A VIRTUAL LABORATORY FOR EDUCATION ON GAS TURBINE PRINCIPLES AND OPERATION

K. Mathioudakis[1], N. Aretakis[1], P. Kotsiopoulos[2], E. A. Yfantis[3]

[1]Laboratory of Thermal Turbomachines
National Technical University of Athens

[2]Department of Aeronautical Sciences
Hellenic Air Force Academy

[3]Department of Naval Sciences
Hellenic Naval Academy

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- **Why A Virtual Lab**
- **Computer Representation Versus Actual Gas Turbine**
- **The Virtual Lab Software**
  - **Gas Turbine Principles and Components**
  - **Design Point Analysis**
  - **Off Design Operation**
  - **Virtual Test Facilities and Exercises**
- **Further Educational Aspects-Conclusions**

Why A Virtual Lab

- ☞**New instruction methods are needed to augment the traditional teaching paradigms.**
- ☞**Rich online learning media:** supply current information, promote student's technology proficiencies.
- ☞**Traditional educational tools (textbooks, lectures, and laboratories) :** Static, not easily customized, cannot provide newest scientific information.
- ☞**Information technologies can provide with up-to-date information (Internet).**
- ☞**Computational media:** powerful to train students, the next generation of learning materials.
- ☞**For teachers:** multimedia education can help explain difficult concepts more clearly.
- ☞**True computational media should incorporate:** dynamic animations, interactivity, visual design to stimulate, challenge, and test students.

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Computer Representation Versus Actual Gas Turbine

☞**A Gas Turbine:** **engineering system comprising components performing different kinds of tasks.**

☞**Building-up knowledge on the operation of a Gas Turbine engine may be a tedious experience.**

☞**How to examine an engine's behavior?**

- ☞**to have a "test engine"**
- ☞**to observe an engine operating in the field.**
- ☞**to run a "toy engine" (an engine made for educational purposes).**

☞**With actual engines:** **expensive, long time to gather information, instruments in difficult positions.**

☞**The computer model:** **gives very easily a lot of information which would be difficult, expensive and some times even impossible to obtain on an actual engine.**

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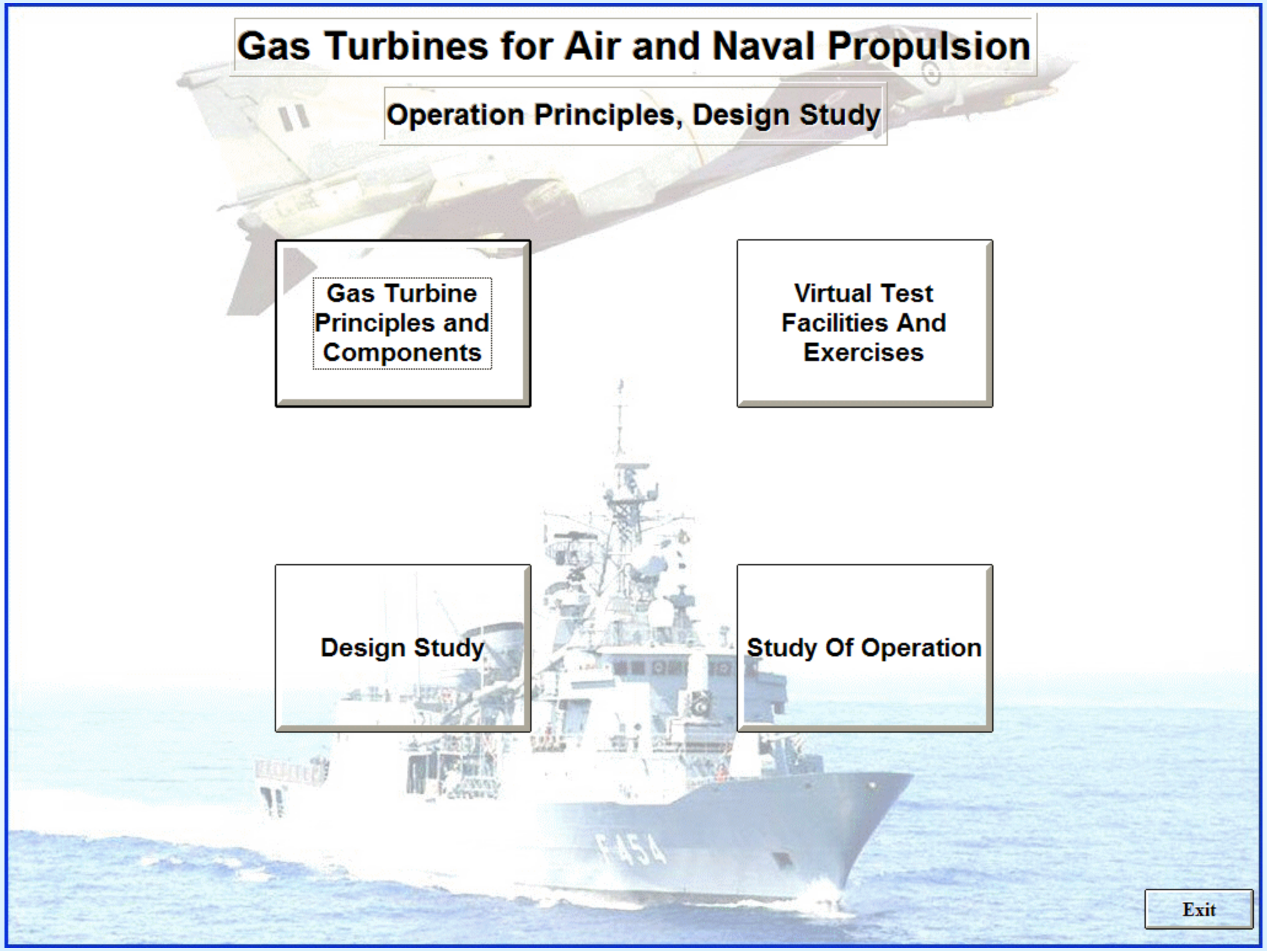
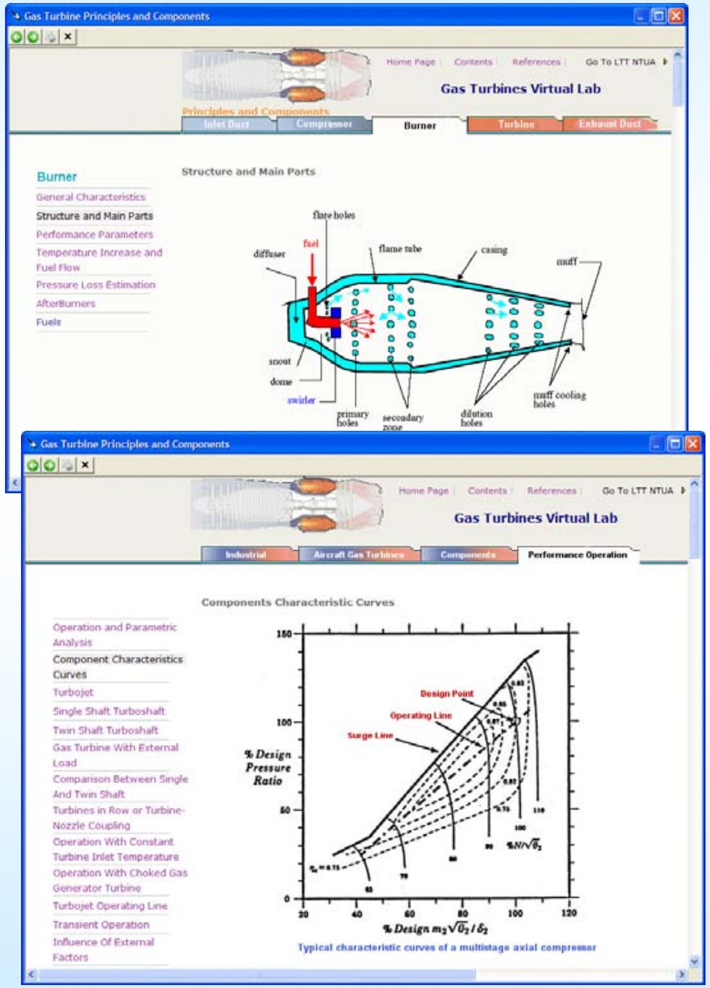
The Virtual Lab Software



