TURBOPROP AND TURBOSHAFT ENGINE

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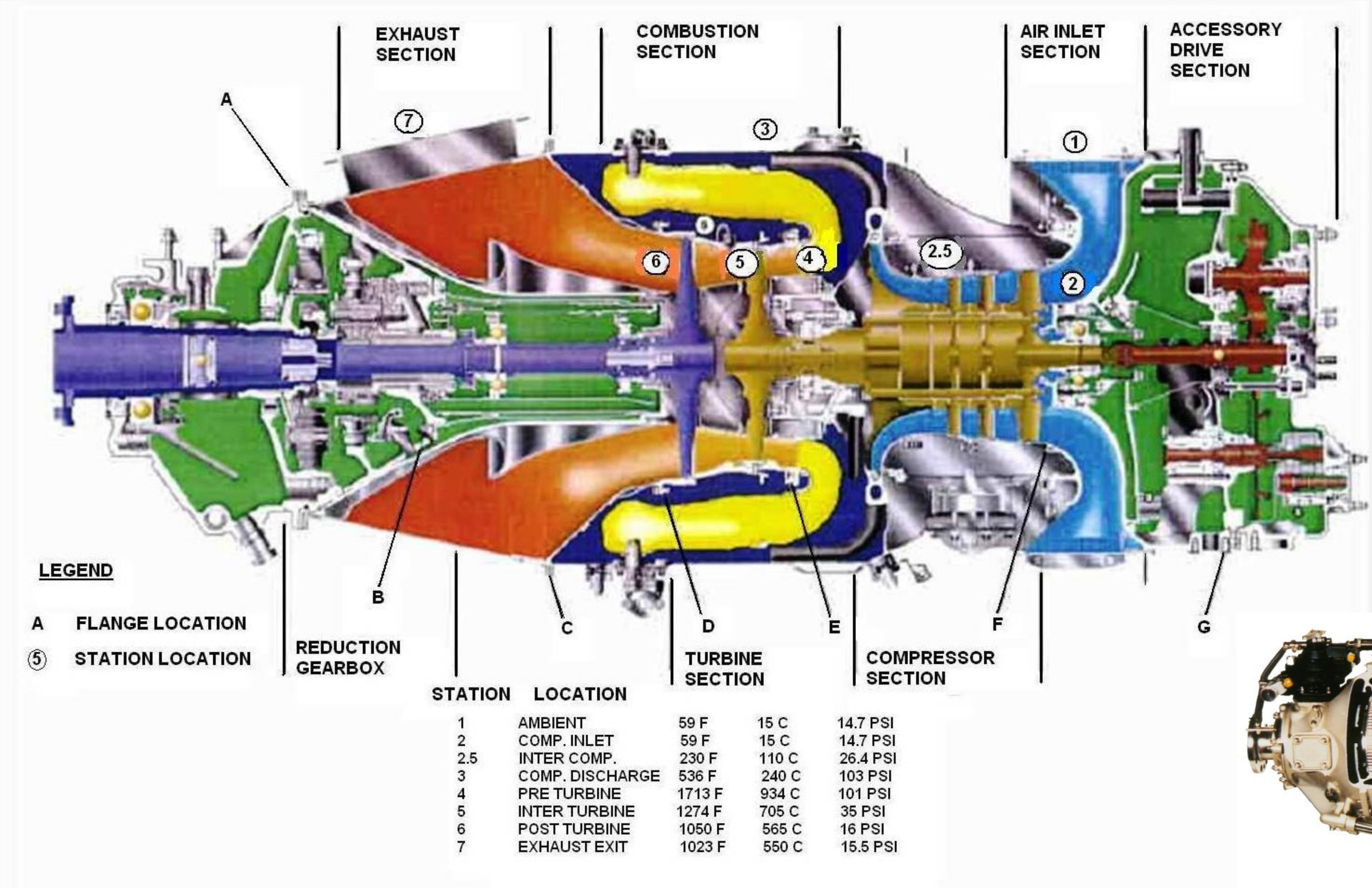
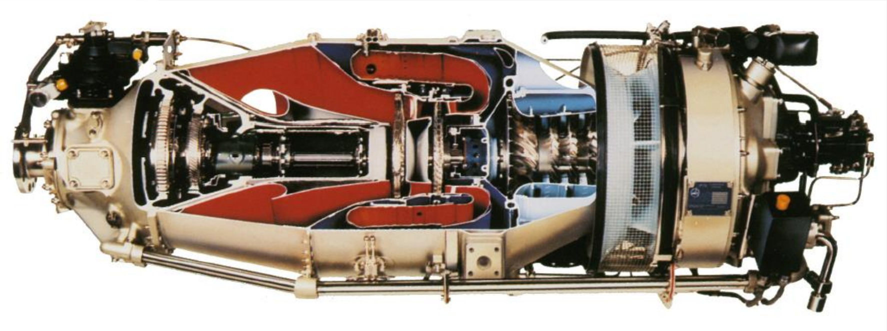
LITERATURE:

