Basic information TJ 100
Issue date: 25.8.2008
Number of pages: 12

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Turbo-jet engine TJ 100

BASIC INFORMATION

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Content:

Annexes:

Assembling list of the TJ 100 engine	
Layout of devices on the engine	drawing no. B3-0470-11287
Time diagram of the engine function	
Wiring diagram	drawing no. B2-0470-11286
Dimensional drawing of the ignition source	drawing no. B3-0470-11155
Dimensional drawing of the connecting lead	drawing no. B3-0470-11145
Dimensional drawing of the engine TJ 100C	drawing no. B1-0470-10337
TJ 100A……	drawing no. B1-0470-10385

I. Introduction

Turbo-jet engines of TJ 100 type are designed as drive unit for MAE UAV and pilot flying vehicles. Development of this engine was founded in the year 2002, several serial produced version is at present, versions untrue by length of output nozzle, fastening foot and by power.
We produce TJ 100, TJ 100C, TJ100E, and TJ 100I at power level of 100 daN (225 lbf), TJ 100A and TJ 100S are produced with power of 110 daN (247 lbf).
There are data of both power levels in lover mentioned text. We are permanently working at engine perfection, we are able accept customers requirements resulting from varied engine development.
After signing of NDA could be afford particular specification, with all details, for each type of TJ 100 engine.

II. Technical data

		TJ 100	TJ 100A
Static thrust	/daN/	≥ 100	≥110
Specific fuel consumption	/kg/daN.h/	≤1,07	≤1.11
Oil consumption	/ml/hour/	≤ 50	≤50
Power delivered into network	/W/	750	720
Weight of the engine	/kg/	16,5	17,5
Weight of the engine including electronic control, switched source, ignition system and cabling	/kg/	19,5	20,5
Outside diameter	/mm/	272	272
Length	/mm/	485	625
Service life	/hour/	≥ 100	≥ 50
Number of starts	/ - /	≥ 600	≥ 600
Uninterrupted operation	/hour/	≥ 2	≥ 2

Thrust of the engine depends on the engine speed, on intake air pressure and temperature.
Under standard conditions: p_0 = 101,325 kPa
t_0 = 15 °C
v = 0 km/hour
engine has the parameters according table:

Operating mode	Rotor speed %	Run time /min/		Minimal thrust /N/		Max. SEC * kg/N/h/		Temperature behind turbine /°C/	
		TJ 100	TJ 100A	TJ 100	TJ 100A	TJ 100	TJ100A	TJ 100	TJ 100A
Max. starting	100	5	5	1000	1100	0,107	0,111	680	730
Nominal	97	continous	30	870	1000	0,105	0,107	620	680
Cruising	91	continous	continous	620	740	0,106	0,105	520	560
Cruising lowered	84	continous	continous	480	510	0,116	0,115	470	480
Idle (ground)	50	continous	continous	140	150	˜0,24	˜0,24	450	450

* hold for JET A-1 fuel

III. Operation conditions

3.1 Working fluids

Fuel – aviation kerosene - TS-1, T2, RT according to GOST 10227 - 86
JET A, JET A-1, JET B according to DERD 2494

Fuel cleanness must correspond to Class 10 to 11 as per GOST 17216-71 or 7 to 8 as per NAS 1638.

Oil 5 5 cSt - MOBIL JET OIL II according to MIL-L-23699,
3 cSt - AEROSHELL TURBINE OIL 390

Oil cleanness must correspond to Class 14 as per GOST 17216-71 or 10 as per NAS 1638.

3.2 Working temperatures

Ambient temperature range for starting	-20°C to +45°C with oil 5 cSt -30°C to +45°C with oil 3 cSt
Intake air temperature range	-50°C to +45°C
Inlet fuel temperature range	-40°C to +50°C

3.3 Working pressures and flows

	TJ 100	TJ 100A
Intake air quantity	˜1.7 kg/sec	˜1,85 kg/sec
Scale of fuel consumption	30-130 l/hour	30-148 l/hour

Inlet fuel pressure (underpressure-overpressure)	-20 kPa to +50 kPa
Max. fuel pressure in the engine	1.5 MPa

