FINAL REPORT

ACCIDENT 2021/1037

State Commission on Aircraft Accidents Investigation (PKBWL)

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FINAL REPORT

ACCIDENT

OCCURRENCE NO – 2021/1037

AIRCRAFT – Tecnam Astore, I-C326

DATE AND PLACE OF OCCURRENCE – 9 May 2021, EPZP

The Report is a document presenting the position of the State Commission on Aircraft Accidents Investigation concerning circumstances of the air occurrence, its causes and safety recommendations. The Report was drawn up on the basis of information available on the date of its completion.

The investigation may be reopened if new information becomes available or new investigation techniques are applied, which may affect the wording related to the causes, circumstances and safety recommendations contained in the Report.

Investigation into air the occurrence was carried out in accordance with the applicable international, European Union and domestic legal provisions for prevention purposes only. The investigation was carried out without application of the legal evidential procedure, applicable for proceedings of other authorities required to take action in connection with an air occurrence.

The Commission does not apportion blame or liability.

In accordance with Article 5 paragraph 6 of the Regulation (EU) No 996/2010 of the European Parliament and of the Council on the investigation and prevention of accidents and accidents in civil aviation […] and Article 134 of the Act – Aviation Law, the wording used in this Report may not be considered as an indication of the guilty or responsible for the occurrence.

For the above reasons, any use of this Report for any purpose other than air accidents and accidents prevention can lead to wrong conclusions and interpretations.

This Report was drawn up in the Polish language. Other language versions may be drawn up for information purposes only.

WARSAW 2022

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Abbreviations

Abbreviation	Meaning
AFIS	Aerodrome Flight Information Service
AFM	Airplane flight manual
ANSV	Agenzia Nazionale per la Sicurezza del Volo (Italy)
ARC	Airworthiness Review Certificate
ARP	Aerodrome Reference Point
ATOM	Actual Take-Off Mass
ATS	Air Traffic Services
AZL	Ziemia Lubuska Aero Club
CG	Center of Gravity
CofR	Certificate of Registration
EASA	European Aviation Safety Agency
EH	Engine Hours
EW	Empty Weight
FH	Flight Hours
IIC	Investigator in Charge
LAPL	Light Aircraft Pilot Licence
LDA	Landing Distance Available
LMT	Local Mean Time
MAC	Mean Aerodynamic Chord
METAR	Meteorological Aerodrome Report

MM	Maintenance Manual
MTOM	Maximum Take-off Mass
POH	Pilot Operating Handbook
PPL(A)	Private Pilot Licence (aeroplanes)
RPM	Revolutions per minute
RWY	Runway
SEP(L)	Single Engine Piston (Land)
TORA	Take-off Run Available
TOW	Take-off Weight
TSN	Time since new
ULC/CAA	Civil Aviation Authority of the Republic of Poland
UTC	Coordinated Universal Time
VFR	Visual Flight Rules
VMC	Visual meteorological conditions
VML	Correction for defective distant, intermediate and near vision
WBR	Weight and Balance Report
WGS 84	World Geodetic System 1984

General information

Occurrence reference number:	2021/1037			
Type of occurrence:	ACCIDENT			
Date of occurrence:	9 May 2021			
Place of occurrence:	EPZP			
Type and model of aircraft:	Aeroplane, Tecnam Astore			
Aircraft registration marks:	I-C326			
Aircraft user/operator:	Private			
Aircraft Commander:	PPL(A)			
Number of victims/injuries:	Fatal	Serious	Minor	None
	1	-	-	-
	ULC, EASA, ANSV			
Investigator-in-Charge:	Roman Kamiński			
Investigating Authority:	State Commission on Aircraft Accidents Investigation (PKBWL)			
Accredited Representatives and their advisers:	Accredited Representatives – ANSV Technical adviser – Engineer of Tecnam company			
Document containing results:	Final Report			
Safety recommendations:	No			
Addressees of the recommendations:	Not applicable			
Date of completion of the investigation:	07.07.2022			

Summary

On 9 May 2021, the pilot intended to make an enroute (touring) flight with the Tecnam Astore airplane, registration marks I-C326, from the Przylep aerodrome near Zielona Góra (EPZP) to the Żar aerodrome (EPZR). Around 09:08[1] the pilot reported start of the engine in hangar and then taxied to RWY 24 threshold. Short of the threshold the pilot performed an engine run-up and following the information from the AFIS about traffic situation at the aerodrome, he entered RWY 24 and commenced take-off around 09:15. The aircraft lifted off after a 150 m take-off run and commenced a climb.

After reaching an altitude of approximately 30 - 40 m, near the halfway point of the runway, the pilot reported a problem with the engine operation (without providing any details) and the intent to land downwind. Following that, the pilot aborted the climb and changed the direction of the flight to the right. Then, he began a left turn.

The pilot made a low-altitude turn with increasing bank angle, which led to stall and spin of the airplane. While in the first phase of spin, the airplane hit the apron (runway strip perimeter) with its left wing and propeller, then rebounded and moved several meters to the direction of the flight, and then burst into flames. Witnesses took action to extinguish the fire using fire extinguishers available at the aerodrome. As a result of the accident, the pilot died on the spot.

The investigation into the occurrence was conducted by the PKBWL Investigation Team in the following composition:

Roman Kamiński	Investigator-in-Charge
Jacek Bogatko	Team Member
Grzegorz Pietraszkiewicz	Team Member

After the investigation PKBWL determined following causes of the accident:

Bringing the aircraft to stall and spin due to the following pilot errors following the decision to land downwind:

- **failure to gain an appropriate speed for emergency landing;**
- **making a 180º turn at a low altitude prohibited in airplane flight manual;**
- **exceeding the maximum allowable bank angle when making a turn.**

[1] The time in the report is in the LMT = UTC+2.

Contributing factors:

- Aircraft mass close to MTOM;
- Wind direction pushing the aircraft to the left at the final stage of the turn.

After completing the investigation, PKBWL has not proposed any safety recommendations.

1. FACTUAL INFORMATION

1.1. History of flight

On 9 May 2021, the pilot intended to make an enroute (touring) flight with the Tecnam Astore airplane, registration marks I-C326, from the Przylep aerodrome near Zielona Góra (EPZP) to the Żar aerodrome (EPZR).

Around 09:08, the pilot reported the start of the engine in hangar and then taxied to RWY 24 threshold. Sort of the threshold pilot performed an engine run-up and following the information from the AFIS about traffic situation at the aerodrome, entered RWY 24 and commenced take-off around 09:15. The airplane lifted off after a 150 m take-off run and commenced a climb.

Based on the recordings from the aerodrome cameras as well as witness statements, no noticeable problems related to the take-off process occurred during this phase of the flight. After reaching an altitude of approximately 30-40 m near halfway of the runway, the pilot reported a problem with the engine (without providing any details) and his intention to perform a downwind landing. Following that, the pilot aborted the steep climb and changed the flight direction to the right. Then, he began a left turn, intending to return to RWY 06.

The pilot was making a low-altitude turn with increasing bank angle, which led the airplane to stall and spin. During the first phase of the spin the airplane hit the airfield with its left wing and propeller. Then, the airplane bounced and moved several meters in the direction of flight and burst into flames. The airplane tanks were full of fuel. The witnesses began to extinguish the fire using fire extinguishers found at the aerodrome. Firefighting was continued after the arrival of the firefighters from State Fire Service. As a result of the impact, the pilot died at the scene.

Fig. 1 shows a time-lapse recording of the airplane take-off.

Fig. 1 The course of the take-off reconstructed using time-lapse photography made at 1-second intervals
[source: a camera on a house on the outskirts of the EPZP aerodrome].

1.2. Injuries to persons

Injuries	Crew	Passengers	Others	Total
Fatal	**1**	**-**	**-**	**1**
Serious	**-**	**-**	**-**	**-**
Minor	**-**	**-**	**-**	**-**
None	**-**	**-**	**-**	**-**

1.3. Damage to aircraft

The airplane was destroyed as a result of the collision with the ground and fire. A major part of the airframe structure burned down (Fig. 2), while the engine was damaged to a much lesser extent.