- **Gordon C. Oates, Aerothermodynamics of Gas Turbine and Rocket Propulsion, AIAA Education Series, 1997 (Chapter 7)**
- **Jack D. Mattingly, Elements of Gas Turbine Propulsion, Tata McGraw Hill Education Private Limited, 2013 (Chapter 7)**
- Jack D. Mattingly, William H. Heiser, David T. Pratt, **Aircraft Engine Design, Second Edition,** American Institute of Aeronautics and Astronautics, Inc. 2002 (**Appendix K**)

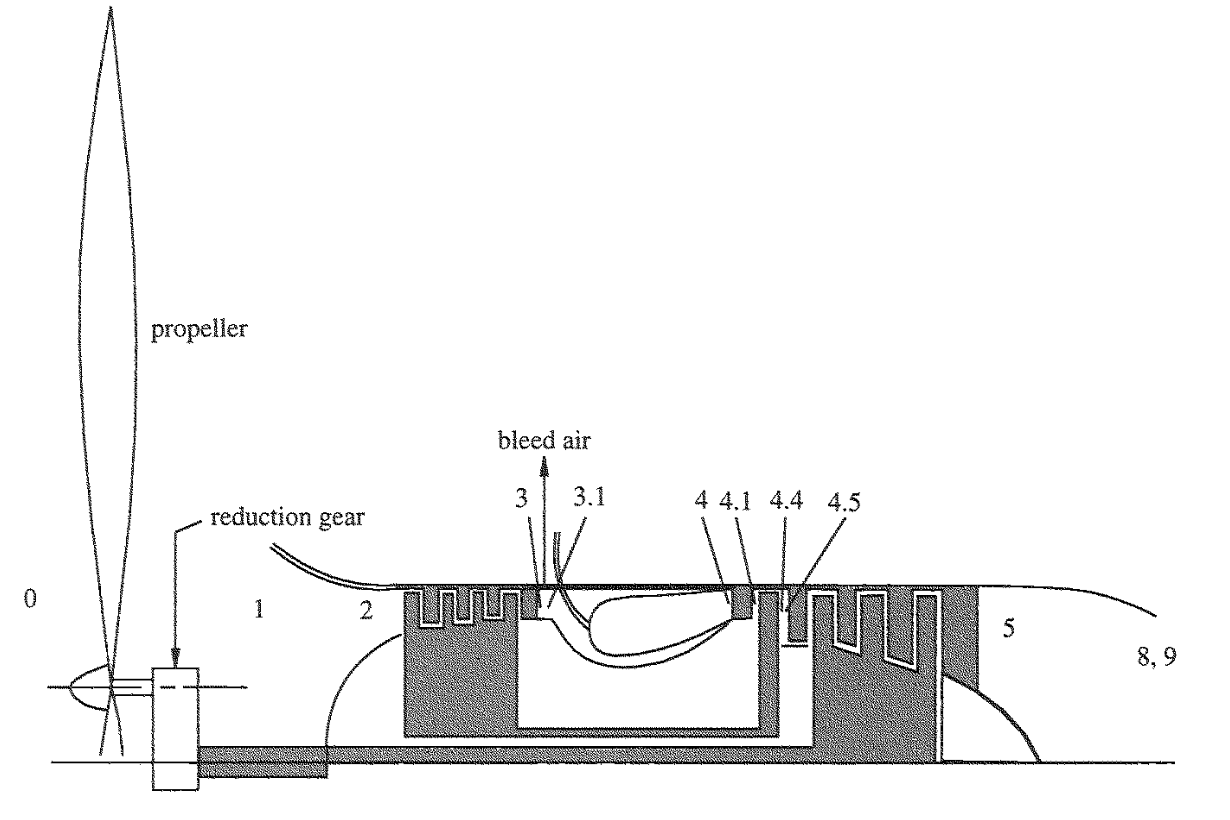
TURBOPROP/TURBOSHAFT ENGINES EXAMPLES



PT 6 A/B



FREE POWER TURBINE TURBOPROP



Power of the power turbine

$$P_{PT} = \dot{m}_{45} Cp_T (T_{t45} - T_{t5})$$

Power transmitted to the propeller: Shaft Power

$$P_{SP} = \eta_m \eta_G P_{PT} = \eta_m \eta_G \dot{m}_{45} \; Cp_T (T_{t45} - T_{t5})$$