3.4 Altitude

Range for starting	0 to 4 000 m (M=0)
Range for operation	0 to 9 000 m

3.5 Flight speed

Range for starting	0 to 0.3 Ma
Range for operation	0 to 0.8 Ma

3.6 Electric network

Board network voltage	24/28.0 V DC
Battery capacity for starting	min 12 Ah
Battery capacity for the engine operation	min 2 Ah
Average consumption per 1 start	0.3 Ah
Permissible network voltage at starting	≥ 18 V
Max. current consumption from battery at starting	100 A
Power output of built-in source 28.0 VDC	1000 W
Self consumption of the engine	150 to 350 W (depending on mode)
Power output delivered to the board network in the range of engine speed	50 - 100%

IV. Operation limitations

Temperature behind turbine at starting	1000 °C max. for 3 sec. time
Temperature behind turbine at operation	780 °C max.
Max. starting time	30 sec.
Restart after unsuccessful start	1 min
Restart after previous run	3 min
Oil tank value	˜400 ml
Oil replacement after run time	≤ 10 h

V. Engine description

TJ 100 is single-shaft engine with single-stage radial compressor, annular combustion chamber, single-stage axial turbine, and stationary exhaust jet.
In the compressor intake there is a brushless starter generator, which enables the starting from the board network and power generating in course of the engine operation.
The intake air is compressed in the radial compressor wheel, proceeds through radial and axial diffuser into the combustion chamber, where it is mixed with fuel sprayed by several fuel nozzles. Combustion gases arising in fuel burning in the combustion chamber expand through the single-stage axial turbine and exhaust jet into the atmosphere.
The rotor of the engine is mounted on 2 ball bearings lubricated with pressure oil.

5.1 Oil system

Lubricating system is autonomous, and consists of the following components:
- oil tank
- geared oil pump driven by an electric motor
- oil - air cooler
- oil filter
- pressure switch
- control valve
- oil - fuel cooler
- oil centrifuge driven by an electric motor

Oil is drawn by the pump from the reservoir, cooled, filtered, and by piping delivered to the injection nozzles of the bearings. The mixture of oil and air is drawn to the fuel-oil exchanger and next to the centrifugal separator from the space of bearings; oil returns into the tank, air is exhausted outside the oil system.
A part of oil is led via the control valve back into the tank; the control valve maintains roughly constant overpressure of the oil: approx. 100 kPa.

5.2 Fuel system

Fuel is drawn from the external tank via the filter 50 μm and a fuel valve, which are not accessories of the engine. Fuel is supplied throught the fuel-oil exchanger into the fuel nozzles by the electric gear pump fed from the electronic control of the engine. Fuel pump speed determines the injected amount of fuel and thus the working mode of the engine. A part of fuel supplied into the nozzles returns via the bypass controller and one-way valve into the suction of the fuel pump. The amount of the relieved fuel is controlled depending on inlet pressure of the fuel in front of the fuel nozzles.
All devices of both the fuel and oil system are mounted on the engine itself; fuel inlet fitting is in the front left down.

5.3 Control system

Control system of the engine is a microprocessor system, which controls safe run of the engine including engine starting, maintaining required speed, stopping and aftercooling.

The system is equip with inputs for:
- communication with superior control system
- engine mode selection by control voltage (0 to 10 VDC)
- engine speed (signal is derived from the generator function)
- intake air temperature (thermo-sensor Pt100)
- exhaust gas temperature (thermocouple CH – A)
- oil pressure reaching indication

By means of separate controllers it provides power supply of three brushless motors of:
- starter
- electric motor of the fuel and oil pump
- oil centrifuge

Besides the electric motors, the control system provides power supply of the ignition device and fuel valve.

Control system switches the engine off in the following cases:
- low oil pressure
- unsuccessful start
- exceeding the high speed limit
- exceeding maximum permissible temperature of exhaust gases
- decreasing the speed below the low speed limit
- failure of the centrifugal oil separator

After the engine shutdown the control system ensures automatic aftercooling of hot parts of the engine; it switches feeding on the starter at a reduced power output and keeps the oil centrifuge running.

