International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

# A Review-Differentiating TV2 and TV3 Series Turbo Shaft Engines

***[1]Lijalem Gebrehiwet, [2]Yared Nigussei, [3] Tesfu Teklehaymanot***

[1]M. Sc. Mechatronic Engineering, Beihang University (BUAA), Beijing, China; From ESSTI
[2]M. Sc. Aerospace Engineering, Defense Institute of Advanced Technology (DIT), India; From MIDI
[3]M. Sc. Gas Turbine Engineering, Defense Institute of Advanced Technology (DIT), India; From Power Engineering

DOI: https://doi.org/10.55248/gengpi.2022.3.8.55

**ABSTRACT**

The paper embodies differences of TV2/TV3 engines. The Klimov initially called as Isotov TV2/TV3 gas turbine turbo shaft engines used in Helicopters. It is designed to develop power required for the rotation of the rotors and consists of different parts. The engines internal constructions are source of driving power where as the external parts are accessories like starter, fuel system, oil system, e.t.c. Their main differences are mainly in engine construction and performance. It is a wide scope to cover and get basic parameters in all engine series. There are limitations in the availability of description manuals for TV series engines. In addition to this it requires engines' detail practical knowledge acquired by experience on TV series engine operation including test bench, ground and flight tests. It is not recommended to refer all manuals to get a specific technical and operational data in maintenance workshop for beginners or junior technicians. The engine power operation is directly affected by the cyclic and collective pitch sticks as well as the engine itself. Differentiating Isotov TV2/TV3 engines greatly help operators, Engineers, trainers and technicians to easily understand the basic data of Klimov engines installed on Russian Mil helicopters.

Keywords: Turbo shaft engine, Klimov, engine performance, Isotov engines, engine construction

## 1. Introduction

The most common engine used by helicopters is turbo shaft engines. It is applicable in most helicopters, marine and auxiliary power units. The turbo shaft plays a great role in the aviation industry as well as for industrial power generation [1].

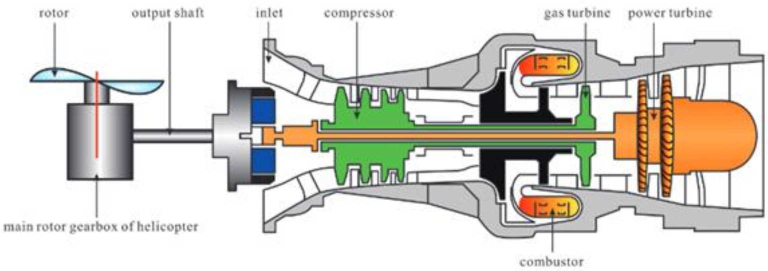


**Fig.1-General Turbo shaft engine configuration [2]**

The Figure above shows an internal view of a typical turbo shaft engine. Air is sucked and passed into engine inlet by means of a compressor. The compressor compresses the air to some temperature and low speed to facilitate smooth combustion. The compressor may have one to many stages of both centrifugal and axial compressors types.

This depends on the engine size, manufacturer and power output. Finally the compressed air is then sent through the combustor to burn with atomized fuels with raising the temperature of the air [1]. The TV2/TV3 series engine consists of different parts, components and systems. These are engine control system, engine starting system, inlet/outlet devices, engine cooling system, engine fuel system, engine oil system, engine fire fighting system, power transmission, main gearbox coupling, nacelles and cowling.

## 2. Literature Review

Turbo shaft engines used by Mil Russian helicopters are the Klimov TV2 and TV3 series engines.

### *2.1 Klimov TV2-117 series*

The Klimov TV2-117 initially sometimes called as Isotov TV2-117 is a gas-turbine turbo shaft engine used in Russian helicopters. It was designed in the early of 1960s by the Isotov design bureau and later produced by Klimov production in 1997 [3].

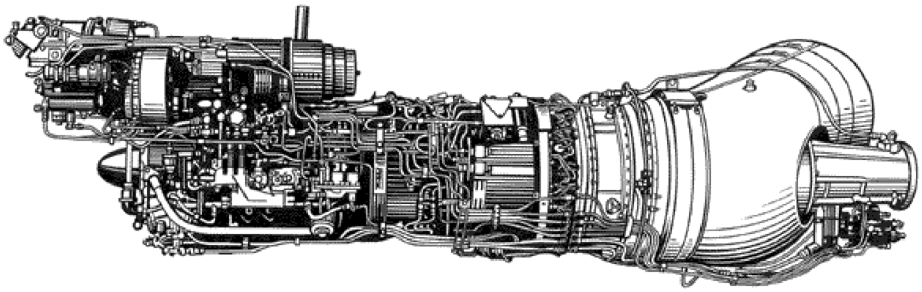

**Fig. 2- The Klimov TV2-117 turbo shaft engine [4]**

The TV2-117A is a turbo shaft engine with a free-turbine composed of two rotors namely the gas generator rotor in the front and the free power turbine at rear [5]. The TV2-117A engine features several improvements over the basic model. The modification is mainly on soft coatings in the compressor is substituted by tougher deposited coating on the steel parts of the stator.

**Table 1 The main features in TV2 series engines [6, 7];**

| | |
|---|---|
| TV2-117AG engine | Carbon sealing applied in the second bearing support |
| TV2-117A engine | Soft coatings are applied in the compressor are substituted by tougher deposited coating on the steel parts of the stator; |
| TV2-117F engine | It is used for Mi-8FT helicopter and certified in Japan under the US airworthiness standards (FAR-33). It has emergency power which made it distinctive feature; |
| TV-117TG engine | It equipped with fuel controls that was designed to operate on liquefied propane, butane, gasoline, gas condensates, kerosene, diesel fuel (summer or winter fuels as well as any mixture thereof). The engine is designed for operation on Mi-8TG helicopters in remote areas of Siberia. It is also operational at Arctic, Antarctic and other regions with an extremely harsh climate. |

### *2.2 Construction of Klimov TV2-117 series*

The helicopter power plant is designed to develop power required for the rotation of the rotors and it consists of the following engine parts; Ten-stage axial flow, two-stage compressor turbine, combustors (Eight-chamber can-annular), two-stage power turbine, exhaust pipe an engine mount and attachment units.