Fig. 2 Wreckage at the place of collision with the ground [source: PKBWL]

1.4. Other damage

As a result of the fire, a grassy surface of approximately 40 m² was destroyed.

1.5. Personnel information (crew data)

Pilot – male, aged 71.
Holder of PPL(A) with SEP(L) rating valid until 31 May 2021.

The validity of the SEP(L) rating has been determined based on documents from the aviation personnel register maintained by the CAA. The register also contains documents confirming the renewal of the rating in 2017.

The available version of the license issued on 1 September 2014 shows an entry for renewal of SEP(L) rating until 31 August 2016. The license does not contain any entries about the renewal of rating in 2017 and 2019.

Medical assessment - Class II with VML limitation valid until 12 August 2021; LAPL valid until 12 August 2022.
Total flight time - approximately 1500 - 2000 FH (according to the statement of the family of the pilot).
Total flight time on Tecnam Store aircraft – 182 FH.
Flight time from 20 July 2020 on the Tecnam Astore aircraft - 23 FH.

1.6. Aircraft information

1.6.1. General information

Tecnam Astore is a single-engine, two-seat low wing airplane equipped with a tricycle landing gear with a nose wheel. The structure is mostly metal, with fairings in carbon and glass fibers with epoxy matrix. The airplane involved in the accident was equipped with a ROTAX 912ULS engine and a two blade fixed pitch wooden-composite wrapped Sensenich propeller.

Certificate of Registration (CofR) - valid on the date of the occurrence:

- Register number - I-C326 (Italian Civil Aircraft Register);
- Entry date - 4 December 2015;
- Aircraft declared for permanent residence in Poland on 16 March 2016. (Register of Civil Aircraft - item 5/2016).

Tecnam provided information that for ultralight aircraft Certificate of Airworthiness is not required. Instead, the Certificate of Compliance was issued on 10 February 2016.

Third party insurance - valid on the date of the accident:

- issue date - 29 May 2020;
- expiration date - 28 May 2021.

Fig. 3 Tecnam Astore demonstration airplane [source: manufacturer's website, https://www.tecnam.com/aircraft/astore/]

1.6.2. Service life data

AIRFRAME - Tecnam Astore

Serial number	044
Manufacture year and month	December 2015
Time since new (TSN)	240 FH

Airframe total cycles since new (ATCSN)	235
Date of the last check	10 May 2019
at the total flight time	118 FH
Maintenance check was performed by a licensed aircraft mechanic.	
Airframe flight time since the last check (annual/100 FH)	122 FH

ENGINE - Rotax 912ULS2 - 01

Manufacture year	2015
Serial number	6784767
Date of engine installation on the airframe	February 2, 2016
Total Time Since New (TTSN)	241 EH
Date of last maintenance check (annual/100 FH/5 years)	08/05/2021
after TTSN	239 EH
Maintenance check was performed by a licensed aircraft mechanic.	
Engine operation time since the last check	2:00 EH

Propeller - Sensenich W68T2ET -70J

Year of manufacture	2016
Serial number	AK6462
Date of propeller installation on engine	2 February 2016
Time since new (TSN)	240 FH
Date of the last inspection (annual/100 FH)	10 May 2019
after TTSN	118 FH
Inspection performed by a licensed aircraft mechanic.	
Propeller operation time since the last check (annual/100 FH)	122 FH

1.6.3. Maintenance

Airframe and propeller maintenance was performed by licensed aircraft mechanics until 10 May 2019 (date of the last maintenance). In the aircraft maintenance book there are no entries confirming annual/100 FH maintenance in 2020 as well as 100FH/5 years in 2021 (maintenance after five years relates to the replacement of rubber hoses).

Engine maintenance was performed by licensed aircraft mechanics in a timely manner and in accordance with the Engine Maintenance Manual.

According to Italian regulations, the owner of the aircraft is responsible for the maintenance and making entries in the maintenance book.

Since 20 July 2020, the user (the pilot who performed the accident flight) has not made any entries in the maintenance book.

1.6.4. Weight and balance

Weight and Balance Report:

- aircraft weighing date: 2 February 2016;
- MTOM: 600 kg;
- EW: 414 kg;

- CG: 25.4% MAC.

The weighing report was provided by Tecnam.

TOW and CG values of the aircraft were calculated by the Commission for the flight on 9 May 2021.

a) fuel:
   - automotive gasoline Pb 95: 114 l;
   - density at 15°C: 720÷775 kg/m3;
   - weight: 85 kg (for a density of 745 kg/m3);

b) pilot: approx. 80 kg;

c) luggage: approx. 20 kg.

Based on the above data, the following calculations were carried out:

- TOW: approx. 599 kg;
- CG: 27.6% (acceptable limits: 19 - 32%)

Calculations were carried out according to the loading and balancing sheet (AFM).

1.7. Meteorological information

The flight was performed in daylight in VMC .

METAR report from the time of the accident, made for EPZG aerodrome located 29 km northeast of EPZP aerodrome.

METAR EPZG 090900Z 18008KT 130V210 CAVOK 19/05 Q1014

- date: 09/05/2021;
- time: 09:00 UTC;
- wind direction: 180°;
- wind speed: 8 kt;
- wind from extreme directions: 130° - 210°;
- visibility: 10 km and more, no phenomena;
- ambient temperature: 19°C;
- dew point temperature: 5°C;
- pressure: QNH 1014 hPa;

The general wind direction and speed was confirmed by the flight coordinator of EPZP aerodrome.

1.8. Aids to navigation

Not applicable.

1.9. Communications

The pilot maintained radio communication with the EPZP flight coordinator on the 130.780 MHz frequency. Correspondence in both directions was clear.

1.10. Aerodrome information

The accident occurred at the Przylep aerodrome (EPZP).

Fig. 4 EPZP aerodrome [source: Google Earth, PKBWL analysis]

Status - Public use aerodrome, CAA registry no. 17.
Aerodrome reference point - N51°58'46.3″ E15°27'50.6″.
Aerodrome elevation - 253 ft.
RWY - 062/242 (06/24), 720 x 180 m (1110 x 180 m), grassy surface.

1.11. Flight recorders

The accident aircraft was not equipped with flight recorders.

1.12. Wreckage and impact information

The airplane was destroyed as a result of the collision with the ground and fire. A major part of the airframe structure burned down except for strength parts, landing gear and some of the components installed in the cabin and on the firewall. Essential parts of the engine sustained the least damage. However, the components installed on the outside of the engine have been deformed and partially burned.

1.13. Medical and pathological information

The investigation team did not obtain any information about factors that may have affected the pilot's condition, thus contributing to the occurrence of the accident.

1.14. Fire

After collision the ground, the airplane burst into flames. Aerodrome personnel took immediate firefighting action using two powder generators and portable fire extinguishers. The fire was partially suppressed. The State Fire Service team that arrived to the accident site extinguished the smoldering materials with powder extinguishers. The firefighters have also used one current of water to extinguish some of the fire outbreaks exposed to the strong wind.

1.15. Survival aspects

As a result of the collision with the ground and following fire, the pilot died on the spot. The pilot was wearing a seat belts, which was torn and partially burned. A helicopter of the Medical Air Rescue based at the EPZP (600 m from the accident site) also arrived at the scene.

1.16. Tests and research

1.16.1. Reconstruction of the flights from CCTV cameras recordings of 8 and 9 May 2021

PKBWL used recordings from CCTV cameras installed on the AZL building and on a private building located on the outskirts of the aerodrome. Frames from both videos were assembled into a single image shown in horizontal plane in Fig. 5.

