THE ONERA TRANSONIC COMPRESSOR TEST FACILITY

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Abstract

The freon loop of ONERA Palaiseau Center has been modified for the experimentation, with air, of a new transonic compressor. This stage includes a rotor, the blades of which are made with carbon fibres and resin epoxy, and a stator.

The purpose of the experiments is to study the upstream flow field of the compressor, running near surge, by using various technics : unsteady pressure transducers, hot wires and laser velocimetry. Parallelly this test facility is also used for the development of a capacitive transducer for tip clearance measurement.

1 - INTRODUCTION

For about fifteen years, the Palaiseau ONERA Center is equipped with a transonic/supersonic compressor test facility. Several axial compressors and one centrifugal compressor have been tested using freon as working gas.

At the origin, this test loop made use of freon with the aim of obtaining transonic or supersonic Mach numbers with moderate speeds of rotation and without important mechanical problems. But uncertainty on the thermodynamic properties of the freon 114, used for the tests, appeared. Therefore it was decided to experiment the new compressors with air as working gas, in spite of some limitations.

2 - DESCRIPTION OF THE TEST FACILITY

The figure 1 shows a view of the air test facility which is nearly the same as the freon test facility :

- the loop circuit is the same,
- the electric motor is the same,
- the multiplier is also the same.

Only the outer casing of the test section has been adapted to the size of the compressor and to the instrumentation. On the contrary, the freon generating station, which previously allowed to run with almost pure freon, is now useless.

Table I gives the main characteristics of the test facility.

Table I

Power	:	$\leq$ 1000 kW
Speed of rotation	:	$\leq$ 12000 rpm
Upstream total pressure	:	$P_o \leq$ 1 atm
Outer diameter of the test section	:	D_o = 564 mm = c.t

When reading this table, it appears that the speed of rotation is relatively limited while the size of the test section is rather favourable to obtain peripheral velocities, lightly supersonic. Furthermore, the pressure drops in a loop may not be neglected.

It was decided to choose to test a high performances compressor with a high hub to tip ratio. This corresponds to a typical HP compressor (Figure 2).

Table II gives the main geometric and aerodynamic characteristics of the compressor (without inlet guide vane).

Table II

Outer diameter at rotor inlet	: ϕ_e =	564	mm
Inner diameter at rotor inlet	: ϕ_i =	450	mm
Hub to tip ratio	: ν #	0.80	
Number of rotor blades	:	47	
Number of stator blades	:	59	
Nominal power	: P =	902	kW
Standard mass flow	: Q_{Si} =	17	kg/s
Pressure ratio of the rotor	: π_r =	1.89	
Pressure ratio of the stage	: π_s =	1.72	
Efficiency of the rotor	: η_r =	0.935	
Efficiency of the stage	: η_s =	0.92	
Relative Mach number at hub rotor inlet	: M_{Wh} =	1.195	
Relative Mach number at tip rotor inlet	: M_{Wt} =	1.01	
Peripheral Mach number at the hub	: M_R =	1.070	

3 - RESEARCH PROGRAM

The purpose of this experimental study concerns especially the unstarted flow regime of the rotor. Since, as indicated on the figure 3 which shows a meridional section of the machine, the stator is placed about one chord downstream from the rotor. Several kinds of measurements will be possible :

- conventional measurements, by using probes and flow traverses in different sections. The purpose of these measurements is to determine the characteristic map of the compressor : pressure ration, efficiency and the mass flow which will be measured by an upstream venturi.

  Then it will be possible to compare the theoretical and the experimental performances of the compressor.

- unsteady measurements, by using wall transducers and specific probes to determine the rotor upstream flow field.