η_m - mechanical efficiency

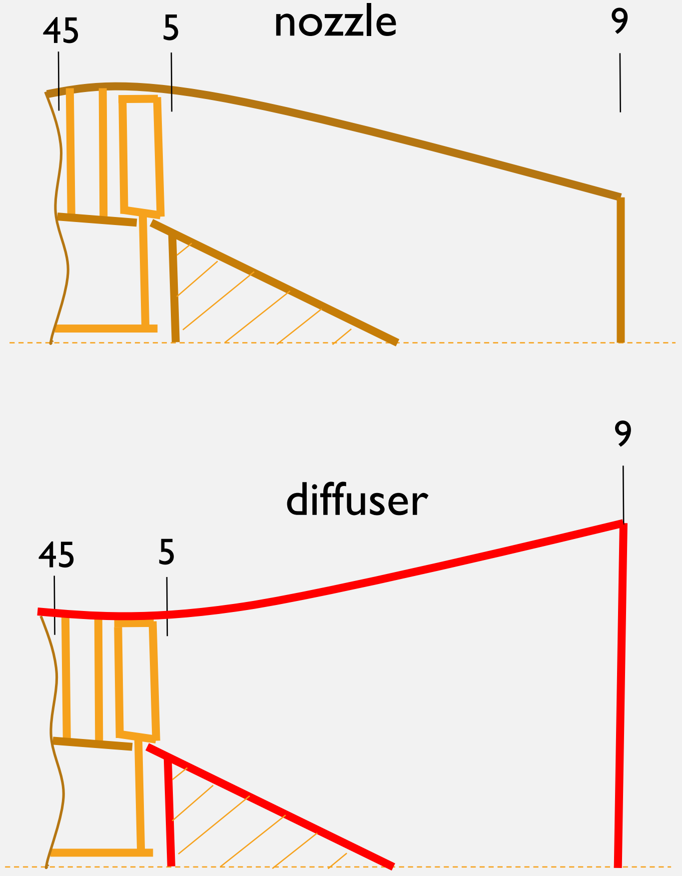
η_G - gear efficiency

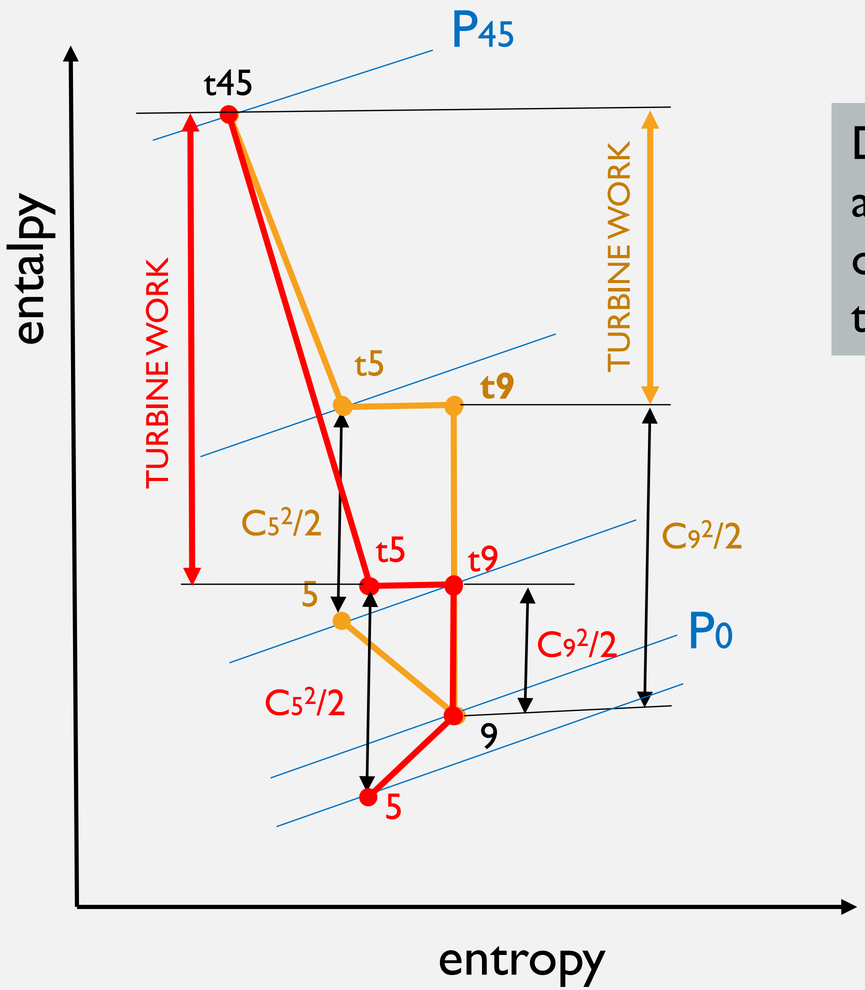
Propeller thrust

$For\ V_0 > 0$ $\quad T_{PR} = \frac{\eta_{PR} P_{PR}}{V_0}$ $\quad \eta_{PR}$ - propeller efficiency

$For\ V_0 = 0$ $\quad T_{PR} = B_{PR} P_{PR}$ $\quad B_{PR}$ - propeller thrust to power ratio