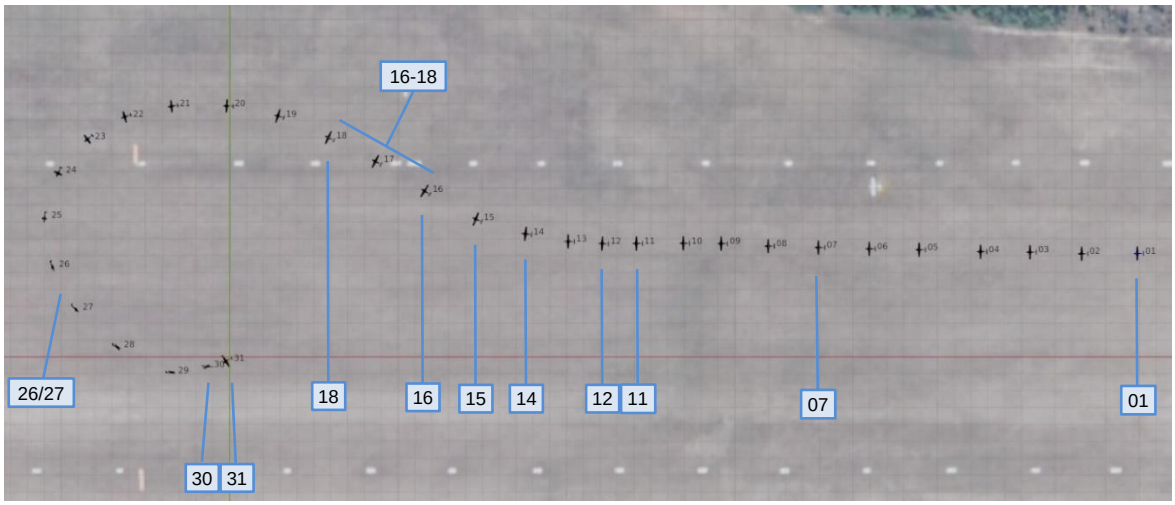

Fig. 5 Horizontal plane from position 01 [source: PKBWL analysis].

The CCTV recording from the AZL building cover position 01-31 whereas the recordings from the cameras installed on a private house cover position 09-31.

The locations of the airplane maneuvers and recorded phenomena (black and white smoke) that may have influenced the event are marked in Fig. 5.

The following positions were selected for further analysis:

- 01 immediately after the airplane lift-off and the beginning of the climb;
- 07 beginning of a steep climb;
- 11 end of a steep climb and the moment when most likely the pilot reported a problem with the engine;
- 12 beginning of a right turn;
- 14 appearance of a puff of black smoke behind the airplane;
- 15 appearance of a puff of white smoke behind the airplane;
- 16 the end of a right turn;
- 16-18 horizontal flight;
- 18 beginning of a left turn;
- 26/27 initiation of airplane stall and entry into spin;

30 airplane collision with the ground;
31 position of the wreckage after coming to rest.

PKBWL has also reconstructed two flights from EPLS on 8 May 2021 (the day before the accident). Those flights parameters were used as comparison material for the analysis of the accident flight.

1.16.2. Fuel

The following data were used to estimate the quantity of fuel present in the airplane tanks prior to the accident flight:

- fuel before the test flight 34 l;
- fuel consumed during the test flight approx. 6 l;
- fuel added at EPLS aerodrome on 8 May 2021 39,1 l;
- fuel consumed during the flight to EPZP approx. 6 l;
- fuel added at EPZP aerodrome on 8 May 2021 53,21 l.
- **fuel quantity prior to the accident flight** **approx. 114.31 l**

Quality certificates for the fuel (automotive PB 95) added on 8 May 2021 has been secured. The fuel fueled up at EPZP was examined by the members of PKBWL. It did not contain any contamination or water.

1.16.3. Airframe, cockpit and propeller

During the visual inspection of the accident site on 9 May and 13 May 2021, PKBWL determined that the airframe components had been damaged to an extent that made it impossible for PKBWL to assess its technical condition prior to the accident.

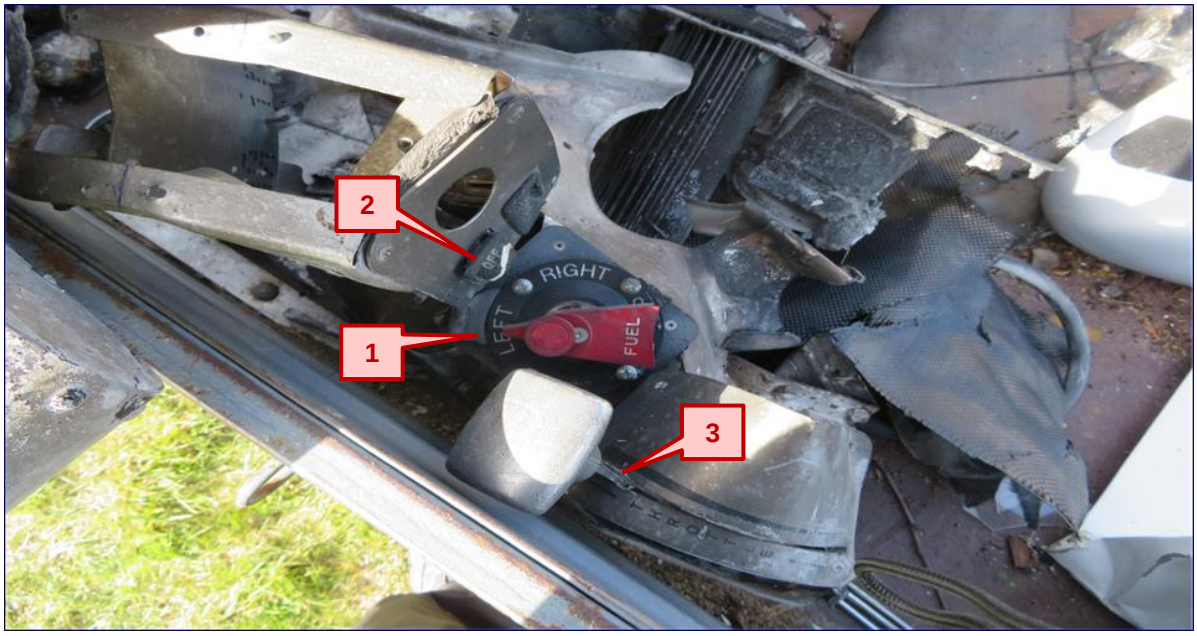

Fig. 6 Settings of: fuel valve (1), electric fuel pump switch (2), throttle lever (3) [source: PKBWL analysis].

During the examination of the elements from the airplane cabin found at the accident site, PKBWL determined the position of the following elements: fuel valve (left tank), electric fuel pump switch (off), throttle control lever (in the maximum rotation position).

The propeller blades (wooden-composite wrapped) were broken off due to the collision with the ground and have been found at the scene.

1.16.4. Engine

During the visual inspection of the accident site on 9 May and 13 May 2021, it was determined that parts of the engine and its components sustained numerous mechanical damages as a result of the collision, whereas the electrical wires and elements of the ignition system were destroyed due to the fire. The main part of the engine, visible from outside, was only slightly damaged.

Fig. 7 Engine view [source: PKBWL].

Taking into account the mechanical condition described above and high probability of identifying possible damage prior to the accident, PKBWL ordered the engine examination (Rotax 912ULS2 - 1). The disassembly and examination of the engine was carried out on 16 – 18 August 2021, in the Institute of Aviation in Warsaw, in the presence of a representative of PKBWL and an expert of the Prosecutor's Office.

Institute of Aviation provided an expert opinion on 13 September 2021.

1.16.5. Expert opinion results

1) “Left” carburetor

The carburetor was ripped out of the engine and was hanging on one cable from the throttle control. The carburetor showed damage that occurred primarily due to the fire (Fig. 8).