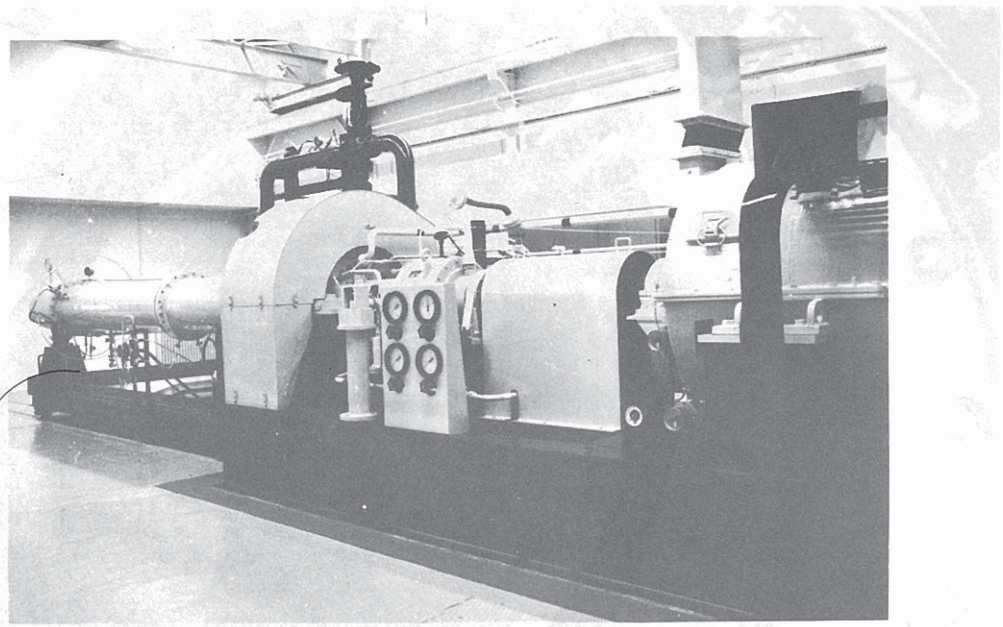
- laser velocimetry measurements, by using Doppler technic (LDA) or two focus technic (L2F).

In addition, this test facility will be used for the development of an ONERA capacitive transducer intended to measure the clearance between the blades of a rotor and the outer casing.

4 - CONCLUSION

At present, this compressor is just beginning to run, therefore there are no results available.

It will be a very useful tool for the understanding of the flow pattern in a transonic compressor and especially in unstarted flow regimes.