The main screen of virtual lab software.

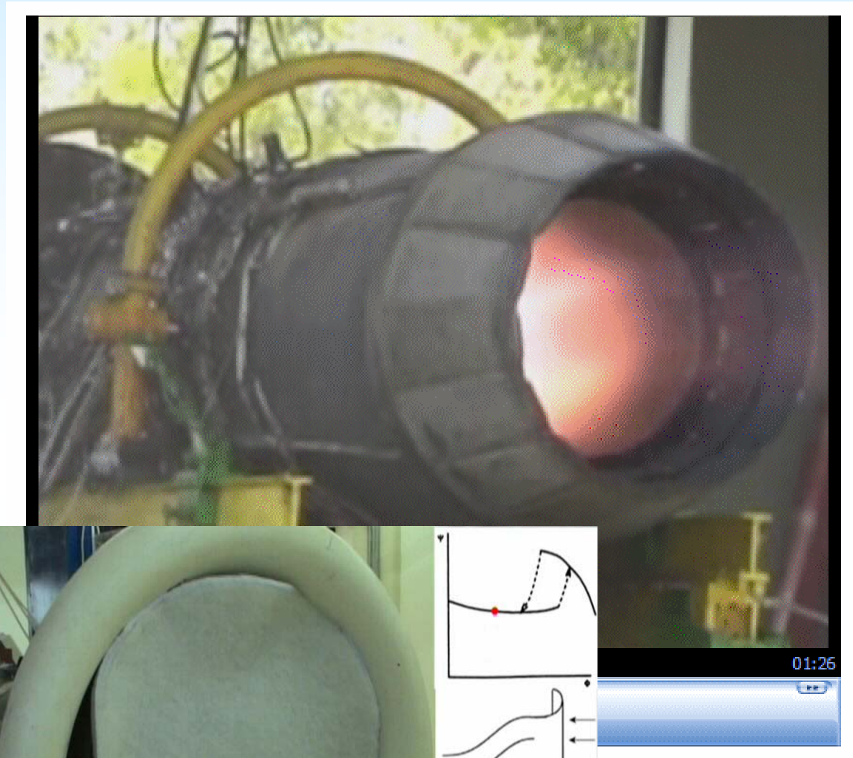
Gas Turbine Principles and Components (I)

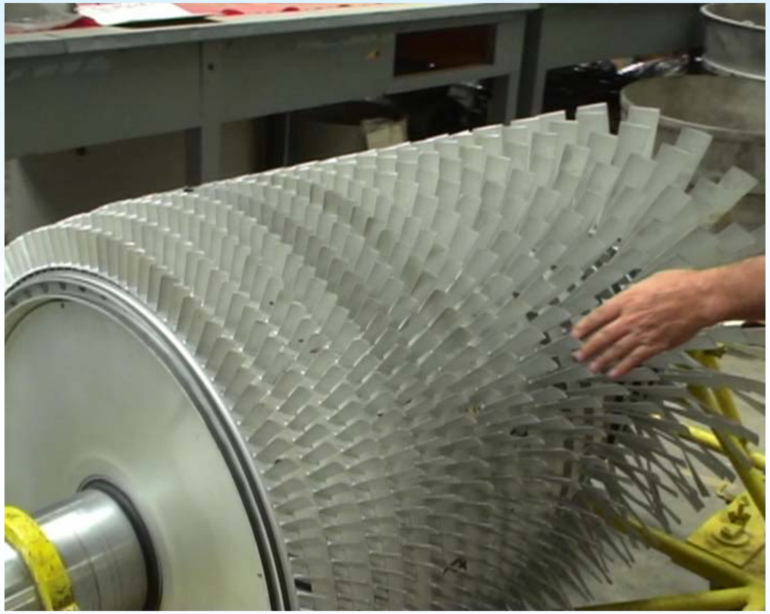


Example screens of compressor, burner and performance operation sections

Gas Turbine Principles and Components (II)