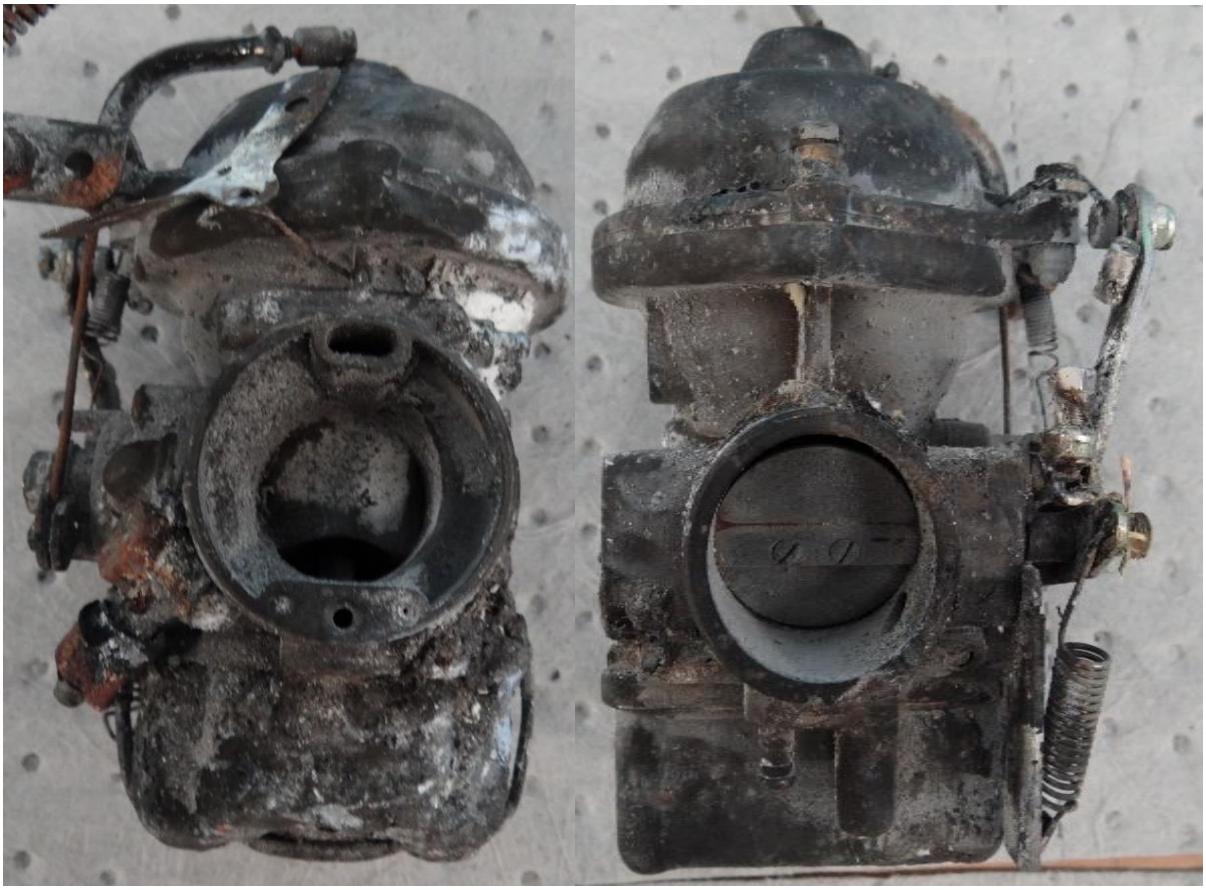

Fig. 8 View of the left carburetor from the throttle and air intake side [source: Institute of Aviation expert opinion].

Damage to the floats caused by heat exposure was detected after removing the float bowl cover (Fig. 9). The floats have been weighed; their total weight was 5,750 g (according to MM < 7 g).

Fig. 9 View of the interior of the float chamber with damaged floats [source: Institute of Aviation expert opinion].

As a result of heat exposure, the control diaphragm of the carburetor piston was burned (Fig. 10); the intake valve control lever was not rotating.

Fig. 10 View of carburetor body and carburetor piston with debris of burnt diaphragm [source: Institute of Aviation expert report].

The rest of the carburetor components were operative and in a good mechanical condition.

2) "Right" carburetor

The carburetor had no visible signs of heat exposure. The floats were not damaged and their total weight was 6.2641 g.

All components of that carburetor were functional and their interaction did not raise any reservations (Fig. 11).

Fig. 11 View of the "right" carburetor from the control side [source: Institute of Aviation expert opinion].

3) Electric fuel pump

An operation test of the pump was performed (Fig. 12). One end of a hose was submerged in the aviation fuel tank, while the other was connected to the intake spigot. When the pump was powered with 12 V direct current, it started operating and pumping the fuel in a continuous manner.

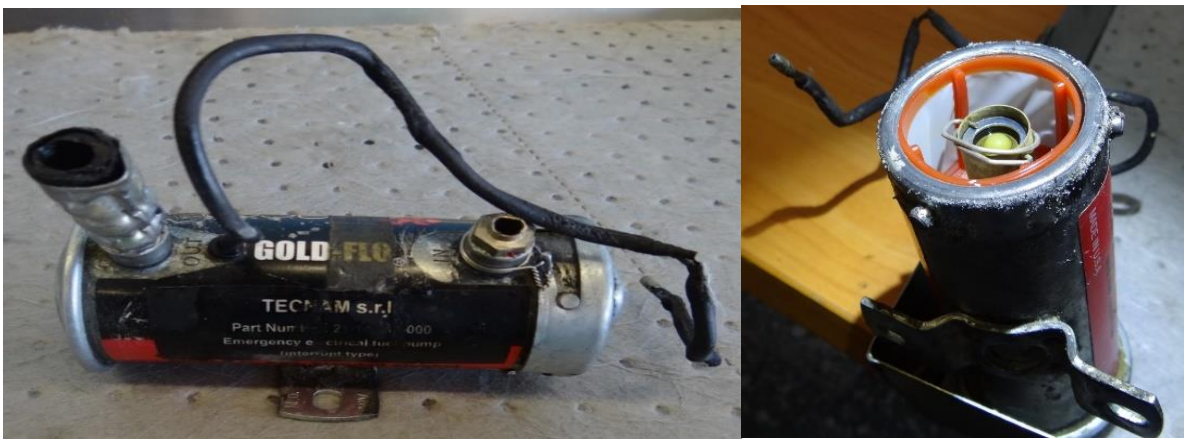

Fig. 12 View of electric fuel pump [source: Institute of Aviation expert opinion]

4) Mechanical fuel pump

Fig. 13 General view of the mechanical fuel pump [source: Institute of Aviation expert opinion]]

An operation test of the mechanical fuel pump was performed (Fig. 13). When the suction hose was immersed in fuel and the drive pin was pressed, fuel was flowing out through the pressure line without any external leakage

. 

Fig. 14 View of mechanical fuel pump after disassembly [source: Institute of Aviation expert opinion]]

After disassembly, no damage to the diaphragm or valves was found (Fig. 14).

5) Spark plugs

NGK DCPR 8R spark plugs were installed in the engine (in accordance with the recommendations of the manufacturer). The electrode gap - 0.7 - 0.75 mm - was confirmed on all spark plugs. According to the applicable standard, it should be within 0.6 - 0.9 mm limit.

Fig. 15 View of the ignition spark of the lower spark plug in cylinder no. 3 [source: Institute of Aviation expert opinion].

In addition, the plugs were tested with a SPT101 type tester. During the test, a clear electric arc was observed between the electrodes. Fig. 15 shows a plug from cylinder

no. 3. However, the condition of the other spark plugs was comparable to the figure above.

There was no carbon deposit on the plugs. Only a velvety black residue on the face (visible in the above photo) was found.

6) Electrical and ignition systems

The electrical wires were burned to a considerable extent (Fig. 16 a).

