 Brookpark Road
   Cleveland, Ohio 44135
   Reference: TSP70-10671

Patent status:

No patent action is contemplated by NASA.

Source: O. I. Ford, W. E. Campbell and E. K. Bair of Aerojet-General Corp. under contract to Lewis Research Center (LEW-11105)