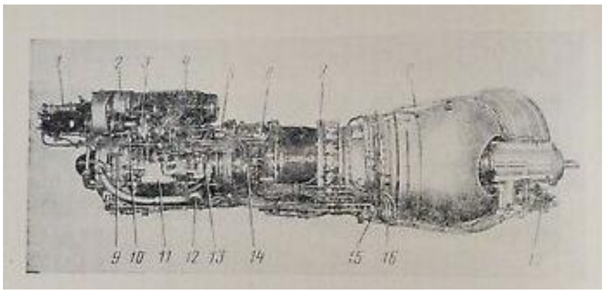

**Fig. 3- Engine parts [8]**

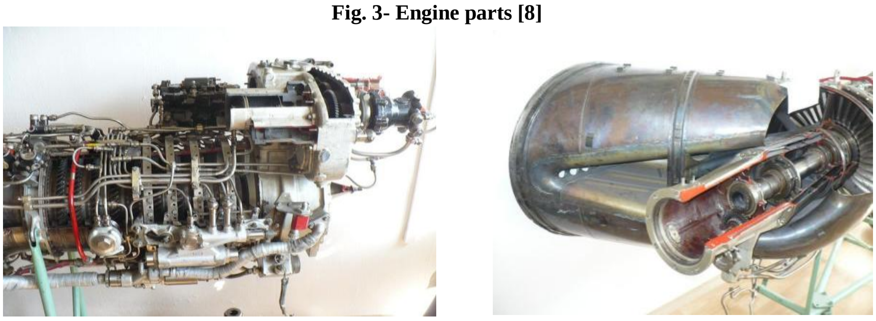

**Fig. 4- Inlet part with engine fuel system (Left); Exhaust pipe and turbine output shaft (Right) [9]**

Figure 5 below shows TV2-117A engine testing procedure and its final test results. First the starting torque is established at 100 Nm. The engine must be with the free turbine speed around 97 % in order to operate the engine for higher regimes [10].

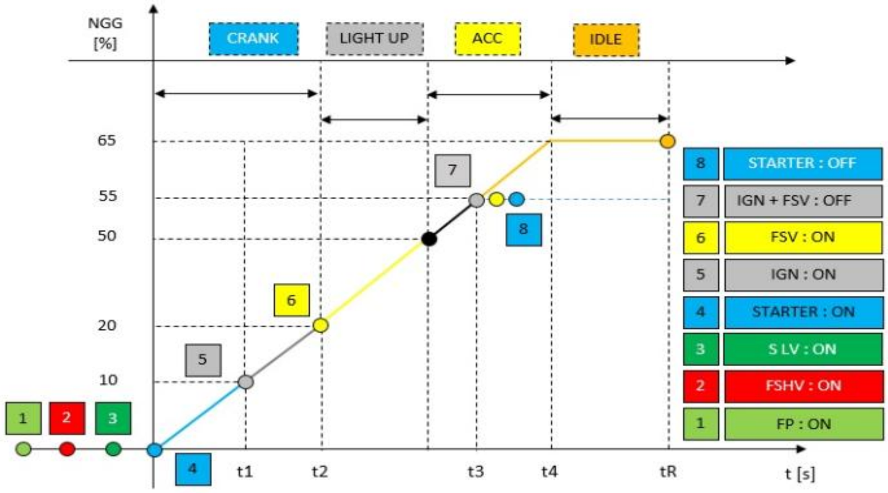


**Fig. 5- TV2-117A engine start-up diagram**

**Table 2 Principal specifications of the TV2-117 engine [6, 11]**

| **Specifications of TV2-117 engine** | |
|---|---|
| Full thrust performance at (H= 0, V= 0, ISA + 15°C) | |
| Take- off power, hp | 1500 |
| specific fuel consumption, g/hp/hr | 275 |
| Cruising performance (H=0, V=0, ISA+15°C) | |
| power, hp | 1000 |
| specific fuel consumption, g/hp/hr | 310 |
| Dimensions, mm | |
| Length | 2843 |
| Width | 550 |
| Height | 748 |
| Weight, kg | 334 |
| Overall pressure ratio: | 6.6:1 at 21,200 rpm |
| Air mass flow: | 8.1 kg/s (1,070 lb/min) |
| Turbine inlet temperature | 1,150 K (880 °C) |
| Specific fuel consumption : | 0.606 lb/(hp·h) (0.369 kg/kWh) |
| Power-to-weight ratio: | 2.06 hp/lb (3.39 kW/kg) |

### *2.3 Klimov TV3-117 series*

The TV3-117 engine is a turbo-shaft engine designed to drive the helicopter rotor and its auxiliary units. The engine is upgraded for a better performance requirement with a new model series called TV3. TV3-117 turbo shaft engine was developed in 1974. Later it was installed on 95% of all helicopters designed by Mil and Kamov Engineering Centre [12].

**Fig. 6- The Klimov TV3-117 turbo shaft engine [12]**

TV3-117 engines are the main power unit of Mi-8 / Mi-17 / Mi-171 / Mi-24 helicopters. There were a number of versions created for different types of helicopters. In the turbo-propeller version TV3-117VMA-SBM1 are even mounted on Antonov-140 aircraft. The power plants of these helicopters (except Mi-28) incorporate main gearboxes that were also developed by the Klimov Company such as VR-14, VR-24, VR-252 and VR-80 [12].

**Table 3 Different engine features for TV3-117 turbo shaft engine [13].**

| | |
|---|---|
| TV3-117M engine | "M" stands for "marine" for Mi-14 helicopters incorporates special features to be used at sea. |
| TV3-117MT engine | "MT" stands for "modernized, transport" was designed for Mi-8MT/Mi-17 helicopters |
| TV3-117KM engine | "KM" means Kamov, marine was designed for Ka-27 helicopters; |
| TV3-117V engine | "V" stands for "high altitude" was designed for Mi-24 helicopters operated in the mountains. |
| TV3-117VK engine | "VK" stands for high altitude and is a model similar to the TV3-117B engine. It is adapted to Ka-27, Ka-29 and Ka-32 helicopters. |
| TV3-117VM engine | "VM" means high altitude, modernized engine with features of automatic switch to emergency power. It was designed for Mi-28 helicopters. |
| TV3-117VMA engine | "VMA" stands for high altitude, modernized of model "A" and was designed for Ka-50 helicopters. Export models are equipped with TV3-117VMAR engines (an extra «R» stands for "power") whose rated power and cruising power are similar to those of the TV3-117VKR engine; |
| TV3-117(A) | A turbojet engine for unmanned reconnaissance aircraft Reis and Reis-D developed by the Tupolev Design Bureau. |

### *2.4 Construction of Klimov TV2-117 series*

The main parts of TV3-117 engines are 12 Stage Compressor (1), coupling twin shaft connecting two stage turbine with compressor (2), combustion chamber (3), two-stage turbine (4), free turbine (5), exhaust pipe (6), shaft from free turbine to reducer (7) as shown in the figure below..