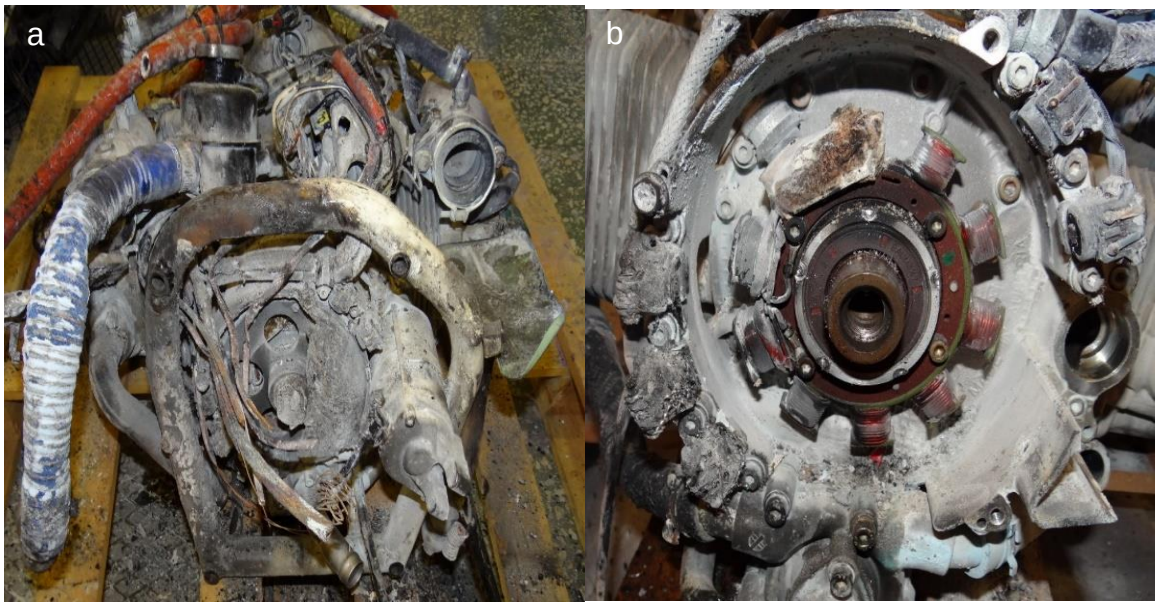

Fig. 16 View of the electrical system (a) and ignition coils (b) [source: Institute of Aviation expert opinion].

The ignition system was damaged to a much lesser extent that the electrical system (Fig. 16 b).

7) Crankshaft rotation test

Free rotation of the crankshaft and reciprocating motion of the crank-piston system was confirmed.

8) Cylinders, pistons

Fig. 17 View of the piston of cylinder no. 2 [source: Institute of Aviation expert opinion].

No damage was found on the piston and piston rings (Fig. 17). Pistons and rings in the other cylinders were found in a similar mechanical condition.

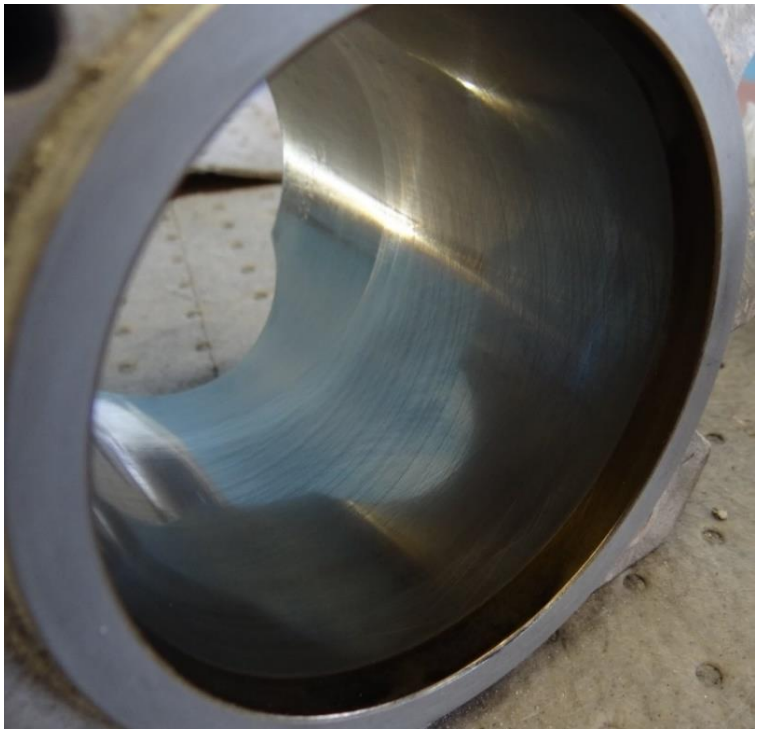

Fig. 18 View of cylinder no. 2 [source: Institute of Aviation export opinion].

No scratches, signs of overheating or other damage were detected on the inner surface of cylinder no. 2. However, clear traces of internal treatment of the cylinder surface using the honing method were visible. The mechanical condition of the other cylinders was comparable to that shown in Fig. 18.

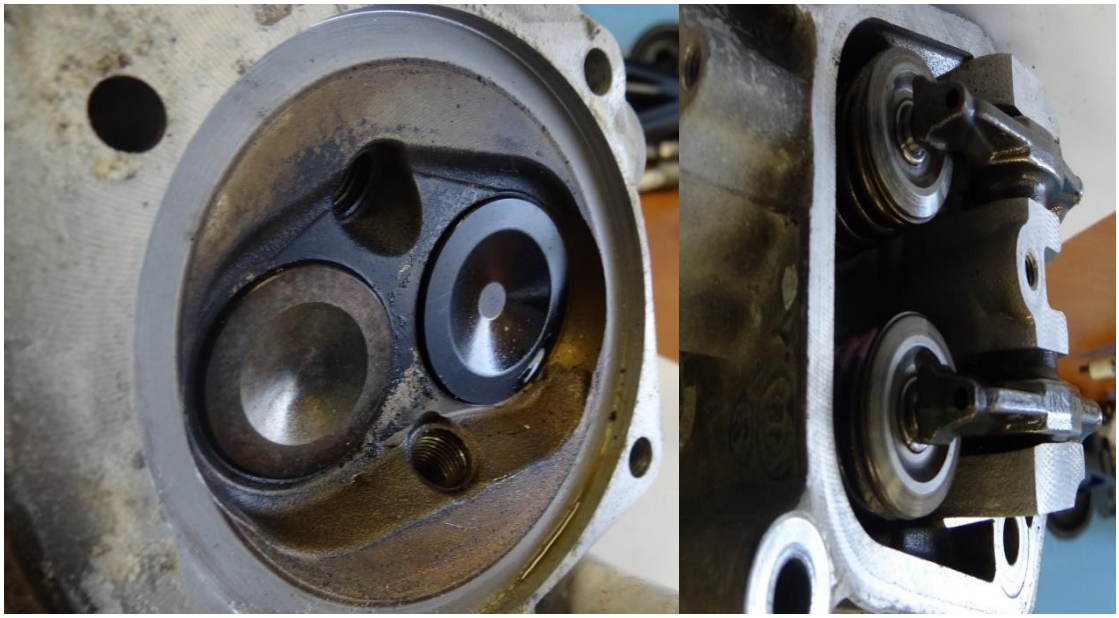

Fig. 19 Cylinder head no. 4 with visible intake and exhaust valves
and engine timing gear components [source: Institute of Aviation expert opinion].

The intake and exhaust valves as well as timing gear components of all cylinders were found intact (Fig. 19).

Fig. 20 View of cylinder and piston crown of cylinder no. 2 [source: Institute of Aviation expert opinion].

Large quantity of lubrication oil was visible in cylinder no. 2 (Fig. 20). A similar quantity of oil was also found in cylinder no. 4 located on the same side of the engine. Oil penetrated into those cylinders from the crankcase during transportation and storing the engine for several months after the accident.

9) Oil and cooling system

The oil tank and the mesh filter were inspected. No contamination was found. The oil pump was removed. It was not damaged and the rotation of the crankshaft caused its impeller to rotate freely. Moreover, no damage to the impeller was found after removing the coolant pump case.

After cutting the filter cartridge out from the oil filter, its condition was inspected; no filings or other pollution was detected (Fig. 21).

Fig. 21 View of the oil filter cartridge [source: Institute of Aviation expert opinion].