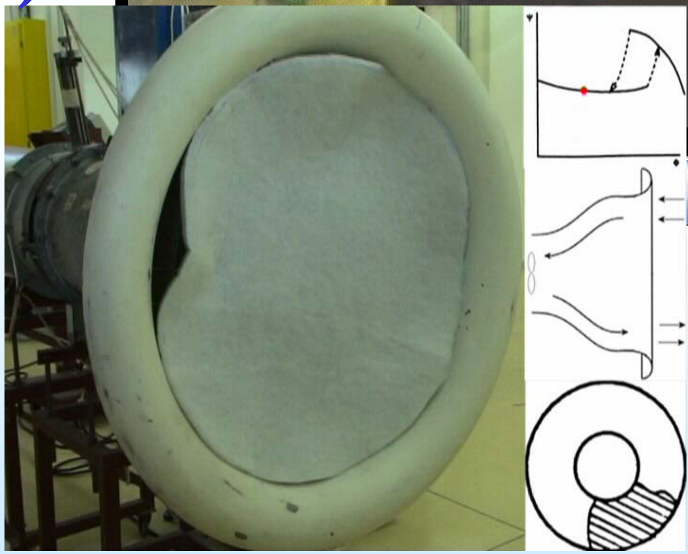
a)





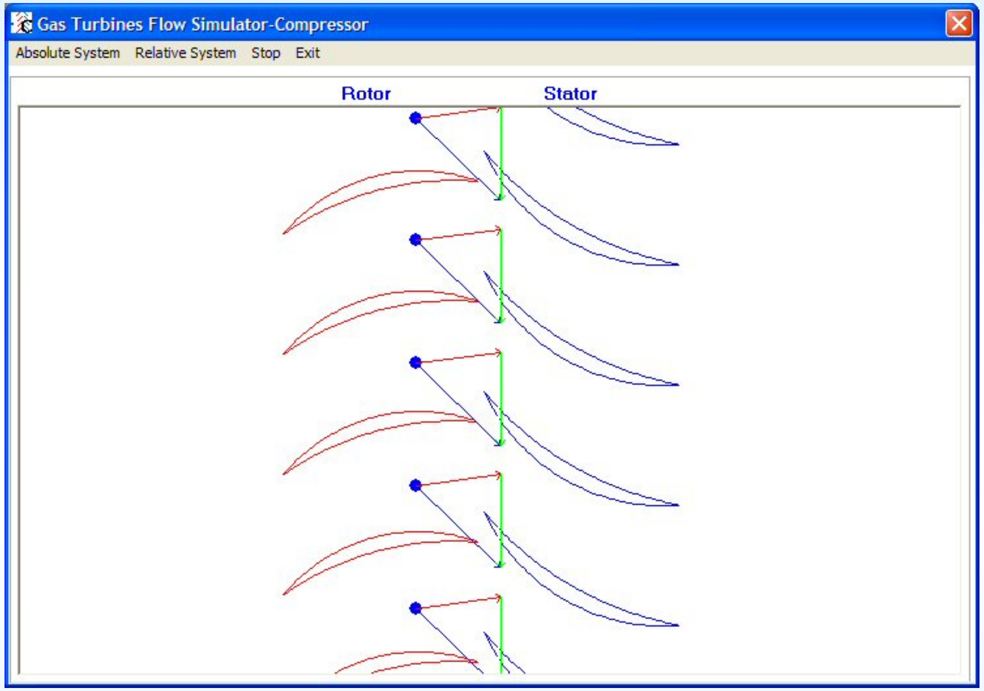
b)

c)

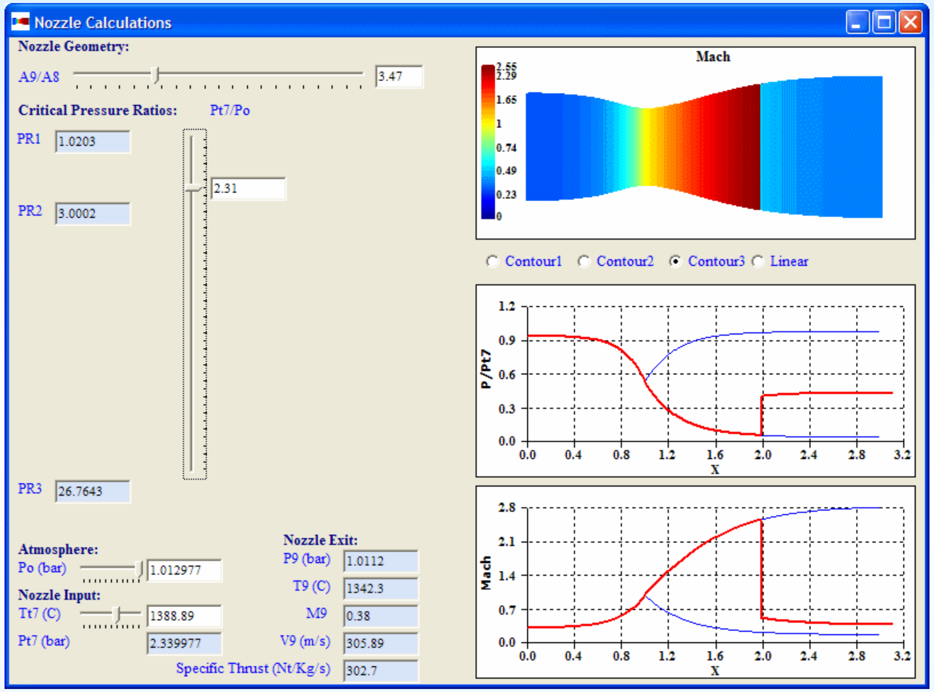


Example screen shots from videos: a) turbojet engine test b) description of a turbojet compressor c) explanation of rotating stall.