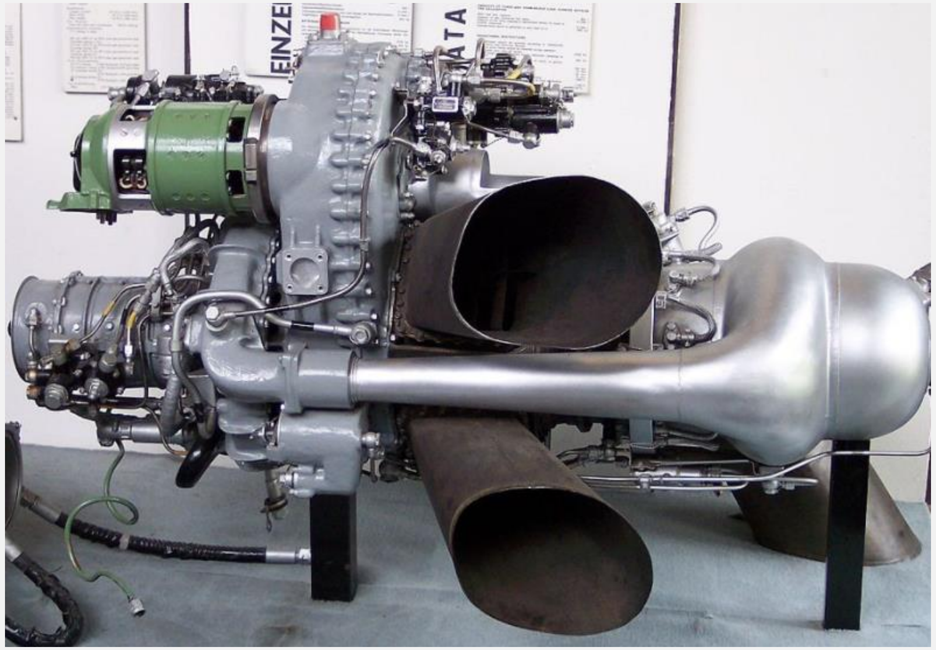
INCREASING POWER OF THE TURBINE THROUGH THE ENGINE EXHAUST



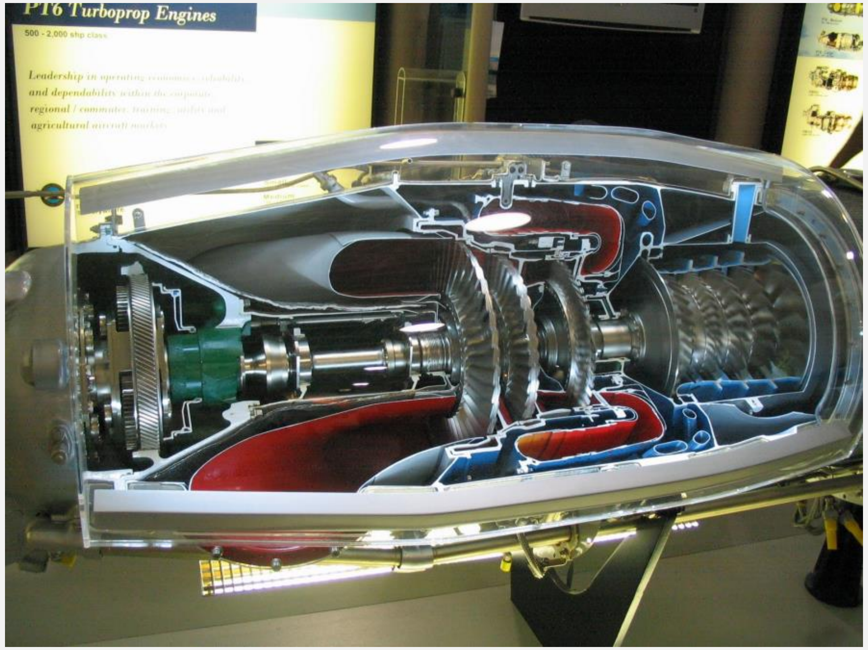


Diffuser in the turboprop and the turboshaft engine outlet allow to increase turbine power

TYPICAL TURBOPROP AND TURBOSHAFT ENGINE EXHAUST

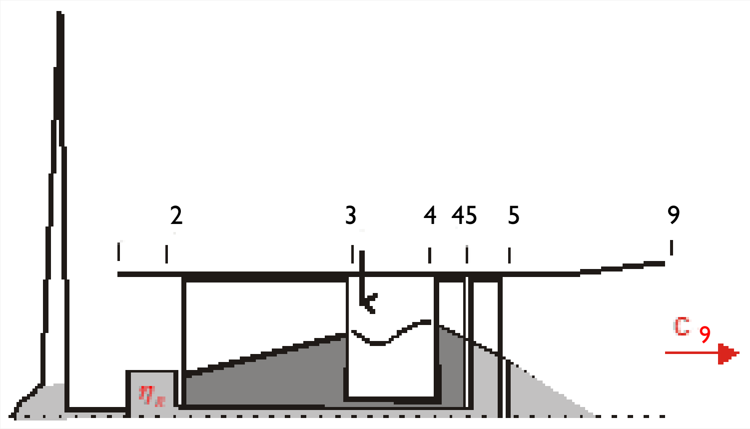


GTD 350



PT6

POWER TURBINE CALCULATION



Parameters to section 45 are calculated as for classical turbojet engine.
Engine outlet flow speed is assumed (outlet diffuser c9=180-240 m/s 0,3-0,4 Ma)
Static pressure in diffuser outlet is equal ambient pressure P9=P0

$$P_{t5} = \frac{P_{t9}}{\pi_D} = \frac{P_9\left(1 + \frac{k_t - 1}{2} {M_9}^2\right)^{\frac{k_t}{k_t - 1}}}{\pi_D}$$

π_D - pressure losses in diffuser

$$\pi_{PT} = \frac{P_{t45}}{P_{t5}}$$ - power turbine pressure ratio

$$W_{PT} = Cp_T(T_{t45} - T_{t5}) = Cp_T T_{t45}\left(1 - \frac{T_{t5}}{T_{t45}}\right)$$

PT power: $P_{PT} = m_{45} W_{PT}$

Higher pressure ratio of the power turbine generate higher work and power of this component

Polytropic efficiency of PT: $T_{t5}/T_{t45} = (P_{t5}/P_{t45})^{\frac{e_{PT}(k_t - 1)}{k_t}}$

Isentropic efficiency of PT: $T_{t5}/T_{t45} = 1 - \eta_T\left(1 - (P_{t5}/P_{t45})^{\frac{k_t - 1}{k_t}}\right)$

SPECIFIC FUEL CONSUMPTION AND SPECIFIC POWER

Specific fuel consumption SFC / for power $$SFC = \frac{\dot{m}_f}{P_{SP}} = \frac{f}{\eta_m \eta_G (1+f) Cp_T (T_{t45} - T_{t5})}$$