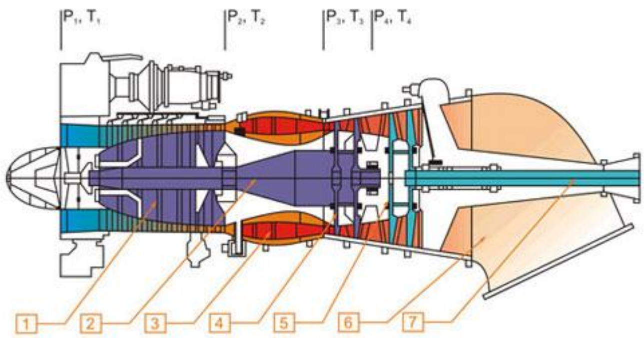


**Fig 7- Schematic section of TV3-117 engine [12]**

Behind the axial inlet device, we find a 12-stage axial compressor which compresses air for combustion. After the combustion chamber there is a two-stage compressor turbine and free turbine.

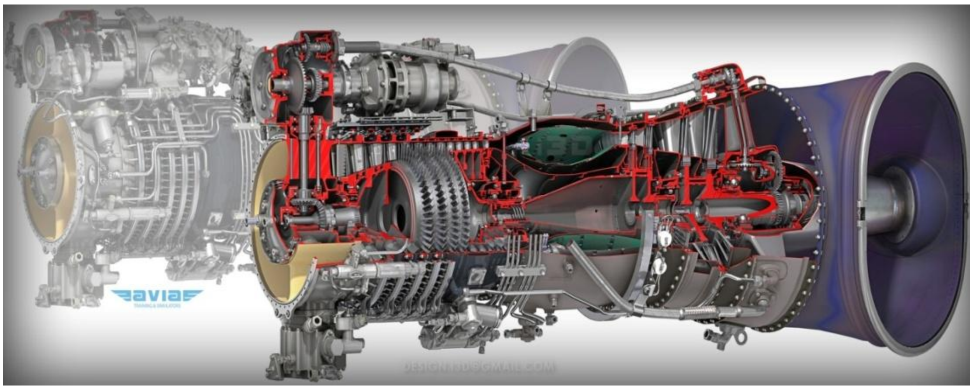


**Fig. 8- Internal parts of TV3-117 turbo shaft engine [14]**

Both engines on the helicopter work independently and can be shut down separately. The engine is started by an APU (auxiliary power unit) which is connected to the air starter turbine by hose. The starter turns the engine compressor on and at the specified speed the fuel ignites. After some operating regime, the starter is disconnected and the engine is already able to accelerate and maintain idle speed.

**Fig. 9- TV3-117. A two-stage turbine driving a compressor and a free turbine driving a rotor and aggregates [12]**

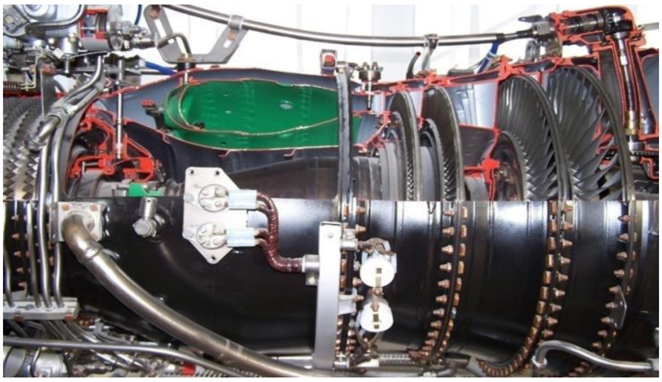

**Fig. 10- Section through the engine, the combustion chamber and turbine driving the turbocharger and the free turbine are visible [12]**

Oil system of aircraft engines are used for cooling and lubricating. The engine rotating parts run at high speeds with high temperatures. The main purpose of oil system is to ensure temperature control of individual engine to lubricate individual parts. The oil prevents corrosion and ensures that all lubrication points in the engine are vented. The fuel system is used to supply and regulation fuel to the combustion chamber in all modes of engine operation. The TV2-117 engines are started by a battery where as TV3-117 engine is started initially by air starter AI-9V which generated pressurized and high speed air to drive the engine.

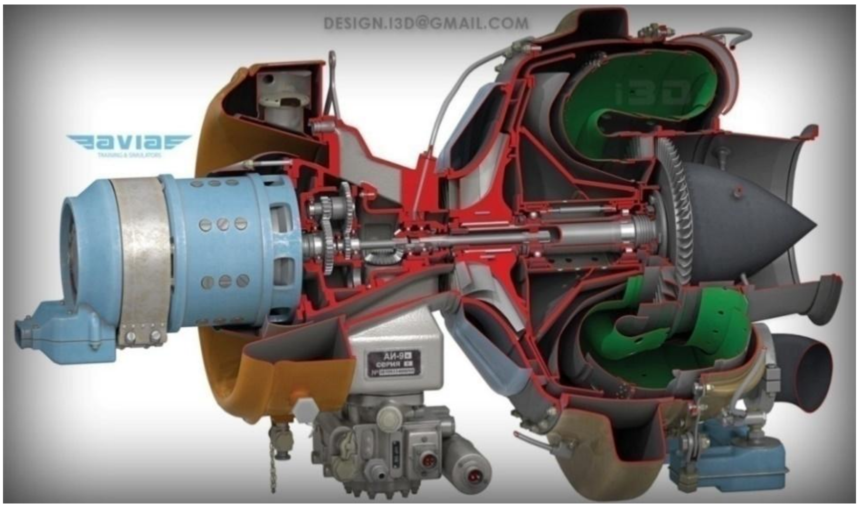


**Fig. 11- AI-9V airstarter [14]**

**Fig. 12- The inlet (compressor) section [15]**

**Table 4 Specifications of the TV2-117 engine [16]**

| TV3-117 versions (OEI) | TV3-117VM | TV3-117VMA |
|---|---|---|
| Emergency performance (H=0, V=0, ISA+15$^0$C): | | |
| power, hp | 2200 | 2400 |
| Takeoff performance | | |
| power (ISA+25/15$^0$C), hp | 2000 | 2200 |
| specific fuel consumption, g/hp/hr | 220 | 215 |
| Cruising performance (H=0, V=0, ISA+15°C) | | |
| power, hp | 1500 | 1500 |
| Dimensions, mm: | | |
| Length | 2055 | 2055 |
| Width | 660 | 660 |
| Height | 728 | 728 |
| Weight, kg | 295 | 295 |

Based on power plant system parts, we can differentiate roughly the major components (equipments) in the different Mil helicopters. This paper work only stresses some systems and components of the power plant.

