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Program for Calculating Total-Efficiency of Specific-Speed Characteristics of Centrifugal Compressors

A computer program has been developed for predicting design point specific speed efficiency characteristics of centrifugal compressors.

Compressor efficiency has been shown to be a function of specific speed. Specific speed is a characteristic that relates compressor inlet volume flow rate, rotation speed, and ideal enthalpy rise. Generally, high efficiencies are associated with high specific speeds, and low efficiencies are associated with low specific speeds. Compressor design point geometries that produce maximum attainable efficiency are also functions of specific speed. Knowing the variation in optimum design point geometric variables with specific speed permits rapid selection of high efficiency configurations.

This computer program uses a one-dimensional mean streamline analysis conducted at fixed stagnation conditions. Seven specific losses are calculated for each set of compressor geometric variables and inlet velocity diagram characteristics studied. These are inlet guide vane, blade loading, skin friction, disk friction, recirculation, vaneless diffuser, and vaned diffuser losses. Each of these individual losses is expressed as a decrement in compressor total efficiency. The effect of these losses is then related to overall compressor performance and specific speed. By examining the program output, the user can select values of inducer hub-tip diameter ratio, inducer tip-exit diameter ratio, impeller blade exit backsweep, impeller exit blade height-diameter ratio, and impeller exit absolute flow angle that will result in maximum total efficiency for the chosen application.

For given inlet stagnation conditions, the user can generate efficiency, pressure ratio, specific speed, and relative loss distribution data corresponding to various combinations of impeller inlet velocity diagram characteristics and impeller overall geometries. By examining the output data, a compressor geometry can be chosen which will yield maximum efficiency under the constraints imposed.

The following categories are used as input information: (1) compressor geometry, (2) thermodynamic properties of the working fluid, (3) velocity diagram characteristics, and (4) iteration limits.

The prewhirl used in this analysis is solid-body vortex. For iterations on inducer tip absolute critical velocity ratio, the inducer tip speed is adjusted to preserve inlet velocity triangle similarity with that determined by the first pair of input inducer tip speed and inducer tip absolute critical velocity ratio. That is, the absolute and relative flow angles are held constant for successive iterations.

For each iteration, the following output information is tabulated: compressor geometry, velocity diagram characteristics and compressor performance characteristics.

The program can be used for working fluids other than air which approximate ideal gas behavior since the thermodynamic properties needed for the equations solved in the program are specified inputs. If a working fluid other than air is used in the analysis, an empirical equation expressing the dynamic viscosity as a function of temperature must be substituted.

Notes:

1. An example is included in the program documentation to demonstrate compressor geometry selection for maximum efficiency.
2. The program is written in FORTRAN IV for use on an IBM 7094 II/7044 direct couple computer.
3. Inquiries concerning this program should be directed to:

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