/ for thrust $$SFC = \frac{\dot{m}_f}{T}$$

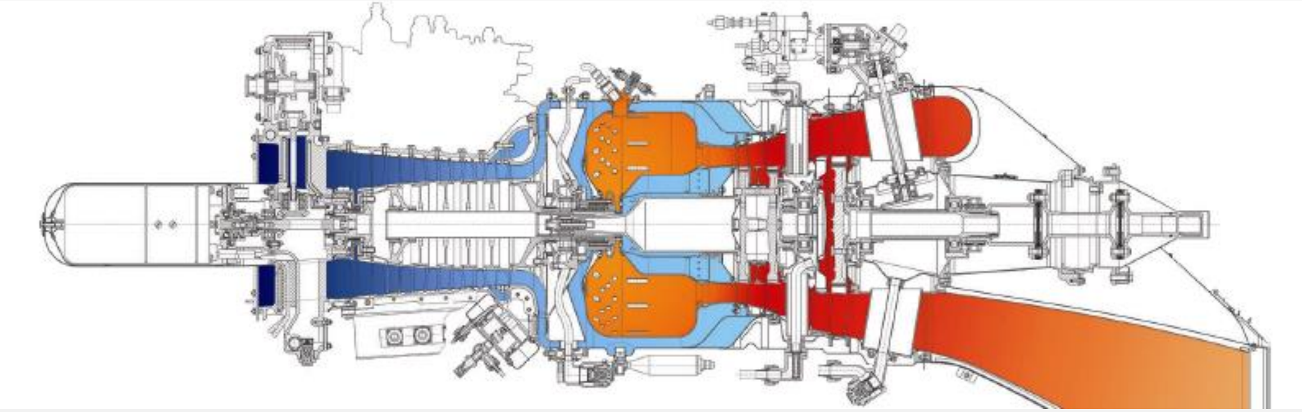
Specific Power: $$SP = \frac{P_{SP}}{\dot{m}_0} = \eta_m \eta_G (1+f) Cp_T (T_{t45} - T_{t5})$$