## 3. Result and Summaries for Engine Differences

The helicopter power plant is designed to develop power required for the rotation of the rotors and it consists of the different engine parts. Based on these power plant components, we can differentiate roughly the major components (equipments) in different Mil helicopters. It covers their purpose, construction, location and data (parameter) related to the respective helicopters. The engine systems included in this study are;

- An engine
- An engine mount and attachment units
- An engine control system
- An engine starting system
- An inlet and outlet devices
- An engine cooling system
- Nacelles and cowling
- Fuel system
- Oil system
- Fire fighting system
- Power transmission and main gearbox

### *3.1 Engine TV-series general data [16,17,18,19,20,21,22]*

**Table 5 TV2/TV3 engine differences**

| **Parameter** | **Data** | **Remark** |
|---|---|---|
| Designation | Mi-8………TV2-117A<br>Mi-17……..TV3-117MT<br>Mi-24……..TV3-117A<br>Mi-35……..TV3-117B | The RH & LH engines of the power plant are interchangeable, subject to turning the exhaust stack. |

| | | |
|---|---|---|
| Type | Mi-8………Turbo-shaft free turbine<br>Mi-17……..Turbo-shaft free turbine<br>Mi-24……..Turbo-shaft free turbine<br>Mi-35……..Turbo-shaft free turbine | Turbo-shaft engine is free turbine type |
| Flight speed | Mi-8……….From 0 – 250Km/hr<br>Mi-17……...From 0 – 250Km/hr<br>Mi-24……...From 0 – 350Km/hr<br>Mi-35……...From 0 – 350Km/hr | |
| Flight altitude | Mi-8……….From 0 – 5000m<br>Mi-17……...From 0 – 5000m<br>Mi-24……...From 0 – 5000m<br>Mi-35……...From 0 – 5000m | Engine starting is ensured up to 4000m |
| Take off power | Mi-8………………...1500hp<br>Mi-17……………….2225(2200) hp<br>Mi-24……….........2200 h<br>Mi-35………………2100 hp | |
| Engine dry weight | Mi-8………………..330 kg $^{+2\%}$ max.<br>Mi-17………………285$^{\pm5.7}$ kg<br>Mi-24………………285$^{\pm5.7}$ kg<br>Mi-35………………285$^{\pm5.7}$kg | **Note:**<br>The engine dry mass does not include the mass of the following engine accessories:<br>- Fuel filter along with piping<br>- Gas generator tacho generator<br>- Oil pressure pick up<br>- Oil temperature sensor<br>- Thermocouple harness |
| Engine length with accessories and exhaust stack | Mi-8………………..2843mm<br>Mi-17………………2055mm<br>Mi-24………………2055mm<br>Mi-35………………2055mm | |
| Engine width with accessories and exhaust stack | Mi-8………………..550 mm<br>Mi-17………………650 mm<br>Mi-24………………650 mm<br>Mi-35………………650 mm | |
| Engine width with accessories and exhaust stack | Mi-8………………..748 mm<br>Mi-17………………728 mm<br>Mi-24………………728 mm<br>Mi-35………………728 mm | |

### *3.2 Compressor related data [16,17,18,19,20,21,22]*

**Table 6 Compressor differences**

| **Parameter** | **Data** | **Remark** |
|---|---|---|
| Sense of rotation (looking FWD) | Mi-8………………..CCW<br>Mi-17………………CCW<br>Mi-24………………CCW<br>Mi-35………………CCW | Compressor rotor. The compressor rotor is of drum-and-disc type |
| Compressor rotor rated rpm | Mi-8……………….12000rpm<br>Mi-17……………...19500rpm<br>Mi-24……………...19500rpm<br>Mi-35……………...19537.5rpm | |
| Compressor-Turbine rotor (Gas generator rotor) | Mi-8………………CCW<br>Mi-17……………..CCW<br>Mi-24……………..CCW<br>Mi-35……………..CCW | It is axial double stage rotor or known as $n_{gg}$ rotor |
| Compressor turbine inlet gas temperature | Mi-8………........850 max<br>Mi-17……………..990C$^0$<br>Mi-24……………..990C$^0$<br>Mi-35……………..990C$^0$ | About the compressor turbine<br>-It is of two-stage axial-flow type.<br>- It serves to rotate the compressor & the engine accessories.<br>Parts<br>- Turbine rotor (it consists of rotor shaft, two blade wheels, rotor rear journal, Labyrinth seal, covering disk & their fastening parts)<br>- Nozzle diaphragm assemblies (1st stage NDA |
| Compressor turbine outlet gas temperature | Mi-8………………600 C$^0$<br>Mi-17……………..640C$^0$<br>Mi-24……………..640C$^0$<br>Mi-35……………..640C$^0$ | |
| Compressor turbine axial speed | Mi-8……………..150m/s | |

| | | |
|---|---|---|
| of inlet gases | Mi-17……………160m/s<br>Mi-24……………160m/s<br>Mi-35……………160m/s | & 2nd stage NDA)<br>- Rotor bearing assemblies (3rd BA) |
| Compressor turbine axial speed of outlet gases | Mi-8……………...146 m/s<br>Mi-17…………….158m/s<br>Mi-24…………….158m/s<br>Mi-35…………….158m/s | |

### *3.3 Turbine related data [16,17,18,19,20,21,22]*

**Table 7 Turbine difference**

| Parameter | Data | Remark |
|---|---|---|
| Free turbine rotor | Mi-8………………..CCW<br>Mi-17………………CCW<br>Mi-24………………CCW<br>Mi-35………………CCW | Rotation is when looking FWD |
| Free turbine type | Mi-8………axial double stage<br>Mi-17……..axial double stage<br>Mi-24……..axial double stage<br>Mi-35……..axial double stage | Note:<br>• FTS are void of kinematical linkage.<br>• FT is sometimes called as power turbine.<br>• It serves to transmit power to the main rotor, tail rotor & accessories via gearbox.<br>Parts<br>• Rotor shaft<br>• Two bladed wheels<br>• Labyrinth seals &<br>• Fastening parts |
| Free turbine rated rpm | Mi-8………1200rpm<br>Mi-17……..1500rpm<br>Mi-24……..1500rpm<br>Mi-35……..1500rpm | |
| Maximum temperature of inlet gases | Mi-8………600 °C<br>Mi-17……..640 °C<br>Mi-24……..640 °C<br>Mi-35……..640 °C | Free turbine parameter |
| Temperature of outlet gases | Mi-8………400 °C<br>Mi-17……..440 °C<br>Mi-24……..440 °C<br>Mi-35……..440 °C | Free turbine parameter |
| Turbine pressure reduction | Mi-8………2.0<br>Mi-17……..2.4<br>Mi-24……..2.4<br>Mi-35……..2.4 | Free turbine parameter |
| Turbine efficiency | Mi-8………0.88<br>Mi-17……..0.9<br>Mi-24……..0.9<br>Mi-35……..0.9 | Free turbine parameter |