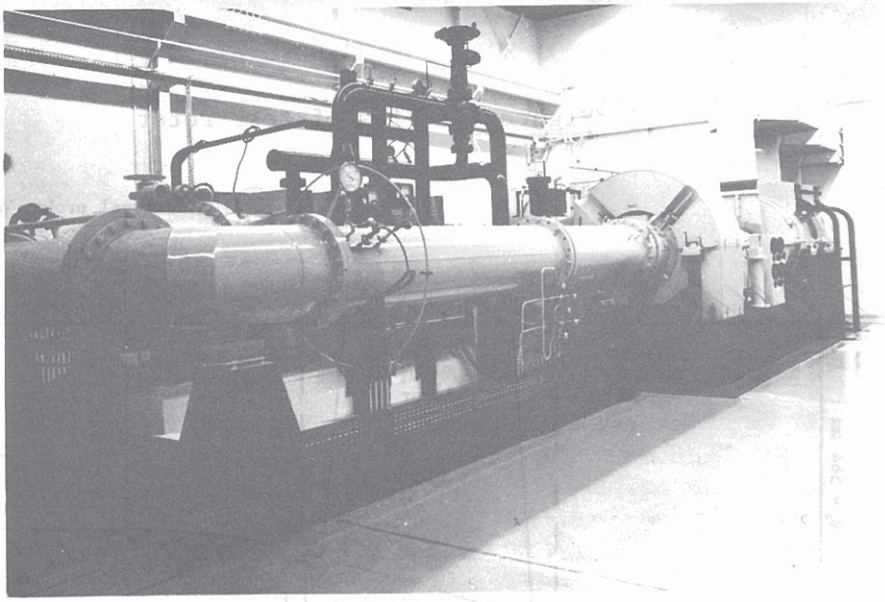


Figure 1 : View of the air test facility

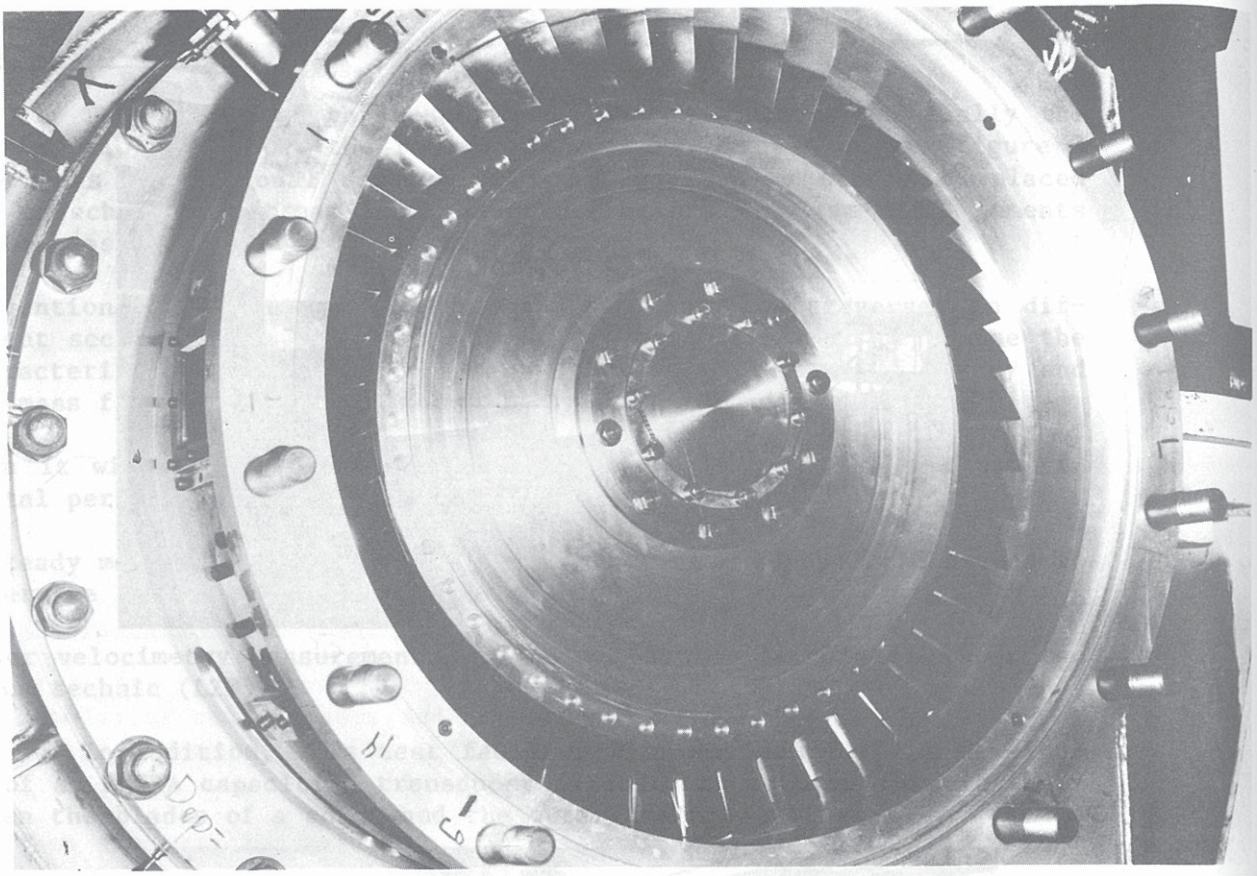