Gas Turbine Principles and Components (III)



Flow simulation program in a compressor cascade



Nozzle calculations program

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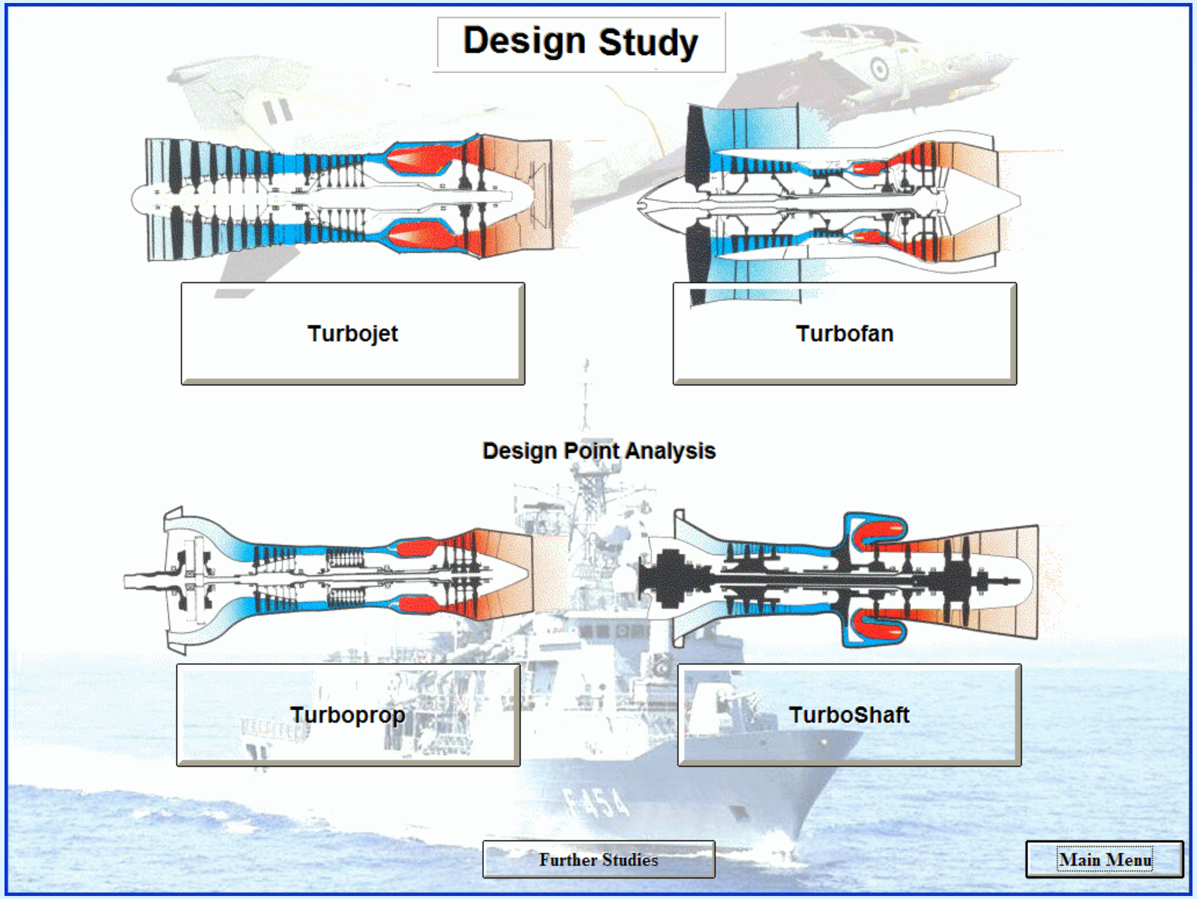
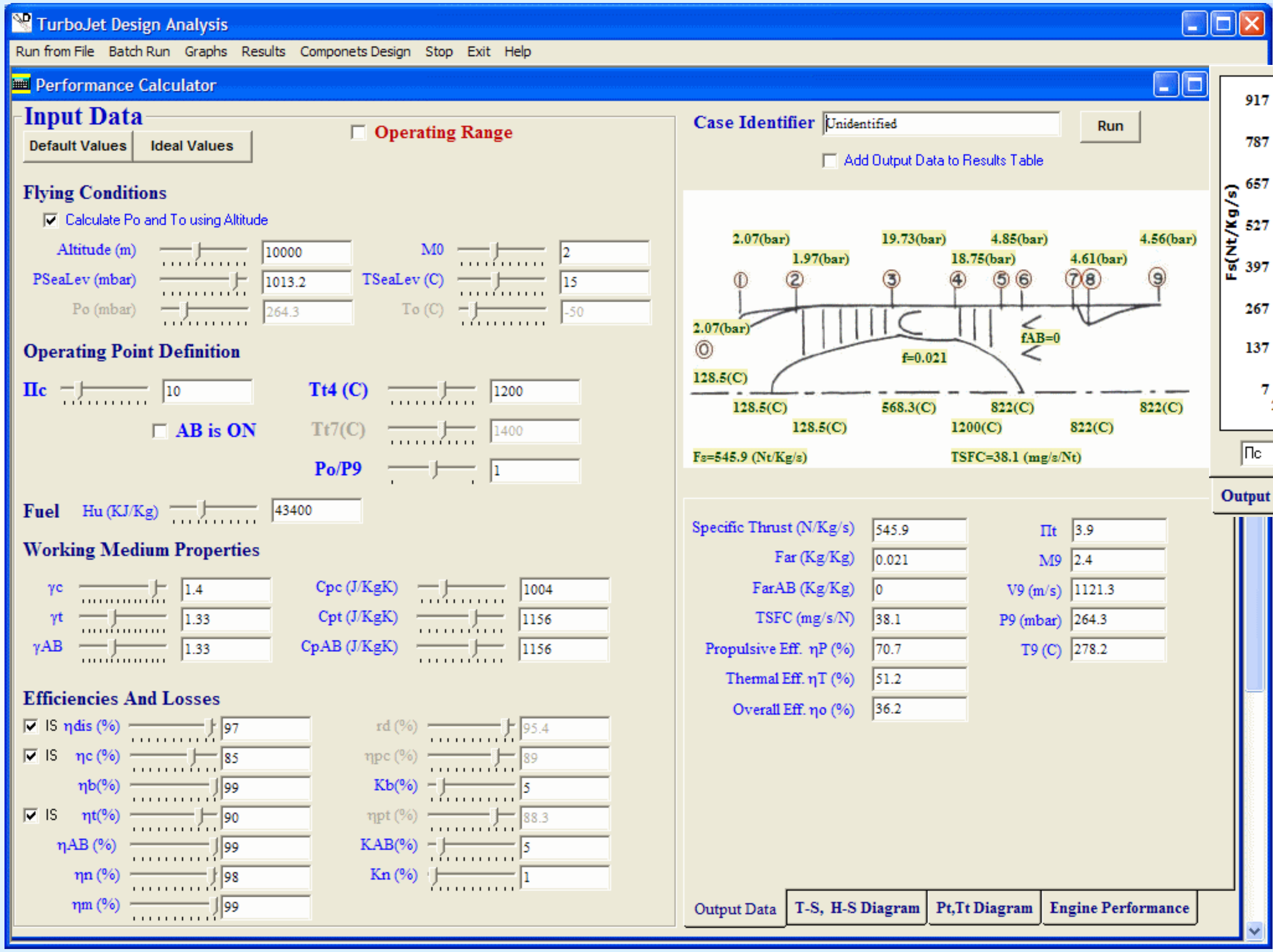
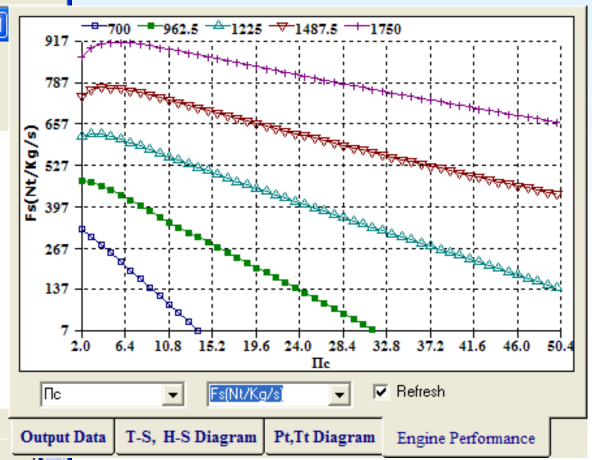
Design Point Analysis (I)