10) Reduction gear

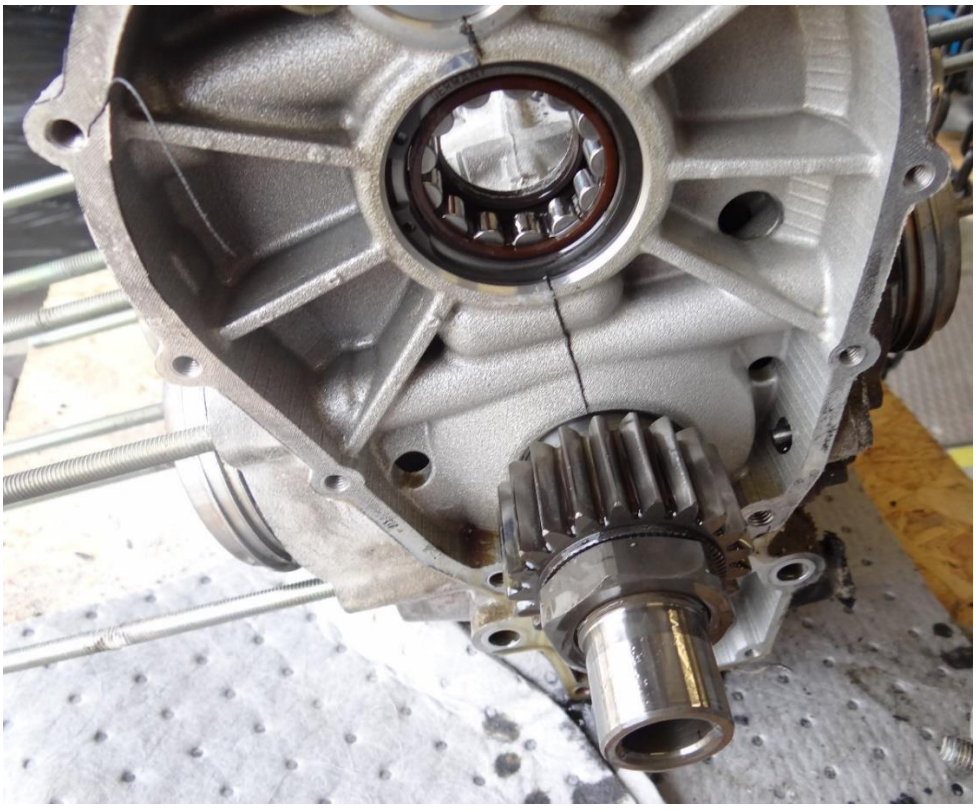

Fig. 22 View of the reduction gear [source: Institute of Aviation expert opinion].

Inspection of the disassembled gear parts revealed no damage to the body, shafts, gears or bearings. (Fig. 22).

1.16.6. Technical documentation, statements and other materials

The available documentation and statements of the mechanics performing the maintenance proved, that there was no information about malfunctions or other remarks when the aircraft was delivered for maintenance.

Based on the collected documents and statements, the circumstances of preparation and performance of the last maintenance on the engine completed on May 8, 2021 were established. In late February 2021, the owner and the pilot (hereafter, the term "pilot" shall refer to the person who performed the accident flight) arrived at EPLS aerodrome in a Tecnam Astore airplane to make arrangements for the date and scope of the engine maintenance at the Rotax Authorized Service Facility. During that visit, the initial assessment of the condition of the engine was conducted. For this purpose, the mechanic performed a test run of the engine in the presence of the owner, which showed fluctuations of the oil pressure (within acceptable limits). The owner had the oil pressure sensor replaced during the service. Other engine parameters did not exceed any limits. The owner flew the airplane to EPLS for maintenance, confirmed the scope of the maintenance to be performed and stated that sometimes the operation of the engine was rough. The owner's statement indicated that he had flown two solo flights with the airplane. Following remarks about the rough operation of the engine, the mechanic additionally checked the condition of the floats in the carburetors. The floats were replaced with new ones because their weight exceeded the applicable limits. Moreover, gas pitch leaks from the connection between the head and the cylinder were detected during the inspection of the engine. Connections on all cylinders were sealed by grinding the mating parts. The inaccuracies described above could have had an impact on the rough operation of the engine.

On May 13, 2021, the Investigation Team verified the scope of performed maintenance 100 F/yearly/5 years in the maintenance documentation at the EPLS airfield. The condition of technical equipment, availability of MM and bulletins necessary to perform maintenance was also checked. The documentation of the maintenance organization showed that the maintenance was carried out within the compulsory scope and were confirmed by entries related to the materials and operating fluids used for maintenance. The parameters of engine operation during the engine tests were within the limits defined in MM. The rubber hoses and mechanical fuel pump were replaced after 5 years of engine operation as part of the maintenance.

In addition to the engine maintenance, the GRS rescue system (Galaxy 60/600) was removed and sent to the manufacturer in the Czech Republic for inspection after 5 years of operation. At the time of the accident the rescue system was still held by the manufacturer. The pilot accepted to perform flights without the system until its return from the inspection.

Prior to the flight test on 8 May 2021, the mechanic noticed that the sound of the operating engine was different than usual. He approached the airplane to determine the cause of the difference together with the pilot. At the same time, the pilot told the mechanic that he was not able to establish communication. After the cabin inspection,

the mechanic noticed that the headphones were not plugged into the audio jack. In addition, he noticed that the choke valve lever was on, which affected the operation of the engine. After setting the valve off, the engine operated properly and the pilot began taxiing.

After the flight test, the pilot did not report any problems with the engine. Then he refueled the airplane on EPLS and flew to EPZP. After landing, pilot confirmed by phone that the engine was airworthy.

The owner of the plane confirmed that a fire broke out on the plane during refueling about 1.5 year prior to the accident. The fire was extinguished and the fuel tank was rinsed several dozen times. After that, the plane was released for further operation. The extent and nature of damage during the fire could not be determined due to lack of witnesses. The owner was not a direct witness to the fire.

1.17. Organizational and management information

The manager of the Ziemia Lubuska Aero Club designated his representative to act as the flight coordinator. He performed his duties from the start place located near the RWY 24 threshold.

1.18. Additional information

CAA, ANSV and BMK got acquainted with the Draft Final Report and did not submit any comments.

1.19. Useful or effective investigation techniques

Standard investigation techniques were used.

2. ANALYSIS

2.1. Air operations

2.1.1. Aircraft take-off

During the climb, at an altitude of about 30-40 m the pilot reported to the flight coordinator a problem with the engine (without giving details) r and his intention to land downwind (180° turn).

According to the Tecnam Astore AFM, after engine failure below 100 m, the pilot should gain secure speed (67 kt) by moving the stick "away" and land straight ahead with a possible deviation of the flight direction ±45° to the left or right. In the investigated case, the pilot should not make a 180° turn.

It was possible to perform a straight landing and a landing with a deviation to the left or right (Fig. 23).

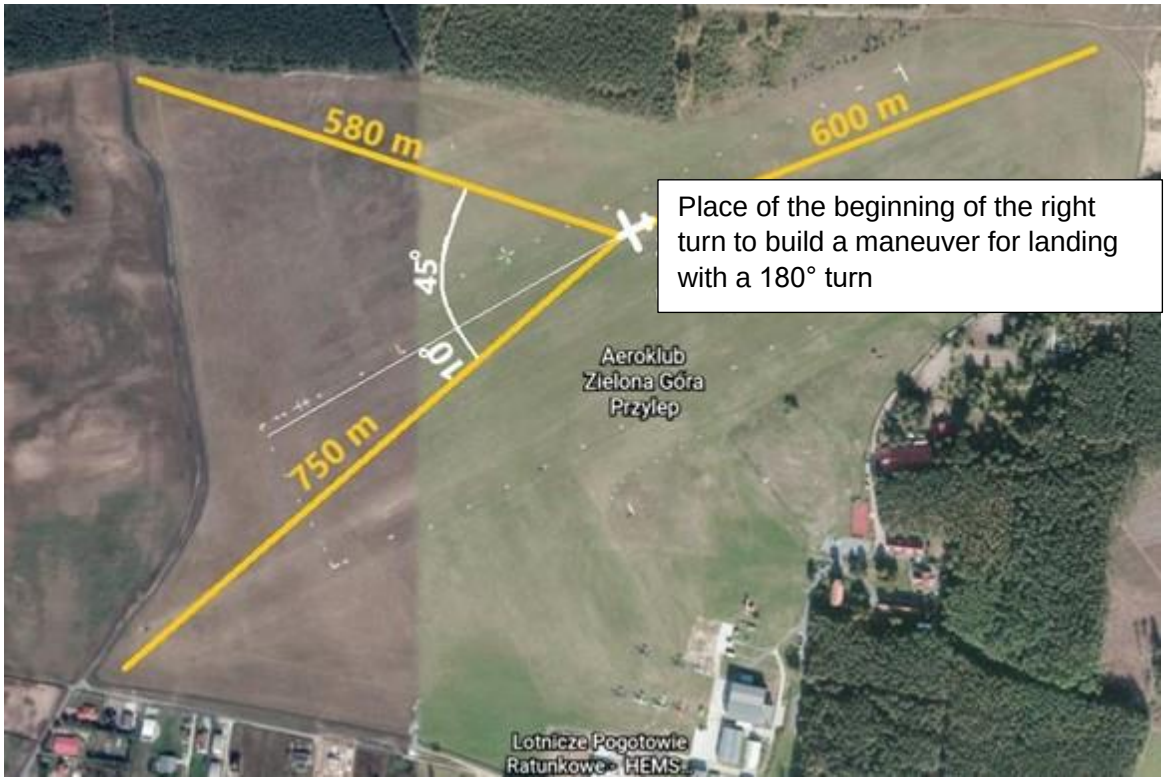

Fig. 23. View of the aerodrome including the highlighted distance to its borders [source: PKBWL].