### *3.4 Compressor design [16,17,18,19,20,21,22]*

**Table 8 Compressor design differences**

| Parameter | Data | Remark |
|---|---|---|
| Compressor rotor type | Mi-8……………...axial type<br>Mi-17…………… axial type<br>Mi-24…………… axial type<br>Mi-35…………… axial type | |

| | | |
|---|---|---|
| Number of stages | Mi-8……………..10<br>Mi-17……………12<br>Mi-24……………12<br>Mi-35……………12 | It is before and after compressor during takeoff mode i.e at H=0 and V=0 |
| The rate of air pressure | Mi-8……………..1-7<br>Mi-17……………1-9.55<br>Mi-24……………1-9.55<br>Mi-35……………1-9.55 | |
| Air consumption | Mi-8…………….TBD<br>Mi-17……………8.75 Kg/s<br>Mi-24……………8.75 Kg/s<br>Mi-35……………8.75 Kg/s | It is at sea level and stand still<br>i.e at H=0 and V=0 |
| Temperature of air behind the compressor | Mi-8……………..372 °C max<br>Mi-17……………335 °C<br>Mi-24……………335 °C<br>Mi-35……………335 °C | |
| Axial speed of<br>air at compressor inlet | Mi-8…………….TBD<br>Mi-17…………...112 m/s<br>Mi-24…………...112 m/s<br>Mi-35…………...112 m/s | |
| Efficiency of compressor | Mi-8…………….TBD<br>Mi-17…………...0.855 m/s<br>Mi-24…………...0.855 m/s<br>Mi-35…………...0.855 m/s | |
| Compressor pressure ratio | Mi-8……………9.45max<br>Mi-17…………..9.45<br>Mi-24…………..9.45<br>Mi-35…………..9.45 | |
| Compressor design features | Mi-8……… Automatically controlled VGV of the IGV assembly.The$1^{st}$, 2nd&$3^{rd}$ stage stator assemblies, as well as automatically controlled air blow off valves.<br>Mi-17/Mi-24/Mi-35……..Have the same design except $4^{th}$ stage stator assemblies | For Mi-17/Mi-24/Mi-35……… Automatically controlled variable guide vanes of the IGVassembly.The$1^{st}$, $2^{nd}$, $3^{rd}$ and $4^{th}$stage stator assemblies, as well as automatically controlled air blow off valves. |
| IGV and stator assembly vane angles | Mi-8………..30° to 0°<br>Mi-17………$27^{\circ+1.5^\circ}$ to $-3^{\circ\pm0.5^\circ}$<br>Mi-24………$27^{\circ+1.5^\circ}$ to $-3^{\circ\pm0.5^\circ}$<br>Mi-35………$27^{\circ+1.5^\circ}$ to $-6.5^{\circ\pm0.5^\circ}$ | It is according to the hydraulic actuator dial reading<br>Note:<br>A/. The range shows closing to opening (upper to lower stop) according to compressor VIGV and VGV setting angle (setting dial)<br>B/. The turning is carried out automatically in the range from Ngg=80% to Ngg=100% |
| Number of air blow off valves | Mi-8……………2<br>Mi-17…………..2<br>Mi-24…………..2<br>Mi-35…………..2 | Note :<br>A/ For TB3 engines two valves bleeding air from $7^{th}$stage<br>B/ After $7^{th}$stage the air is of high temperature and it is discharged in to the atmosphere.<br>C/ A certain amount of air is diverted from compressor stage VII of each engine. This is used by the helicopter systems.<br>Compressor parts<br>- Rotor<br>- Casings<br>- Stator<br>- Two bleed valves<br>- Two rotor supports |
| Air bleed point | Mi-8……………..Downstream $6^{th}$stage<br>Mi-17……………From stage 7 or 12 of compressor<br>Mi-24……………After stage 7<br>Mi-35……………After stage 7 | |
| Air blow off valve closing rpm | Mi-8……………$53^{\pm30}$ %<br>Mi-17…………..TBD<br>Mi-24…………..TBD<br>Mi-35…………..TBD | |

| | | |
|---|---|---|
| Minimum compressor rotor cost down time | Mi-8……………40 mn<br>Mi-17…………..50 mn<br>Mi-24…………..50 mn<br>Mi-35…………..50 mn | Compressor rotor at start |
| Air bleed point | Mi-8……………downstream 8th stage<br>Mi-17…………..after 7thstage<br>Mi-24…………..after 7thstage<br>Mi-35…………..after 7thstage | |

### *3.5 Combustion Chamber [16,17,18,19,20,21,22]*

**Table 9 Combustion chamber differences**

| **Parameter** | **Data** | **Remark** |
|---|---|---|
| Combustion chamber type | Mi-8……..Annular with 8 fuel burners (nozzles)<br>Mi-17/24/35…….Annular with 12 fuel burners | Annular type |
| Quantity of fuel manifolds | Mi-8……………..2<br>Mi-17……………2<br>Mi-24……………2<br>Mi-35……………2 | Parts:<br>Diffuser outer casing<br>Diffuser inner casing<br>Flame tube<br>Fuel manifold<br>Fuel nozzles<br>Ignition plug<br><br>Note:<br>The fuel nozzles are of duplex and centrifugal type |
| Quantity of ignition plug | Mi-8……………..2<br>Mi-17……………2<br>Mi-24……………2<br>Mi-35……………2 | |
| Inlet temperature | Mi-8…………….TBD<br>Mi-17……………335 ºC<br>Mi-24……………335 ºC<br>Mi-35……………335 ºC | |
| Out let temperature | Mi-8…………….TBD<br>Mi-17……………990 ºC<br>Mi-24……………990 ºC<br>Mi-35……………990 ºC | |
| Maximum temperature | Mi-8…………….TBD<br>Mi-17……………2300 ºC<br>Mi-24……………2300 ºC<br>Mi-35……………2300 ºC | |