The main screen of 'Design Study' Section.

Design Point Analysis (II)





Example result (The dependence of specific thrust on compressor pressure ratio for different turbine inlet temperatures)

The main screen of Turbojet Design Analysis program

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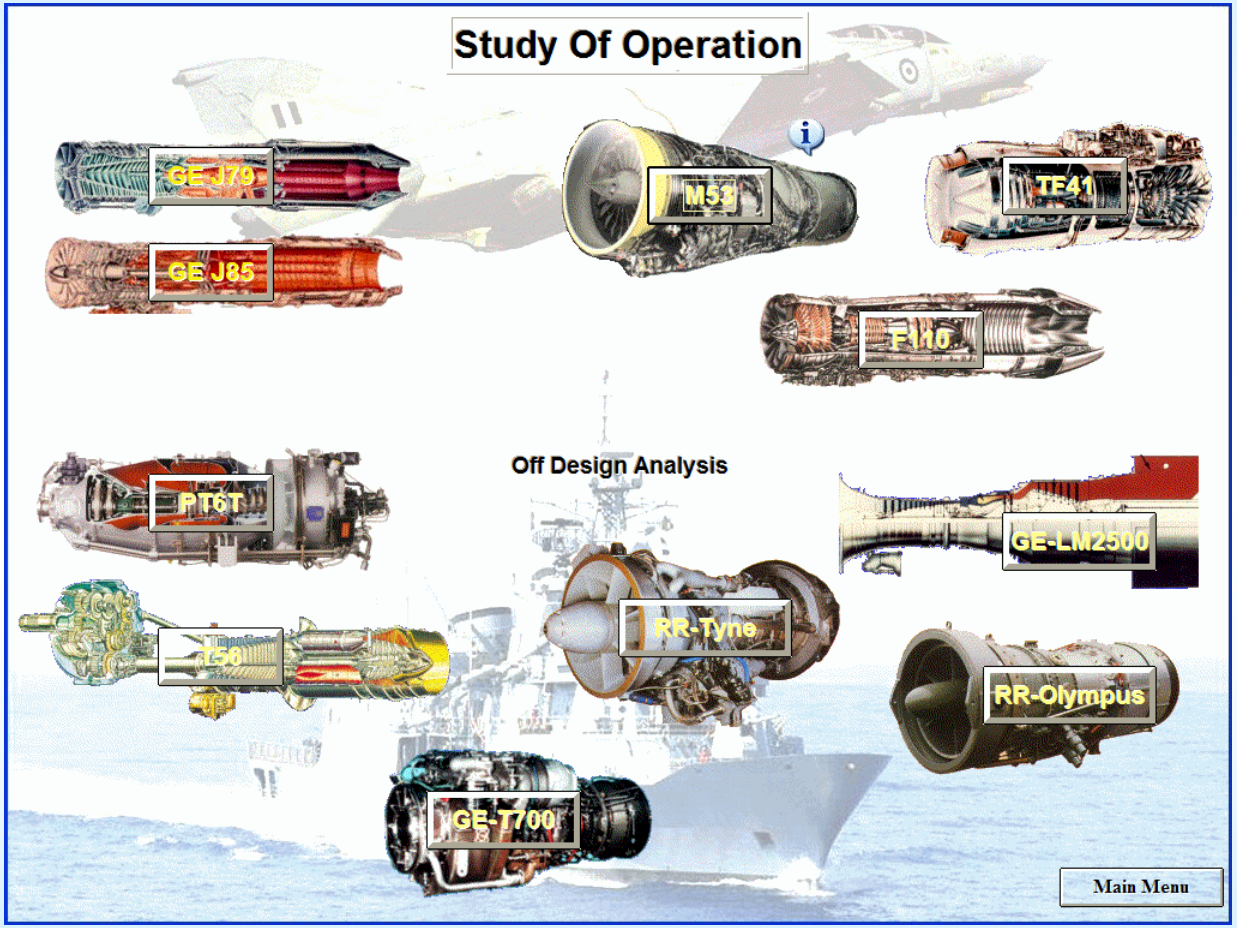
Off Design Operation (I)



The main screen of 'Study of Operation' Section.