According to the findings and analysis of the flight course, the pilot did not execute the actions prescribed in AFM for emergency landing, but was striving for a quick landing with the engine running in the direction opposite to the direction of take-off.

The Investigation Team performed calculations and analysis to reconstruct the flight parameters and to clarify the actions of the pilot in the light of the AFM provisions after his decision to abort the flight.

3D model was made to reconstruct the flight path. The positions of the airplane were determined from videos from TWR and from a house located on the outskirts of the aerodrome,

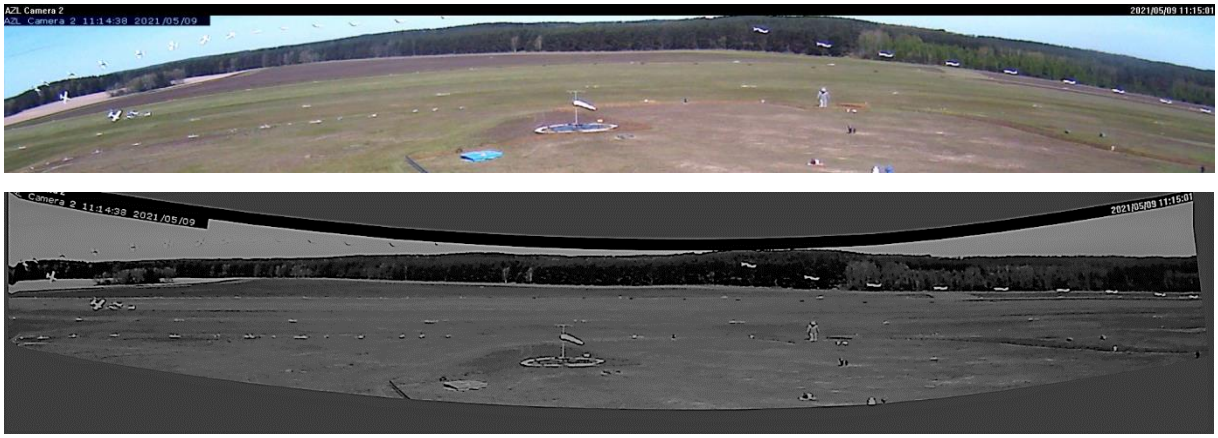

Fig. 24 Airplane positions at 1 s intervals based on the recording from TWR - original (top) and after geometry correction (bottom) [source: PKBWL analysis].

Fig. 25 Airplane positions at 1 s intervals based on the recording from the house on the outskirts of the aerodrome - original (top) and after geometry correction (bottom) [source: PKBWL analysis].

Based on the position of the cameras and the aerodrome objects, a model of the aerodrome was recreated in Blender (ver. 2.93.6) in a 1:1 scale. Then, the flight route of the airplane was reconstructed in the horizontal plane (Fig. 26). Positions 01-31 were determined based on the recordings. Position 00 was reconstructed based on the statement of the flight coordinator.

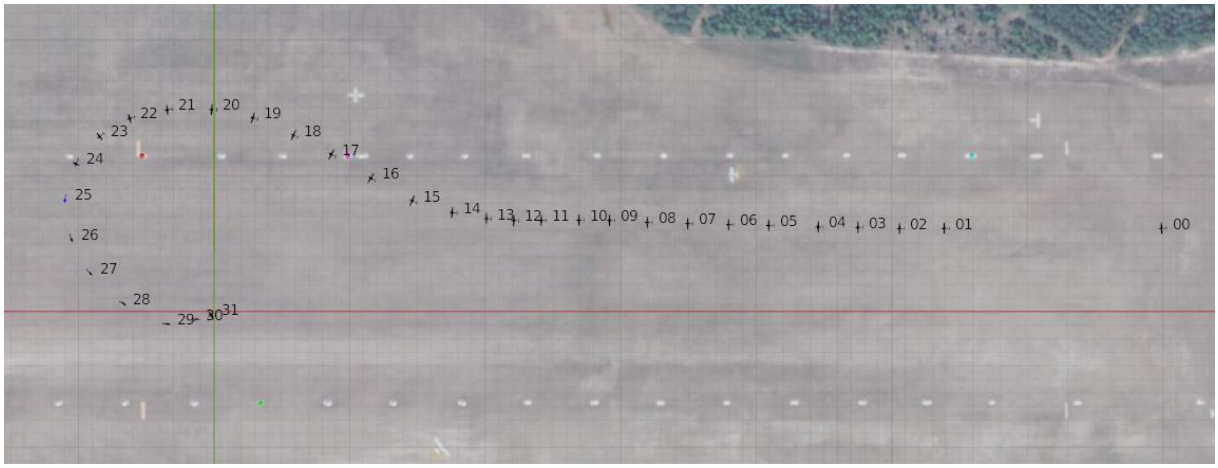

Fig. 26 Flight route horizontal projection plotted on the airfield model [source: PKBWL analysis].

The airplane bank angles measured in Figs. 24 and 25 were also entered into the model, which allowed the flight height to be reconstructed.
Because of the height of the trees (birches - 14 m) in the background of positions 01-07, the flight height was determined based on the converted measurement scale (Fig. 27).

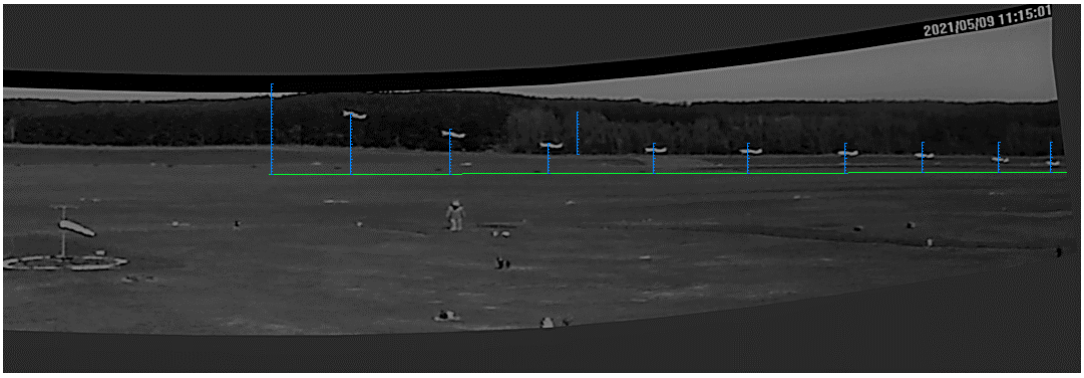

Fig. 27 Determining the flight altitude by comparing the altitude to the tree height [source: PKBWL analysis].

The height of positions 23-29 was determined by comparing the actual wingspan and the wingspan measured on the photograph.