Figure 2 : View of test rotor

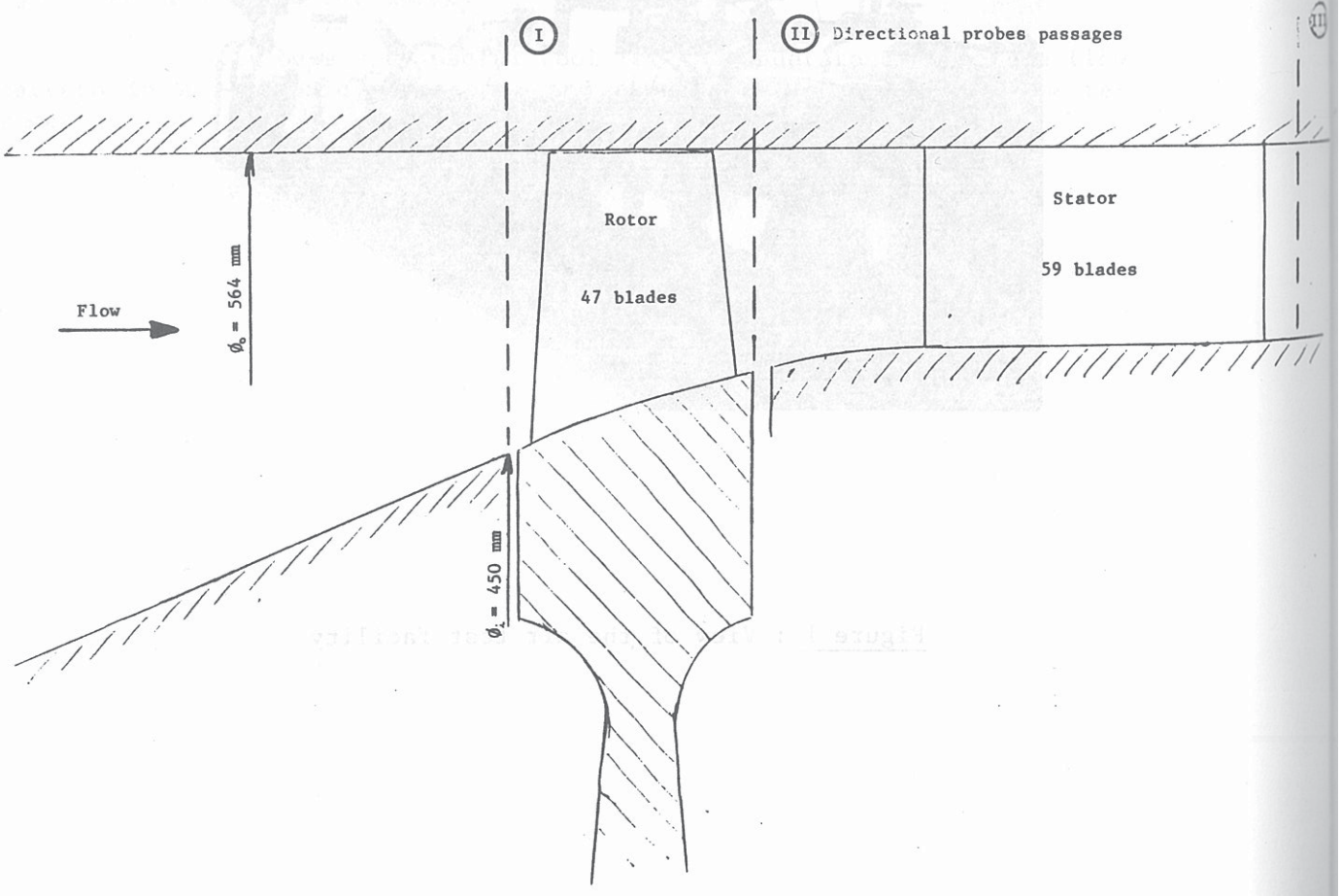


Figure 3 : Meridional section of the machine