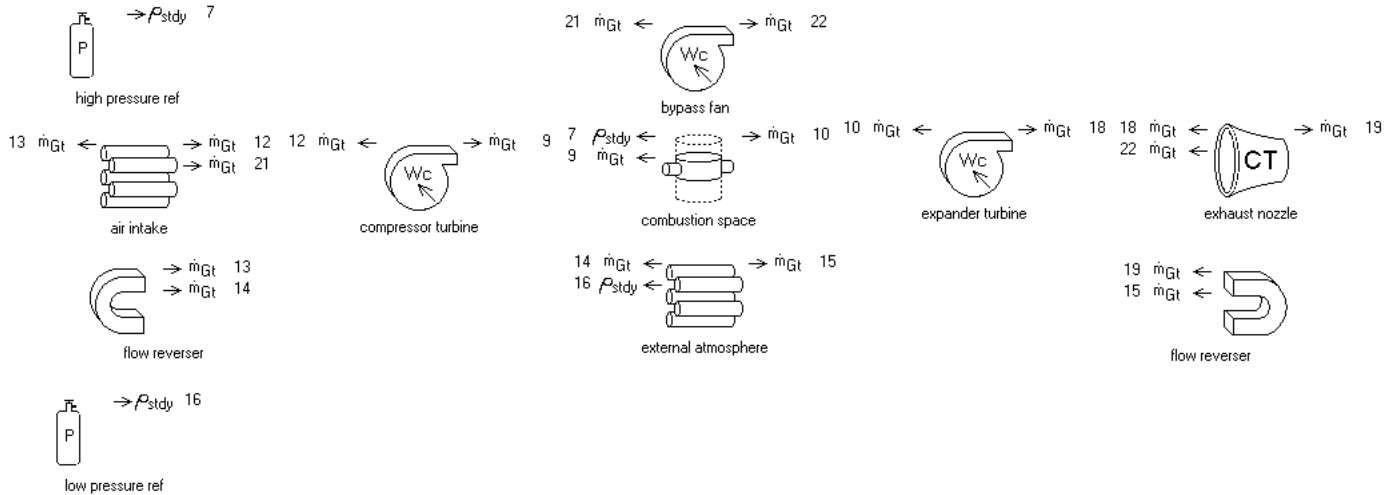


# Sage Model Notes

## turbofan.ltc

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3 November 2011

A variant of the *turbojet.ltc* model that adds a bypass fan to approximate a turbofan jet engine:



Compared to the turbojet model (see *turbojet.pdf*) there is an additional adiabatic compressor component in the top row labeled *bypass fan*. These notes document mainly the new features not already documented in the notes for the turbojet model.

The *bypass fan* forms a parallel flow path to the *compressor turbine* and *expander turbine* and is governed by the pressure established by the *low pressure ref* and the intrinsic pressure drops of the *air intake* and *exhaust duct* (the *external atmosphere* pressure drop is negligible). So it does not require a third pressure reference in the model.

The *bypass fan* is driven by the excess shaft power of the *expander turbine* (the amount beyond that required by the *compressor turbine*) and serves to increase the flow through the exhaust nozzle, resulting in higher thrust and reduced fuel (heating) input.

### Bypass Flow Optimization

The model introduces a new root-level user input

Rbypass	fan bypass ratio (NonDim)	6.8770E-01
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Two user-defined outputs specify the flow through the *compressor turbine* and *bypass fan* in terms of the total mass flow rate specified by the *MdotFlow* input.

MdotCompr	compressor mass flow rate	5.6214E-02
MdotFlow * (1-Rbypass)		

MdotFan	fan mass flow rate	1.2379E-01
MdotFlow * Rbypass		

The inputs for the fan and turbine components are automatically recast in terms of  $\dot{M}dot{Compr}$  and  $\dot{M}dot{Fan}$ .

## Net Shaft Power

The power delivered to the *bypass fan* and *compressor turbine* and the power produced by the *expander turbine* vary as a function of  $R_{bypass}$ . The net power is the sum of all three represented by the user-defined variable.

$$W_{net} = \text{excess turbine shaft power} - W_{expander} - W_{compressor} - W_{fan} = 1.0000E+03$$

The Sage optimizer is set up to solve for the bypass ratio that produces an excess turbine shaft power of 1 kW.