Off Design Operation (II)


M53

Description | Compressor | Burner | Turbine Module | AfterBurner | Nozzle | Accessories

SNECMA M53-P2

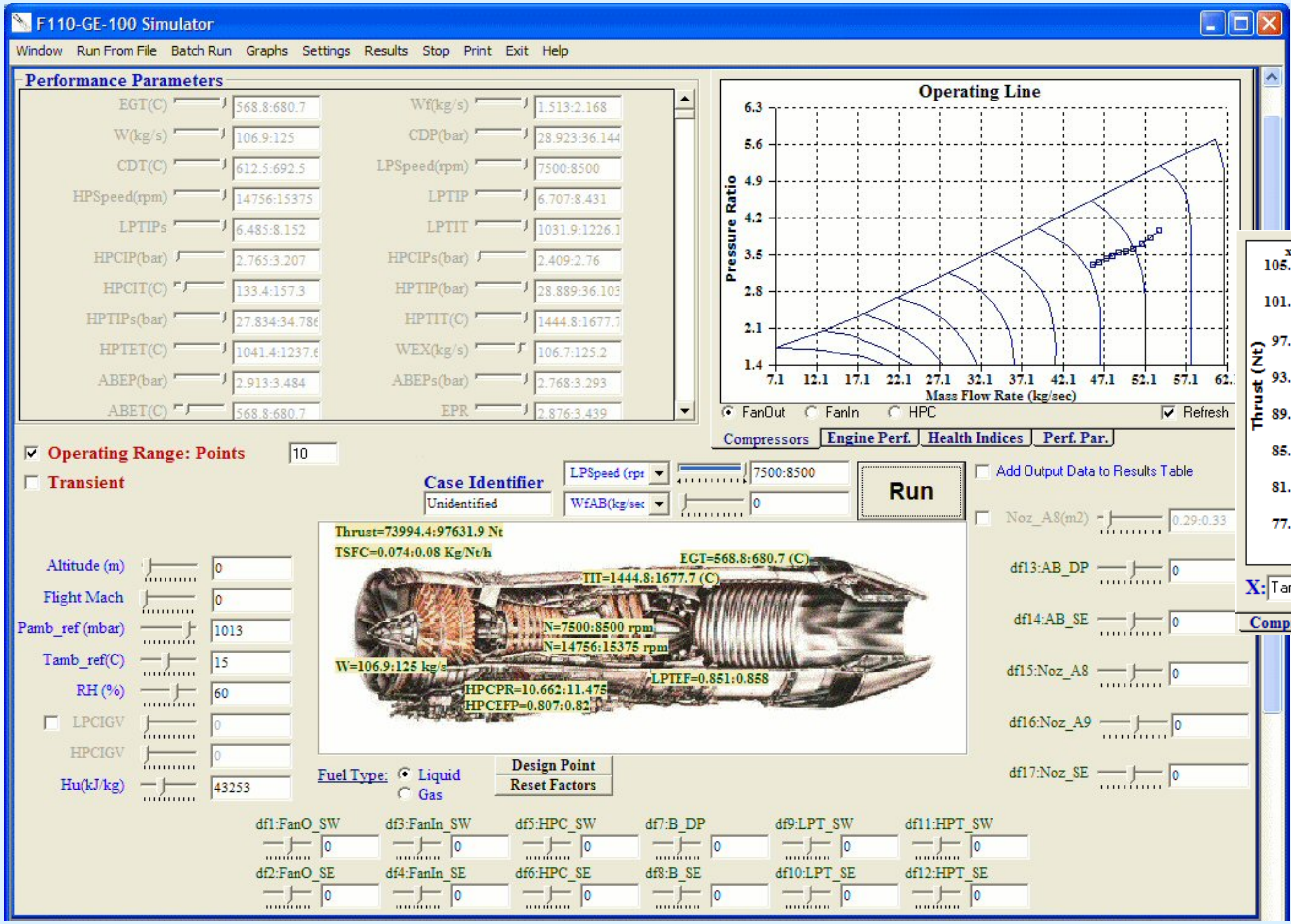
A single spool turbofan with low bypass ratio, with afterburner and convergent variable geometry nozzle.

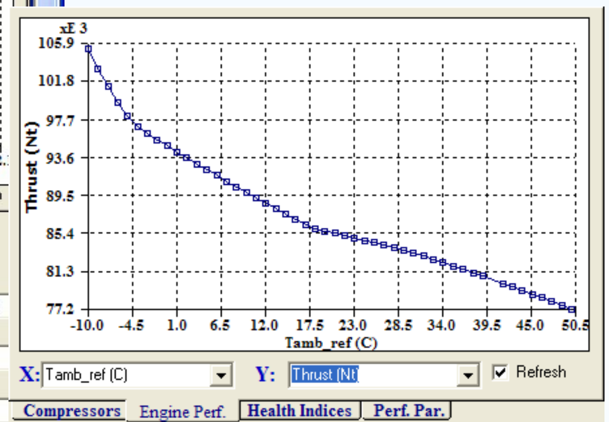
Basic Characteristics:

Manufacturer:	SNECMA
Compressor:	A Low Pressure 3 stage axial and a High Pressure 5 stage axial
Turbine:	2 stage axial
Burner:	Annular with fuel pre-mixer
Maximum Thrust at Sea Level:	(14163-25111 Lb) (6300-11170 daNt)
Specific Fuel Consumption for Maximum Thrust:	0.92-2.12 Lb/Lbf/h (0.94-2.16 Kg/daNt/h)
Air Flow and Compressor Pressure Ratio for maximum Speed:	207 Lb/s (94Kg/s) with pressure ratio 9.8 at 10600 rpm
ByPass Ratio	0.36
Turbine Inlet Temperature	1560K
Nozzle area	3040-5700 cm^2

Example screen with an engine technical information

Off Design Operation (III)





Example result (Thrust versus ambient temperature for constant speed)