Spceific Thrust: $$ST = \frac{T}{\dot{m}_0}$$

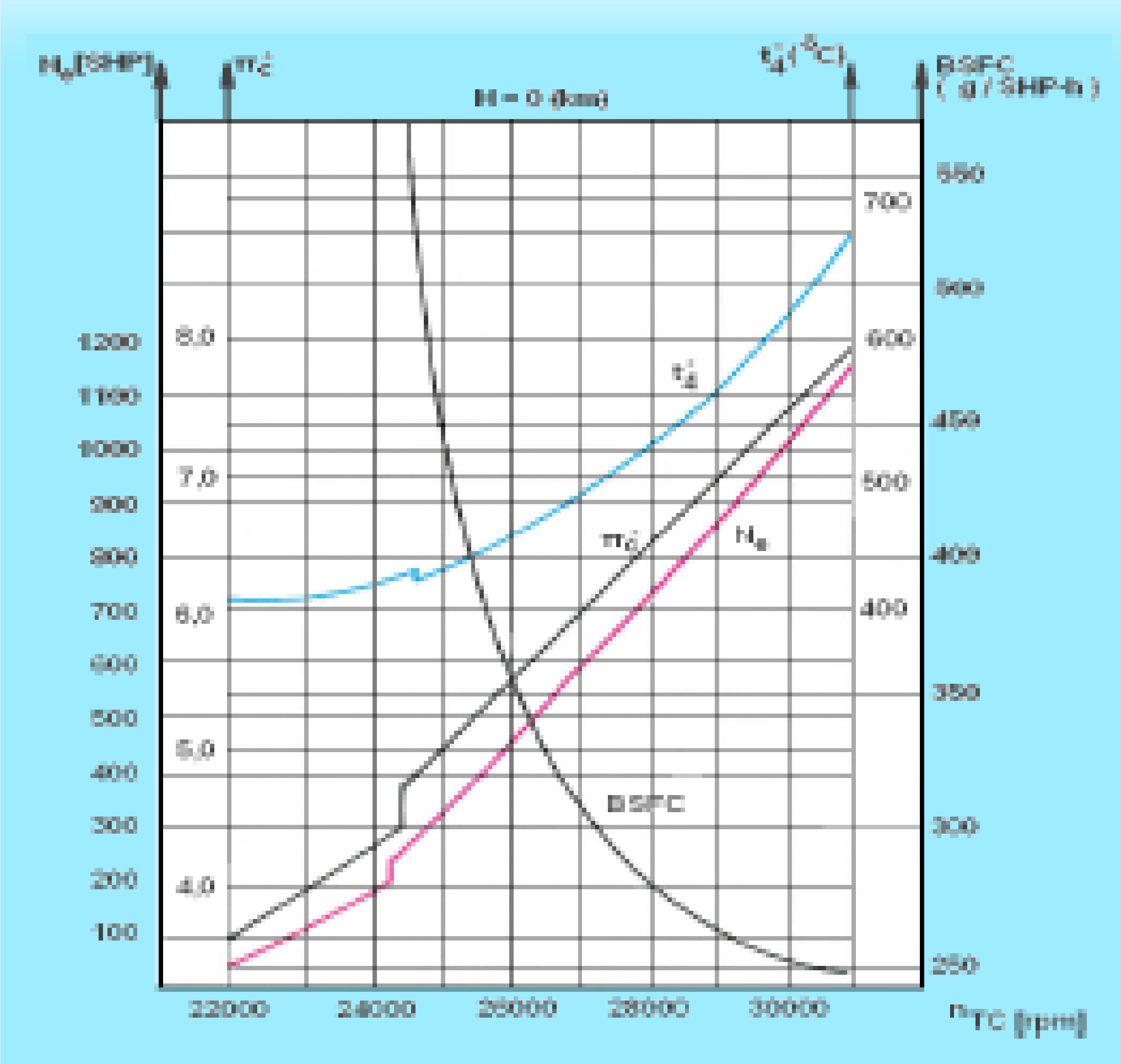
ENGINES PERFORMANCE PARAMETERS COMPARISON

	Specific thrust/ power [daN*s/kg]	**SFC [kg/daN/h]**
Turbojet engine	50-70	0,8-1,1
Turbojet engine AB on	80-110	1,7-2,2
Turbofan mixed stream engine	50-75	0,6-0,8
Turbofan mixed stream engine AB on	75-110	1,9-2,5
High bypass ratio turbofan engine	25-60	0,3-0,7
Turboprop/turboshaft engine	160-300 [kW*s/kg] 240-450 [daN*s/kg]	0,22-0,35 [kg/kW/h] 0,15-0,25[kg/daN/s]

PZL 10W PERFORMANCE



SW-3 Sokół



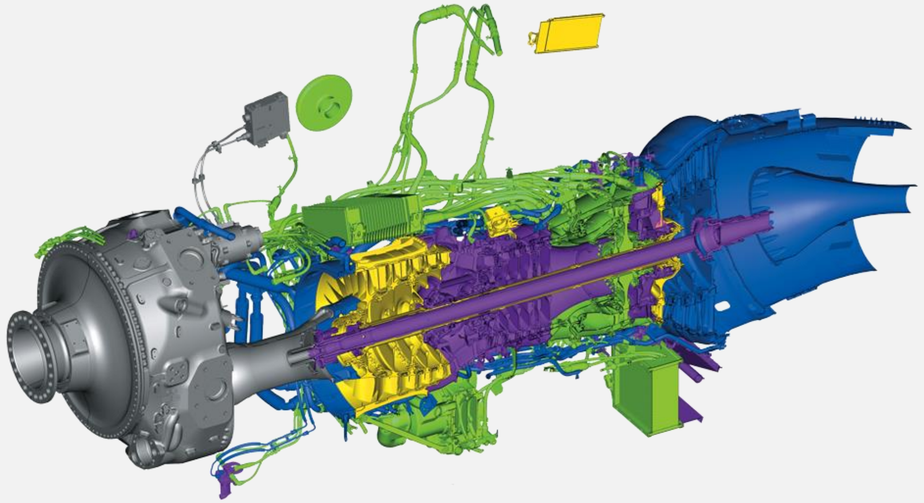
ROLLS-ROYCE M-250/T63

•Shaft power 250 SHP
•Two-shaft modular design featuring a two-stage LP turbine, two-stage HP turbine, and a gearbox with 6,000rpm output.
•The Series II features four to six-stage axial and single-stage centrifugal compressors with a hydro mechanical fuel control system.

