DESIGN STUDY OF HELIUM COMPRESSOR FOR A DIRECT CYCLE GAS COOLED NUCLEAR POWER-PLANT

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The aim of this project is to develop an optimum compressor design to be used in a helium nuclear power plant. In this nuclear plant the same helium that cools down the reactor passes through the whole turbomachinery, i.e. uses a direct cycle. The main target of the project was to optimize the efficiency. The compressor is to be used in a large power plant (around 300 Mw) and differences of 0.5% in efficiency imply tremendous energy losses. In order to optimize the compressor design, advanced aerodesign tools were used.

The initial stage of the project was a cycle analysis of various existing power plants. Following, a parametric study of the components was carried out to establish the best solution. After these preliminary studies a through-flow analysis of the flow field was made by a "streamline curvature method" program. The results of the through flow were the inputs for the next step. In this step an inverse design code, VKI in-house developed, was used to design the compressor, imposing "Controlled diffusion blades" in the design (as shown in Figure 1). The project was completed with the design of 3-D blades for each compressor (Low Pressure and High Pressure) of the power plant. The efficiency and performance of the designed blades was assessed with a 3-D Navier-Stokes solver.

It can be concluded that high efficiency blading has been developed. For the specified design conditions, the number of stages, annulus dimensions, number of blades, stagger angles, etc have been determined. A 3-D detailed flow analysis was conducted with a 3-D Navier-Stokes solver (as shown in Figure 2). Other objective that has been achieved is the through-flow code that VKI have previously used for air, have been validated for helium with a well-known 3-D Navier-Stokes solver, TRAF3D.

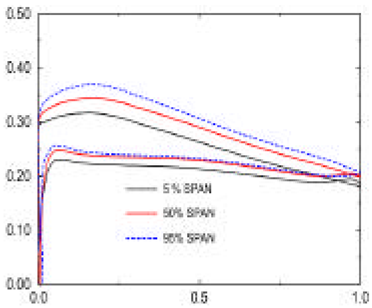

Figure 1: Mach distribution for high pressure compressor ROTOR

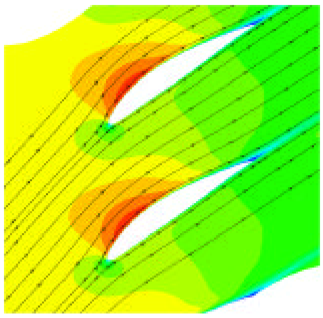

Figure 2: Iso-Mach contours & streamlines for the high pressure compressor ROTOR