The main screen of an engine performance simulator

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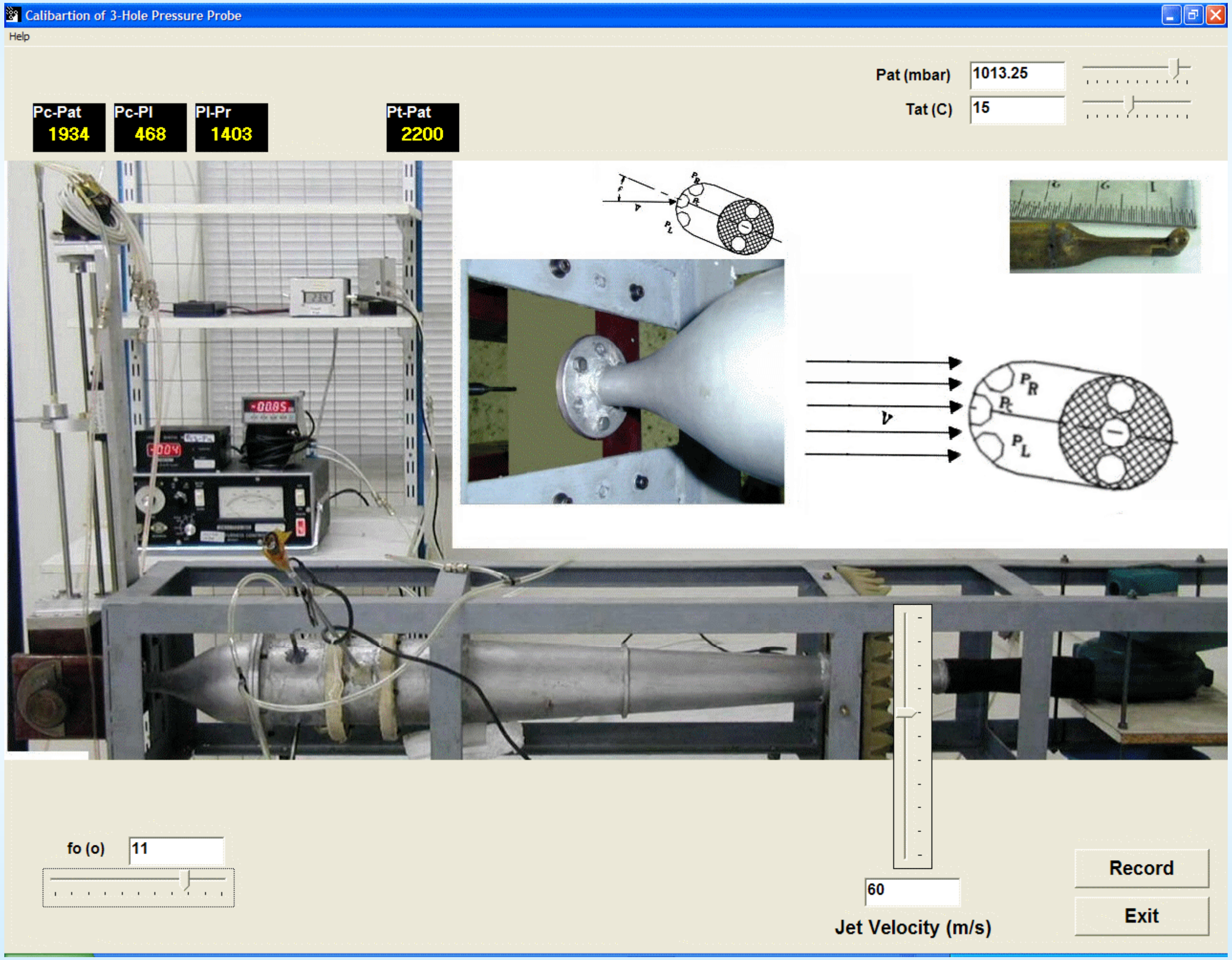
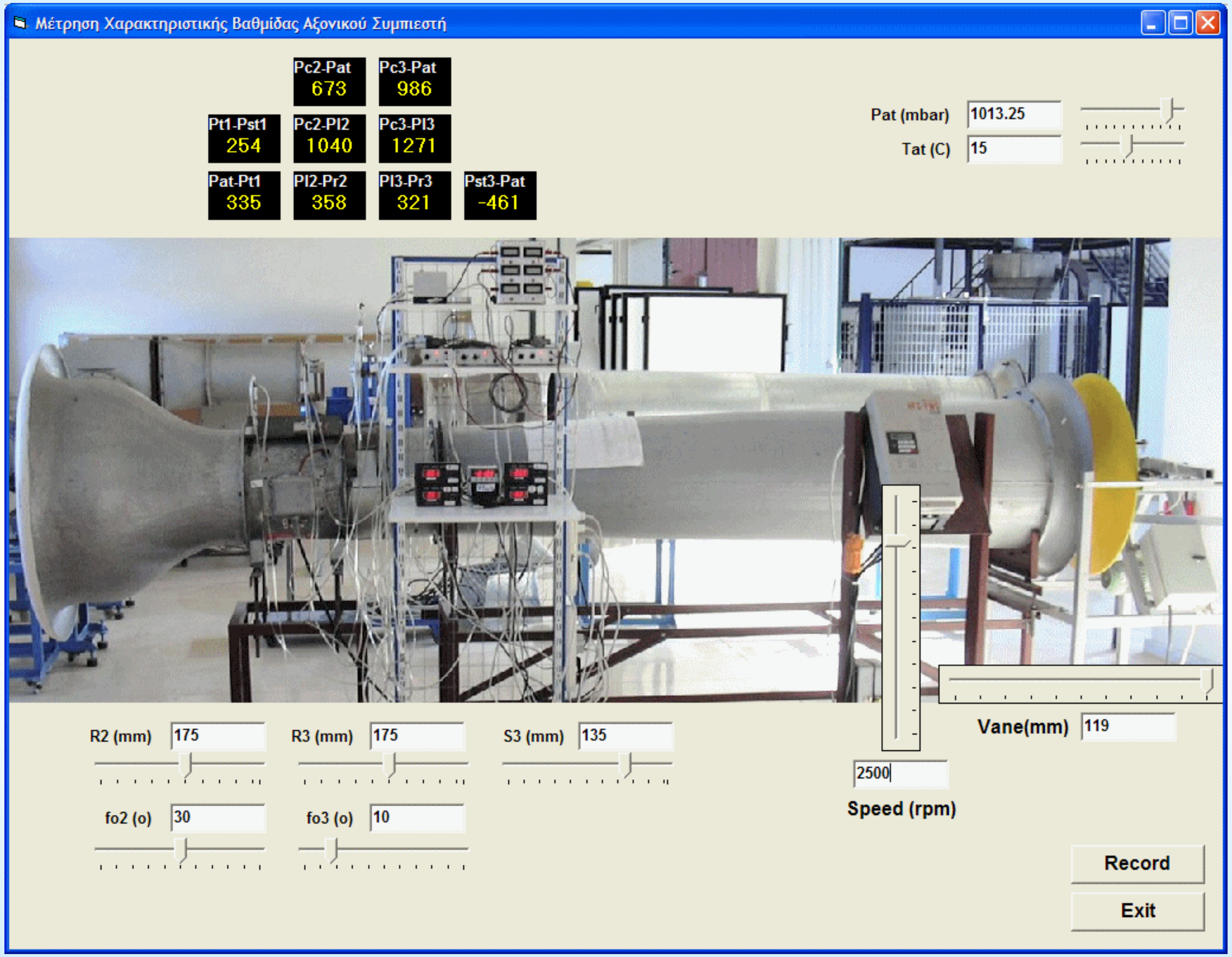
Virtual Test Facilities and Exercises (I)