Silnik RR250-C20R (śmigłowiec PZL SW-4)

TP400-D6

Power (at sea level)	11,000 shp
Pressure ratio	25:1
Length	138 in
Propeller diameter	210 in
Weight	4,189 lbs



Airbus A400M

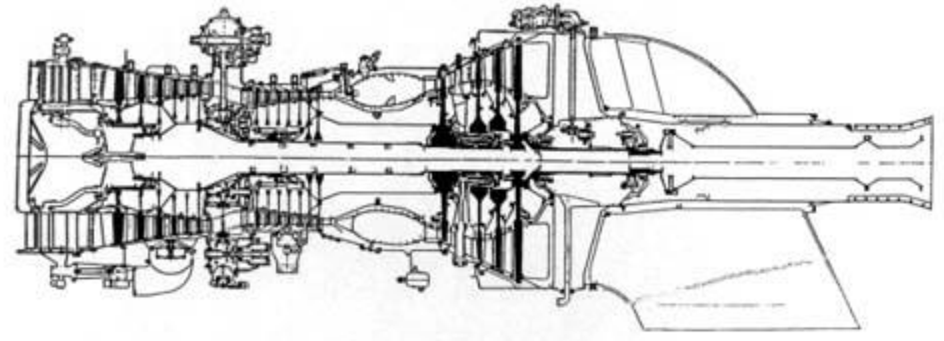
LOTAREV D-136 3-SPOOL TURBOSHAFT

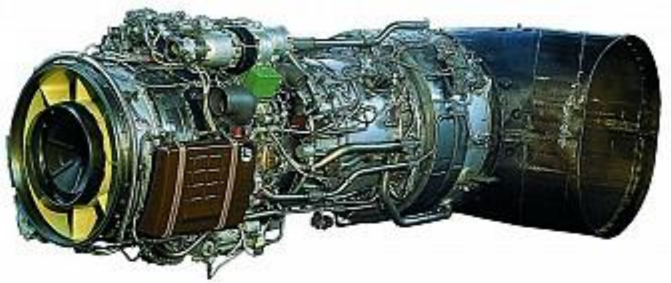
seria 1

Maximum takeoff power conditions (SLS, ISA)	
Power, shp (kW)	11400 (8382)
Specific fuel consumption, kg/hp•h (kg/kW•h)	0.194 (0.263)
Cruise power conditions (H=4600 m, M_{fl}=0,13; ISA)	
Power, shp (kW)	6100 (4486)
Specific fuel consumption, kg/hp•h (kg/kW•h)	0.230 (0.312)
Dry weight, kg	1077

seria 2

Emergency power rating (H=0, M=0, ISA+15°C):	
Power rating, hp (kW)	12500 (9190)
Maximum takeoff power rating (H=0, M_{fl}=0, ISA):	
Power rating (at t_{AMB}=30°C), hp (kW)	11650 (8560)
Specific fuel consumption, kg/hp·h (kg/kW·h)	0.198 (0.269)
Dry weight, kg	1100





- **Compressor:** 7-stage subsonic high-pressure (HP) compressor, 6-stage transonic low-pressure (LP) compressor
- **Combustors:** Annular combustion chamber, 24 fuel nozzles, 2 igniters
- **Turbine:** 1-stage HP turbine @ 14,170 rpm, 1-stage LP turbine @ 10,950 rpm, 2-stage free-power turbine @ 8,300 rpm (±300 rpm)

D27-PROGRESS CONTRA-ROTATING FORWARD PROPFAN

Source: Progress D-27 - Wikipedia

Type: Three-shaft geared configuration propfan engine

Maximum thrust: 12,100 kgf (26,800 lbf; 119 kN) at 1,000 rpm
Overall pressure ratio: 29.25
Air mass flow: 27.4 kg/s (60 lb/s)
Turbine inlet temperature: 1,665 K (2,997 °R; 1,392 °C; 2,537 °F)
Specific fuel consumption: 10.87 g/kN/s (0.384 lb/lbf/h)
Cruise: 11 g/(kN·s)
Power specific fuel consumption: Takeoff: 0.180 kg/(hp·h) (0.241 kg/kWh; 0.40 lb/(hp·h)); Cruise: 0.140 kg/(hp·h) (0.188 kg/kWh)

Compressor: 5-stage axial flow low-pressure compressor (LPC); high-pressure compressor (HPC) with 2 axial stages and 1 centrifugal stage
Combustors: Annular combustion chamber
Turbine: 1-stage high-pressure turbine (HPT), 1-stage low-pressure turbine (LPT), 4-stage free power turbine

THANKS FOR YOUR ATENTION

Questions and Comments ?

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2. …….
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