### *3.6 Exhaust system [16,17,18,19,20,21,22]*

**Table 10. Exhaust system differences**

| **Parameter** | **Data** | **Remark** |
|---|---|---|
| Exhaust system design | Mi-8……….Fixed area with exhaust pipe arranged at 60º relative to the engine axis<br>Mi-17……..FAE arranged to 60º<br>Mi-24……..FAE arranged to 60º<br>Mi-35……..FAE arranged to angles between 75º & 105º relative to the horizontal plane | FAE-Fixed Area Exhaust |
| Maximum temperature | Mi-8……………..1500 ºC<br>Mi-17……………2300 ºC<br>Mi-24……………2300 ºC<br>Mi-35……………2300 ºC | **Parts:**<br>Diffuser outer casing<br>Diffuser inner casing<br>Flame tube<br>Fuel manifold<br>Fuel nozzles<br>Ignition plug<br>Note:<br>The fuel nozzles are of duplex and centrifugal type |

### *3.7 Permissible time of engine operation during overhaul periods in percent to total service life [16, 17, 18, 19, 20, 21, 22]*

**Table 11. Permissible time of engine operation**

| Parameter | Data | Remark |
|---|---|---|
| At takeoff power | Mi-8……………..1%<br>Mi-17……………1%<br>Mi-24……………1%<br>Mi-35……………1% | Note:<br>- Characterized by maximum permissible speed of turbo compressor<br>- IR-117 indicator is above mark "**H"**<br>- Twist grip fully up & collective pitch up most ($15^0$) |
| At limited takeoff | Mi-8……………..5%<br>Mi-17……………5%<br>Mi-24……………5%<br>Mi-35……………5% | Note:<br>A/ 5% includes 1% of the T.O. power<br>B/ Limited T.O. is when there is no armament, full crew and limited fuel Qty<br>C/ Limited take off is always less than take off power<br>D/ T.O. =full fuel + armament + full crew E/ when Ngg=100%, Nmr=95.4%<br>F/ Ngg=100% is equivalent to Nft= |
| At max continuous power | Mi-8……………..40%<br>Mi-17……………40%<br>Mi-24……………40%<br>Mi-35……………40% | Note:<br>- IR-117A indicates above "**K"**<br>- Twist grip fully right correction & collective pitch up |
| At cruising power | Mi-8…………unlimited | |
| At cruise II power | Mi-17………unlimited<br>Mi-24………unlimited<br>Mi-35………unlimited | Note:<br>- It is obtained by optimum power setting (with less fuel)<br>- It is obtained by turning the twist grip CW and increasing the collective pitch to the value at which IR-117 EPR indicator is below the value of "K".<br>***ИР-117A engine pressure ratio (EPR) indicator |
| At cruise I power | Mi-17………unlimited<br>Mi-24………unlimited<br>Mi-35………unlimited | |
| At idle power | Mi-8……………..TBD<br>Mi-17……………20 mn<br>Mi-24……………20 mn<br>Mi-35……………20 mn | Note:<br>- It is selected by twisting the twist grip CCW and pushing the collective pitch fully down ward. |

### *3.8 Engine ground acceleration [16,17,18,19,20,21,22]*

**Table 12. Engine ground acceleration differences**

| Parameter | Data | Remark |
|---|---|---|
| From start button depressed up to idle power | Mi-8…………..60secs<br>Mi-17…………60secs<br>Mi-24…………60secs<br>Mi-35…………60secs | |
| From idle to T.O. power | Mi-8…………15 secs<br>Mi-17…………9 secs<br>Mi-24…………9 secs<br>Mi-35…………9 secs | |

| | | |
|---|---|---|
| From cruise to T.O. power | Mi-8…………..4 secs<br>Mi-17…………4 secs<br>Mi-24…………4 secs<br>Mi-35…………4 secs | Note:<br>Max. Continuous power = Nominal = Right correction. They are similar terminologies |
| From idle to right correction | Mi-8…………..3 to 6 secs<br>Mi-17…………3 to 6 secs<br>Mi-24…………3 to 6 secs<br>Mi-35…………3 to 6 secs | |
| From start to takeoff | Mi-8…………..3 secs<br>Mi-17…………5 secs<br>Mi-24…………5 secs<br>Mi-35…………5 secs | |

### *3.9 Maximum permissible time of engine continuous operation [16,17,18,19,20,21,22]*

**Table 13 Max permissible time of engine**

| **Parameter** | **Data** | **Remark** |
|---|---|---|
| At T.O. power & limited T.O. | Mi-8…………..60 mn<br>Mi-17…………60 mn<br>Mi-24…………60 mn<br>Mi-35…………60 mn | Note:<br>60 mn is part of the 5% of the service life. From 15-30mn only two time is permitted in the service life (it is part of 5%), from 30-60mn it is permitted only once in the service life. After that the engine and main gear box are subjected replacement |
| At max continuous power | Mi-8…………..60 mn<br>Mi-17…………60 mn<br>Mi-24…………60 mn<br>Mi-35…………60 mn | |
| At cruising power | *For TV3-117 engine*<br>*-At cruise II*<br>Mi-17…………unlimited<br>Mi-24…………unlimited<br>Mi-35…………unlimited<br>*-At cruise I*<br>Mi-17…………unlimited<br>Mi-24…………unlimited<br>Mi-35…………unlimited | Note:<br>There is no **cruise I I and I** power in<br>Mi-8 helicopter instead there is cruise power only.<br>.<br>For Mi-8…………..unlimited |
| At idle power | Mi-8…………..20 mn<br>Mi-17…………20 mn<br>Mi-24…………20 mn<br>Mi-35…………20 mn | Note**:**<br>The number denotes that;<br>**A/** we should not operate the engine in the idle power more than **20 mn**<br>**B/** the idle power is not recorded on the record sheet of flying hr |
| Permissible time of engine operation within the service life | Mi-8…………..2000 hrs<br>Mi-17…………2000 hrs<br>Mi-24…………2000 hrs<br>Mi-35…………2000 hrs | |

### ***3.10 Maximum permissible Ngg rpm at all speeds, altitudes of flight and engine ground acceleration (Ngg, gas generator rotor rpm)***[16,17,18,19,20,21,22]

**Table 14 Max permissible of Ngg**

| **Parameter** | **Data** | **Remark** |
|---|---|---|
| At take off power | Mi-8…………..101%<br>Mi-17…………101%<br>Mi-24…………101%<br>Mi-35…………101% | |
| At limited take off | Mi-8…………..-<br>Mi-17…………105%<br>Mi-24…………105%<br>Mi-35…………105% | *** Fluctuation of Ngg of steady state power |

| | | |
|---|---|---|
| At max continuous power | Mi-8…………..100%<br>Mi-17…………98%<br>Mi-24…………98%<br>Mi-35…………98% | condition at max. Continuous and cruise I power is up to ±5% |
| At cruising power | Mi-8…………..96.5%<br>*For TV3-117 engine*<br>*-At cruise II*<br>Mi-17…………96%<br>Mi-24…………96%<br>Mi-35…………96%<br>*-At cruise I*<br>Mi-17…………94%<br>Mi-24…………94%<br>Mi-35…………94% | |
| At idle power | Mi-8…………..$64^{+2}$%<br>Mi-17…………$73^{+6}$%<br>Mi-24…………$73^{+6}$%<br>Mi-35…………$73^{+6}$% | Note:<br>Fluctuation of Ngg at steady state power condition at cruise II and below is up to ±0.7%. |