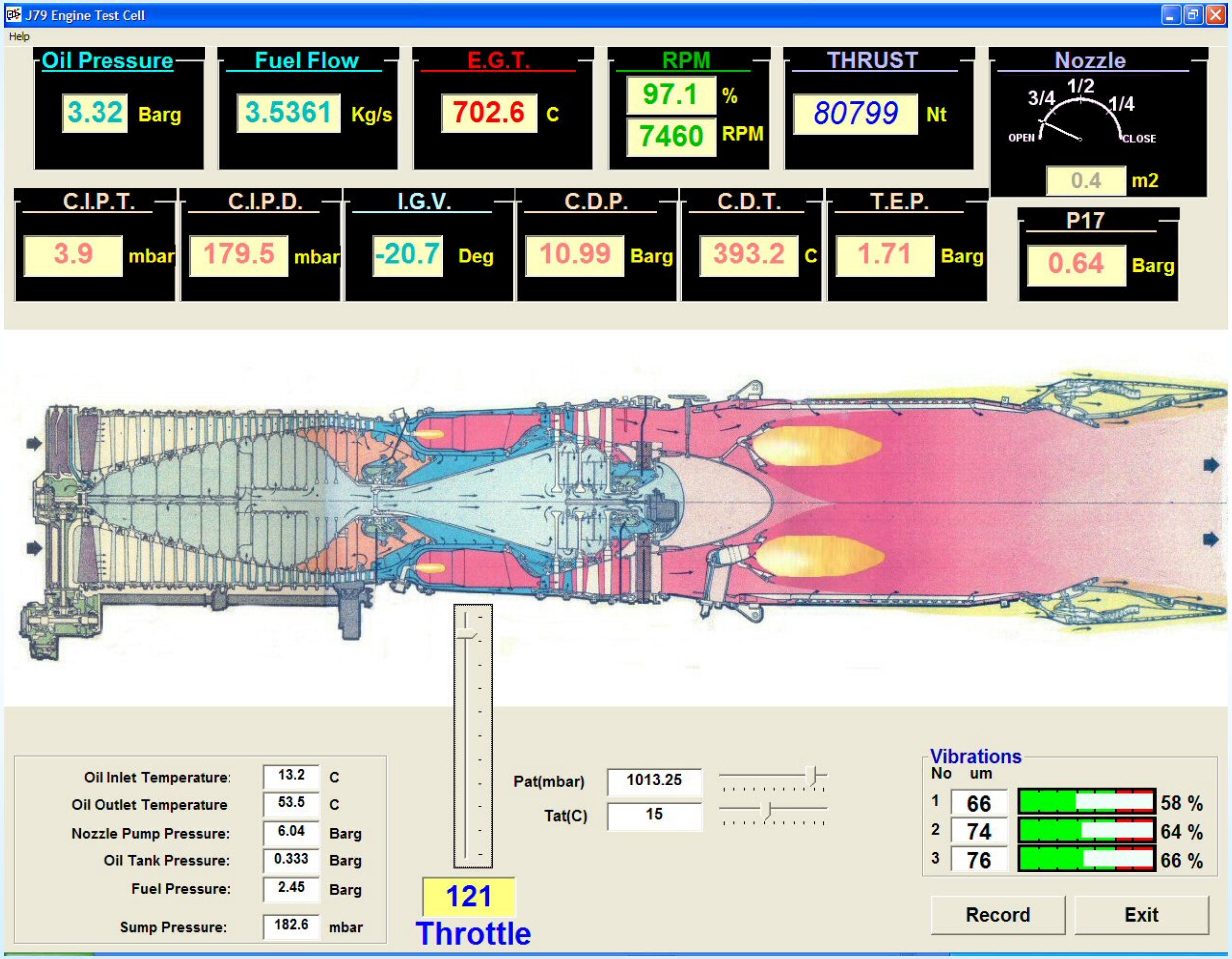
Calibration of a 3-hole pressure probe

Virtual Test Facilities and Exercises (II)



Measurement of characteristic curve of a single stage axial compressor

Virtual Test Facilities and Exercises (III)



Reproduction of a real jet engine test cell

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Further Educational Aspects-Conclusions

- **Features of the software:**
  - **Interactivity**
  - **on-line help possibility**
  - **batch processing**
  - **exporting capability, interaction with other widespread tools**
  - **it can be used from different levels of personnel.**
- **This software has actually been used in a classroom specifically designed for this purpose as a teaching tool.**
- **The software can also be used for further education**
  - **it offers an inclusive reference in the field of gas turbines principles**
  - **it can reproduce all basic trends and behavior of a gas turbine engine, and**
  - **it can be a useful tool for assisting the diagnosis of specific faults.**