Possible modes of the engine operation

Name	Control voltage V-DC	Devices in operation
STOP	0 to 1	-
-	1 to 2	oil centrifuge
COOLING	2 to 3	oil centrifuge + starter (approx. 3000 rpm)
COLD CRANKING	3 to 4	oil centrifuge + starter (approx. 7000 rpm)
START + FUNCTION:	4 to 10	complete system
- idling	4 to 5	complete system except ignition
- maximal	5 to 10	complete system except ignition

Engine regulation support acceleration, declaration and sustains constant reduced engine speed according to temperature of inlet air. By the help of user's software is possible find our residual resurs, wardships hits, function monitoring – rotation speed, temperature etc. Engine operating and work monitoring is possible by serial busbar of CAN type from higher control system through CAN Aerospace V 1.6 protocol.

Control system is inbuilt together with switching sources in fore upper parts of engine. Connection of control system with engine electro equipment, battery and net of flying device is ensured by cable assembly, which is part of the engine. Onboard source is connected by + and – conductor. Rested inputs and outputs are ending by connector (for example except fuel stop valve) – see in enclosed electro schema.

5.4 Ignition system

It consists of an ignition source, connecting lead long approx.˜600 mm, and a spark plug built in the engine. It is a low-voltage, high-energy source; the spark plug is a semiconductor one, with a sliding spark. The ignition system is active for a limited time until stable burning is reached in the combustion chamber.
The ignition source is not a part of the engine; it must be installed on the airframe or is a part of the starting device, and is disconnected after the engine start.

5.5 Source unit

Source unit consists of the built-in three-phase generator, a rectifier, and the switched DC-DC source. In the range of speed approx.˜ 50 - 100%, sufficient voltage and power for self consumption of the engine is induced in the generator winding, and excess power can be used for the network consumption. Output voltage of the generator is rectified and modified to 28.0 V by the switched DC-DC source.
The source maintains the voltage 28.0 V up to the power output 1000 W; if current supply exceeds 28 A, the output voltage is decreased.

The generator is installed in the compressor intake. The rectifier and the switched source are a part of the control unit fixed on the engine suction neck.

VI. Description of the engine function

6.1 Starting the engine – START

The control unit, after the receipt of the start command either from the superior system or by applying control voltage on the input (voltage higher than 4 V), begins the starting process:

- It sets required speed of the centrifuge via the centrifuge speed controller, and checks the centrifuge function
- It ensures smooth start of the engine rotor by the control of the starter generator speed controller

When approx. ˜7% speed is reached:

- switches the ignition device power supply
- switches on the relay for the fuel valve feeding

- sets the fuel pump speed suitable for ignition of the mixture in the combustion chamber
- after mixture ignition, increase of the exhaust gas temperature above the set value of 150 °C and reach of the engine speed approx. 20%, disconnects the power supply of the starter, and the engine itself accelerates to idling or higher speed according to the request from the superior system. When approx.˜48% speed is reached, the power supply of the ignition device is disconnected.
- If the mixture does not ignite in the combustion chamber (speed is not reached in the set time of approx. 15 sec), the control system terminates the starting process.

6.2 Engine run – FUNCTION

The control unit regulates the engine speed according to the request from the superior system or according to the value of control voltage (4 – 5) to 10 V (50 to 100% speed of the turbo-jet engine), and:

- checks acceleration and deceleration
- checks exhaust gas temperature
- limits maximum speed of the turbo-jet engine at set intake air temperature
- checks the oil pressure switch switching
- checks permitted speed range

6.3 Stopping the engine - STOP

The control unit stops the engine when obtain advice:

- from the superior system
- if control voltage is between 0 - 1V
- from protection action

Engine stop as well as unsuccessful start results in:

- stop of the fuel and oil pump
- interruption of fuel valve supply
- delayed stop of the oil centrifuge
- aftercooling of the engine turbine - if the rotor speed drops to approx. 2000 rpm, the starter function is renewed, and the speed is maintained at approx. 2000 rpm by the controller. Aftercooling is performed for at least 30 seconds or until the exhaust gas temperature is decreased to a previously defined limit value.

6.4 Cold cranking

Cold cranking serves for the removal of unburned fuel from the combustion chamber, or for aftercooling of the turbine.
Cold cranking is defined by control voltage 3 - 4 V, the function time is limited to approx. 13 seconds.
When the control voltage is supplied on the control unit input:

- the oil centrifuge starts
- the starter is connected to the controller

The engine runs up to approx. 13% speed and engine is running for a limited time. Fuel supply and ignition function are blocked.
After the termination of the starter function, the oil centrifuge runs for approx. 30 seconds, and then it stops.