### *3.11 Turbine inlet temperature (TIT) at all speeds & altitude of flight [16,17,18,19,20,21,22]*

**Table 15 TIT differences**

| **Parameter** | **Data** | **Remark** |
|---|---|---|
| At take off power | Mi-8…………..880$^{o}$C ,max<br>Mi-17…………990$^{o}$C ,max<br>Mi-24…………990$^{o}$C ,max<br>Mi-35…………990$^{o}$C ,max | Note:<br>The range is 975˚C-990˚C for TB3 engines |
| At limited take off | Mi-8………….. -<br>Mi-17…………999$^{o}$C ,max<br>Mi-24…………999$^{o}$C ,max<br>Mi-35…………999$^{o}$C ,max | |
| At max continuous power | Mi-8…………..860$^{o}$C ,max<br>Mi-17…………955$^{o}$C ,max<br>Mi-24…………955$^{o}$C ,max<br>Mi-35…………955$^{o}$C ,max | Note:<br>The range is 900˚C-955˚C for TB3 engines |
| At cruising power | Mi-8…………..880$^{o}$C ,max<br>*For TV3-117 engine*<br>*-At cruise II*<br>Mi-17…………870$^{o}$C ,max<br>Mi-24…………870$^{o}$C ,max<br>Mi-35…………870$^{o}$C ,max<br>*-At cruise I*<br>Mi-17…………910$^{o}$C ,max<br>Mi-24…………910$^{o}$C ,max<br>Mi-35…………910$^{o}$C ,max | Note:<br>The range is 870˚C-910˚C for TB3 engines<br>Note:<br>The range is 830˚C-870˚C for TB3 engine |
| At idle power | Mi-8…………..600$^{o}$C<br>Mi-17…………780$^{o}$C ,min<br>Mi-24…………780$^{o}$C ,min<br>Mi-35…………780$^{o}$C ,min | Note:<br>Max number of consecutive starting attempts is 5 to be followed by at least 15mn shut down for cooling. |

### *3.12 Main rotor speed (Minimum permissible) [16,17,18,19,20,21,22]*

**Table 16 Main rotor speed difference**

| **Parameter** | **Data** | **Remark** |
|---|---|---|
| In transient conditions of flight (during 30 sec) | Mi-8…………..89%<br>Mi-17…………88%<br>Mi-24…………88%<br>Mi-35…………88% | |

| | | |
|---|---|---|
| In auto rotation with engine running (no time limitations) | Mi-8…………..TBD<br>Mi-17…………88%<br>Mi-24…………88%<br>Mi-35…………88% | Note:<br>It is allowed during 5 sec and four times during the service life |
| At landing with ballooning (free fall) | Mi-8…………..TBD<br>Mi-17…………75%<br>Mi-24…………75%<br>Mi-35…………75% | |
| At failure of one engine | Mi-8…………..86%<br>Mi-17…………75%<br>Mi-24…………75%<br>Mi-35…………80% | For Mi-36 80% is in very rare cases<br>Note:<br>It is allowed during 10 seconds and four times in service life |
| Max. Permissible MR rotational speed at all power conditions in emergency case | Mi-8…………..86%<br>Mi-17…………75%<br>Mi-24…………75%<br>Mi-35…………80% | Note:<br>1/ The number of over speeding (108% or 105%) should not exceed two times during first over haul.<br>2/ It should not exceed 6 times during the service life.<br>3/ The deviation of each over speeding should not exceed 20sec or for<br>Mi-8………5sec<br>Mi-17…….20sec<br>Mi-24………….20sec<br>Mi-35…………20sec<br>4/ During engine failure of one engine, the second engine can operate in<br>T.O. mode for not more than 1hr. After that the engine or main gear box Should be replaced. |

### *3.13 Fuel regulating pump [16,17,18,19,20,21,22]*

Pump-regulator NR-series unit is intended for fuel supply and automatic control of the engine TV3-117. It ensures:

- Fuel metering of engine during starting, acceleration and deceleration;
- Maintain the preset operation modes according to the turbo-compressor rotor speed and free turbine speed;
- Synchronizing air pressure behind compressors

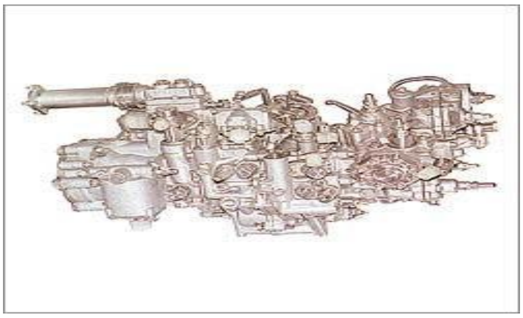

**Fig. 13- Pump-regulator NR-3A**

**Table 17 Fuel regulating pump differences**

| Parameter | Data | Remark |
|---|---|---|
| Fuel regulating pump designation | Mi-8………….. HP-40BГ (HP-40BP)<br>Mi-17………… HP-3MT<br>Mi-24………… HP-3A<br>Mi-35………… HP-3B | Simultaneous operation of two engines;<br>▪ Change of fuel feed as provided by the electronic regulator signs;<br>▪ Fuel distribution around the nozzles;<br>▪ Engine stop; |

| | | |
|---|---|---|
| Type | Mi-8………….. plunger<br>Mi-17………… plunger<br>Mi-24………… plunger<br>Mi-35………… plunger | ▪ Control of compressor directional devices. |

*3.14 DC starting generator [16,17,18,19,20,21,22]*

**Table 18 DC starting generator differences**

| Parameter | Data | Remark |
|---|---|---|
| Designation | Mi-8………….. ГС-18МО or ГС-18ТО<br>Mi-17………… not available<br>Mi-24………….not available<br>Mi-35………… not available | Note:<br>DC starter generator is not found in 3nd series engines the reason is that they have AI-9V air starter but Mi-8 does not have it. |
| Quantity | Mi-8…………..1 | |
| Sense of rotation | Mi-8…………..CCW | |
| Gear ratio | Mi-8…………..0.41 | |

*315 Differentiating engine starting system [16, 17, 18, 19, 20, 21, 22]*

It is used to spin up the gas generator rotor at starting to the required rotational speed and it starts the engine on ground as well as in the air. It is operated by the air supplied by АИ-9В in case of TV3 series engine and is mounted on the upper portion of the engine. It consists of air valve, control unit, turbine, reduction gear & air filter.