6.5 Cooling

The control unit sets the cooling mode either automatically after preceding start or at:
- command from the superior control system
- input control voltage 2 - 3 V

The cooling mode ensures smooth aftercooling of hot parts of the engine, and removes residual heat from the engine.
The cooling mode is terminated after 30 seconds, if the exhaust gas temperature drop below a specified limit.

VII. Selectable outfit of the engine

It is possible deliver device, which was newly developed specially for TJ100 engine at extra cost.

7.1 Electromagnetic fuel valve LUN 2475

Its inside diameter is Js6, and is open under tension (current drain 1,2 A).

7.2 Fuel filter 50µm

The screwing Js6 has character of protective filter with limited capacity. Fuel cleanness must be warrant at tanking!

7.3 Control throtle

Throtle is specifically developed for TJ 100 engine and allows analog control of all engine function by the help of DC tension 0 – 10 V, which is connected over connector and engine harness.

7.4 Monitoring panel

This panel allows optical monitoring of engine working with rotation speed indicator (50 - 108 %), exhaust gas temperature indicator (320 – 900 °C) and with 4 LED diode:
- reaching of operating mode
- additional charge function
- engine lubrication
- wardships hit

and with 2 buttons:
-diode checking
-blocking of wardships

Communication with control box of the engine proceed threw busbar CAN, power supply is from 24 V source.

7.5 Traffic pump DC II

This is displacement pump powered with DC motor 24V, pump is equipped with bypass valve for case of pump drop-out and with safety valve, which sustains optimal exhaust pressure (40 – 50 kPa) it is not dependent on tension and supply, this safety valve has capacity is suitable for all variants of TJ 100 engine.

7.6 Height sensor

This sensor support threw CAN busbar information for engine control box about flight

height and it is possible get optimal regulation characteristics of the engine, especially shorter acceleration and deceleration time.
Height sensor is not need for common working.

7.7 Fuel tank pressure valve

This is mini reducing valve connected for engines air output, valve provide constant pressure at fuel tank (pressure is variable in the range 20 – 50 kPa) for provision of engine function at different high.

7.8 Interface CAN – RS 232

Interface is HW susceptible control and checking of engine function at ground conditions with PC force.
Condition is user's SW installation.

7.9 User's SW

SW allows control, checking of engine function and reading of error message by PC.

7.10 Cockpit of the engine

For TJ 100A version was developed front and back cockpit form Al plate, this cockpit allow outer installation of the engine on pylon – see enclosed photo.
Cockpit could be dismount easily with support of gladhand, mounting of the engine require fittings with special transition pieces.

VIII. Reference

First serial produced pcs. of engines has been successfully tested at pressure chamber in the range of highs 0 – 8000 m at imitation of speed till 0,8 Ma. Good correspondence between calculation and reality has been acknowledged.
Last engines version is tested at flying laboratory L-13 – see. http://www.pbsvb.cz/dlt_motory.php
We achieved starting of engine at 6200 m altitude and engine function at 9700 m altitude. It has been produced 140 pcs. of engine in all versions till this time, most of them is applied as flying target (5 kinds). One of TJ 100 engine version is flying at USA in SALTO sailplane and it is authorized by FAA in experimental category – see. www.vertigoairshows.com

Assembling list of the TJ 100 engine

A) Equipment installed on the engine

- starter generator
- electronic control including switched source 28.0 V DC
- thermocouple CH-A for exhaust gas temperature
- thermo-sensor Pt100 for intake air temperature
- oil tank
- fuel-oil pump
- fuel oil exchanger
- bypass controller
- oil cooler
- oil filter
- oil centrifuge separator
- pressure switch
- oil-fuel cooler
- spark plug

B) Separately delivered equipment

Ignition unit
Ignition cable

C) Accompanying documents

Engine book
Operation and maintenance manual

D) Spare parts 1:1

Set of sealing parts

II. ADDITIONAL VARIABLE ACCESSORIES

- Elektromagnetic fuel valve
- Fuel filter
- Control throtle
- Monitoring panel
- Transport fuel pump
- Altitude sensor
- Fuel tank overpressure valve
- Interface CAN – RS 232
- Operating SW
- Front cover (for TJ 100 A)
- Back cover (for TJ 100 A)

Appendix No. 1