**A. The auxiliary power plant (gas turbine engine)**

Mi-8 ------------------- DC generator
Mi-17 ------------------ АИ-9В
Mi-24------------------ АИ-9В
Mi-35 ----------------- АИ-9В

**B. Interchangeability of АИ-9В**

Mi-8 with Mi-17, Mi-24, Mi-35…………….Mi-8 has not AI-9V
Mi-17 with Mi-24, Mi-35……………………interchangeable
Mi-24 with Mi-35……………………………interchangeable

**C. Air starter**

Mi-8…………………………………...null
Mi-17/Mi-24/Mi-35 …………………CB-78

*3,16 Engine Operating Conditions & Parameters (at H=0, V=0) [16, 17, 18, 19, 20, 21, 22]*

Factors to be considered when tabulating the data for engine operations are listed below. The limited observed speed, $n_{obs}$ is indicated by the MR tachometer generator mounted on the MGB.

**i.** CTIGT is for Compressor Turbine Inlet Gas Temperature
**ii.** There is no cruise & cruise II modes for Mi-8
**iii.** 100% of compressor rotor rpm corresponds to
Mi-8 ………………….21200
Mi-17…………………19500
Mi-24…………………19500
Mi-35…………………19500
**iv.** 100% free turbine rpm corresponds to
Mi-8 ………………….12000
Mi-17…………………15000
Mi-24…………………15000
Mi-35…………………15000

### *3.17 Summary of operating parameters*

| Parameters | **Operating Conditions** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **Mi-8** | | | | **TB3-117 (Mi-17, Mi-24, Mi-35)** | | | | |
| | **Take Off** | **Maximum Continuous** | **Cruising** | **Idle** | **Take Off** | **Maximum Continuous** | **Cruise I** | **Cruise II** | **Idle** |
| CTIGT (Cº) | 850 | 790 | 750 | 600 | 975 | 900 | 870 | 830 | 780 |
| Max. permissible For CTIGT (Cº) | 880* | 860 | 810 | TBD | 990 | 955 | 910 | 870 | TBD |
| Max. SFC (g/hphr) | 275 | 295 | 310 | 100kg/hr | 230 | 250 | 270 | 290 | 165 kg/hr max. |
| shaft power (hp) | $1500_{-30}$ | $1200_{-24}$ | $1000_{-20}$ | | 2225-44 | 1700-34 | 1500-30 | 1200-24 | 200 max |
| Ngg (%) | 98.5 | 96 | 94.5 | +2 | 97.5 ±0.5 | 94.7±0.5 | 93.5± 0.5 | 91.5± 0.5 | 73+6 |
| Ngg, max (%) | 101 | 100 | 98 | 64-1 | 101 | 98 | 96 | 94 | 79 |
| Nft (%) | 101 | 98 | 96.5 | | 98±1 | 100±2 | 100±2 | 100±2 | 65.5 |
| Nmr (%) | $93_{-1}$ | 95±2 | 95±2 | 45±10 | 93±1 | 95±2 | 95±2 | 95±2 | - |
| Oil temp. (Outlet) (Cº) | 30 to125 | | | 40 to+125 | | | | | |
| Fuel pressure (Pf) (kgf/cm$^2$) | 60max | - | - | 18 to 35 | | | | | |
| Oil pressure (Po) (Kgf/cm$^2$) | 3 to 4 | | | 2 to 4 | | | | | |
| Max time of Continuous operation (mn) | 6 | 60 | | 20 | | | | | |

## 4. Conclusion

We conclude that the Isotov TV2 and TV3 or the second and third series engines are totally different in engine construction as well as performance. The TV3 Klimov engines have higher performance and capable of operating in higher terrains (Altitudes). Among the third series engines namely TV3-

117A, TV3-117V, TV3-117MT and TV3-117VM; the VM series engine is more modernized, high altitude engine and updated model of “A”. Mostly the constructions of third series engine are similar.

**References**

John Schenderlein, and Tyler Clayton “Comparison of Helicopter Turboshaft Engines”, University of Colorado, Boulder, CO, 80304, Dec 2015.

Nannan Gu, Xi Wang and Feiqiang Lin “Design of Disturbance Extended State Observer (D-ESO)- Based Constrained Full-State Model Predictive Controller for the Integrated Turbo-Shaft Engine”, Rotor System, pp 2, 2019.

Propulsion plant online (2022).TV2-117engine.

Retrieved from http://www.propulsionplant.ru/dvigateli/aviacionnye-raketnye-morskie promyshlennye/82178217zavod-imeni-v-ja-klimova82178217-gunpp/tv2-117.html

Biblioclub online (2022). Engine encyclopedias.

Retrieved from https://biblioclub.ru/index.php?page=dict&termin=645751&lang=en

Razvan Marius Catana, GrigoreCican and Gabriel Dediu “Gas Turbine Engine Starting Applicated on TV2-117 Turboshaft”, Engineering, Technology & Applied Science Research, Vol. 7, No. 5, 2017, Bucharest, Romania

Available at https://en.wikipedia.org/wiki/Klimov_TV2-117

Available at http://all-aero.com/index.php/64-engines-power/13152-klimov-tv2-117-isotov-tv2-117

Available at https://picclick.co.uk/AIRCRAFT-ENGINE-Klimov-TV2-117-HELICOPTER-MI-8- ARMY-RUSSIAN-363326516800.html

Available at https://www.valka.cz/SOV-Klimov-TV2-117-t114283#397971Version: 0

Răzvan Marius Catană, Gabriel Dediu and Cornel Mihai Tărăbîc “Studies and Experimental Research in the Evaluation of TV2-117A Turboshaft Engine Working Regimes”, MDPI, April 2022, Bucharest, Romania. https://doi.org/10.3390/app12073703.

Available at https://www.klimov.ru/en/production/helicopter/TV2-117/

Available at https://221sqn.cz/motory-tv3-117/

Available at https://en.wikipedia.org/wiki/Klimov_TV3-117

Available at https://ingwar_3d.artstation.com/projects/XdRNR

Available at https://www.armedconflicts.com/Klimov-TV3-117-t114284

TV2-117A maintenance manual

TV2-117A Engine testing and operational manual

Mi-8 helicopter flight manual

TV3-117A maintenance manual

TV3-117A Engine testing and operational manual

Mi-17 helicopter flight manual

Mi-24D/Mi-35 helicopter flight manual