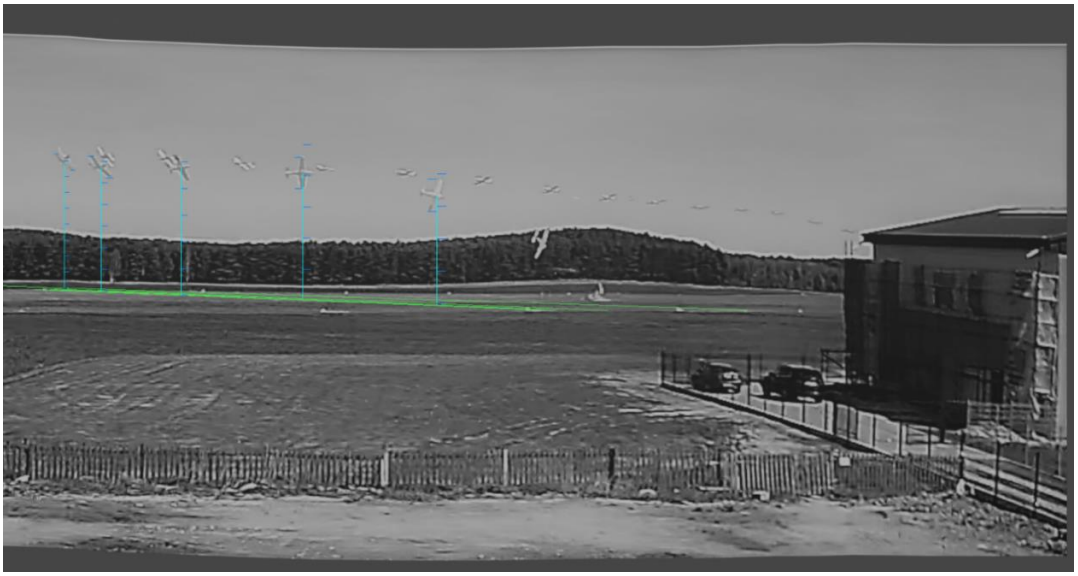

Fig. 28 Establishing the flight height [source: PKBWL analysis].

Once the height has been entered into the model, the flight path of the airplane was reconstructed in the vertical plane (Fig. 29).

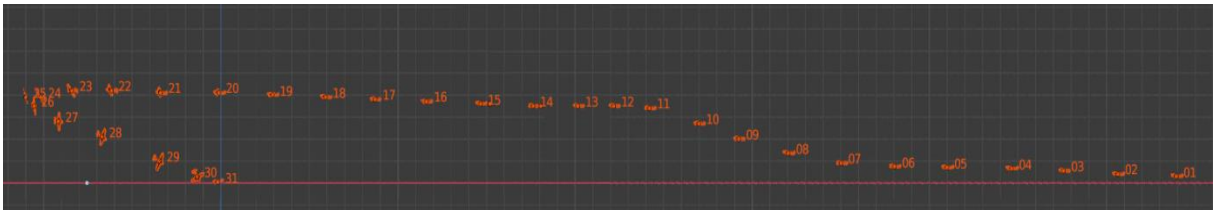

Fig. 29 Side view of the flight route [source: PKBWL analysis]

Based on the methodology presented above, the following parameters have been calculated: distance, time, average flight speed, height and airplane bank angles in the individual positions and sections of the flight route.

The results of speed calculations for selected route sections are shown in the table below.

No.	Positions	Route section	Distance [m].	Time [s].	Speed [kt]
1.	01-07	climb with V_y airspeed	189	6	61,24
2.	07-11	climb with V_x airspeed	111	4	53,95
3.	11-16	right turn	132	5	51,32
4.	16-18	straight flight	65	2	63,02
5.	18-26/27	left turn	249	8,5	56,94
6.	26/27-30	stall and collision	109	3,5	60,54

The analysis of all calculated flight parameters allowed the following flight phases to be established:

1) Positions 01-07. Flight was performed with the V_y airspeed, which was 61.24 kt for this section, and the aircraft reached the height of 9 m. According to the AFM, the speed on this section with the flaps extended for take-off should have been 62 kt.

2) Positions 07-11. Typical steep climb with V_x airspeed, where increase in altitude to approx. 35 m in a short time (4 s) was observed. The average speed in this section was 53.95 kt. According to the AFM, the speed on this section with the flaps extended for take-off should have been 51 kt.
3) Positions 12-16. A gentle change in flight direction to the right with small bank angles up to 5º. The height on this section increased to approx. 37 m.
4) Positions 16-18. Straight level flight in approx. 2 s at constant altitude (approx. 37 m).
5) Positions 18-26. The critical phase of the flight. The pilot made a left turn lasting 9 s with increasing bank angle presented in the table below.

Position	18	19	20	21	22	23	24	25	26
Time of turn [s]	1	2	3	4	5	6	7	8	9
Bank angle [º]	-5	-10	-20	-30	-36	-40	-50	-70	-80

The table shows that the pilot increased the angle of bank in relatively short time (according to AFM, the allowable angle of bank for this plane is 60° at the maneuvering speed of 97 kt).

6) Positions 26/27-30. A sharp increase in bank angle, especially in the last phase of the turn, indicates that a turn was made with the angle of bank exceeding 60°. The plane began to lose lift. In position 27 (angle of bank approx. 80°) the airplane stalled and entered autorotation (spin). The motivation to perform such a maneuver was probably the desire to make a 180° turn "at all costs" and to reach the chosen landing direction.
The airplane hit the ground with the left wing and propeller during the initial phase of the spin.

2.1.2. Comparison of aircraft take-offs at EPLS and EPZP aerodromes

In addition to the footage of the accident take-off from the cameras at EPZP, the Investigation Team had access of the footage showing two Astore airplane take-offs on 8 May 2021 from EPLS aerodrome. The first video shows the take-off to perform the flight test after engine maintenance (Fig. 30 a) whereas the second video shows the take-off to perform the flight to the EPZP aerodrome (Fig. 30 b).

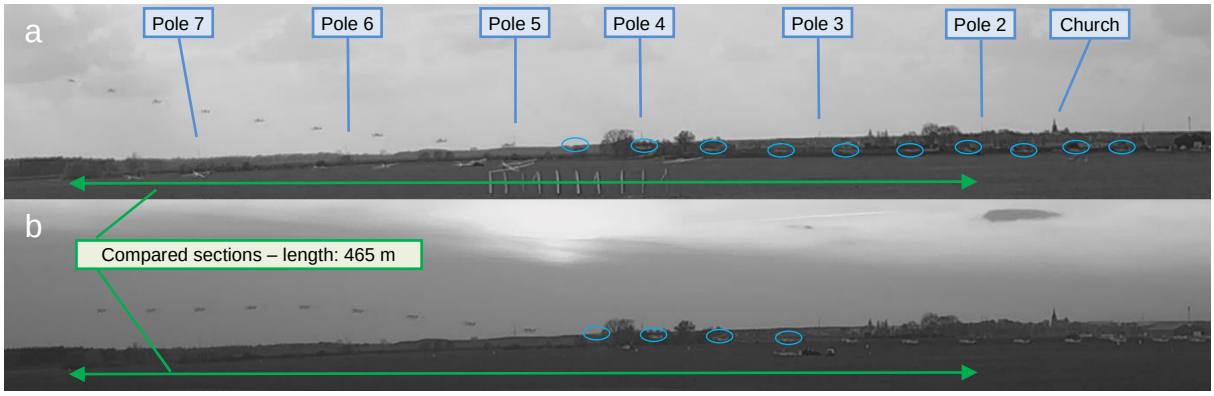

Fig. 30 The airplane positions at 1 s intervals on videos from the camera at EPLS [source: Google Earth, airplane take-off recordings].

After analyzing the accident flight, the Investigation Team made similar calculations for the two takeoffs at EPLS based on the calculated parameters (Section 2.1.1), which allowed the comparison of three take-off recordings.

The average airspeed calculated for each flight section was used to compare the flights.

For the purpose of the comparison, from the accident take-off, the section of 465 m was selected, starting from position 01 (airplane lift-off which marks the beginning of the footage from the TWR camera) to position 17 (horizontal flight).

For the EPLS flights a section of 465 m starting from lift-off was selected. The position of the airplane on the background of landmarks was used to determine the measurement distance (Fig. 31).

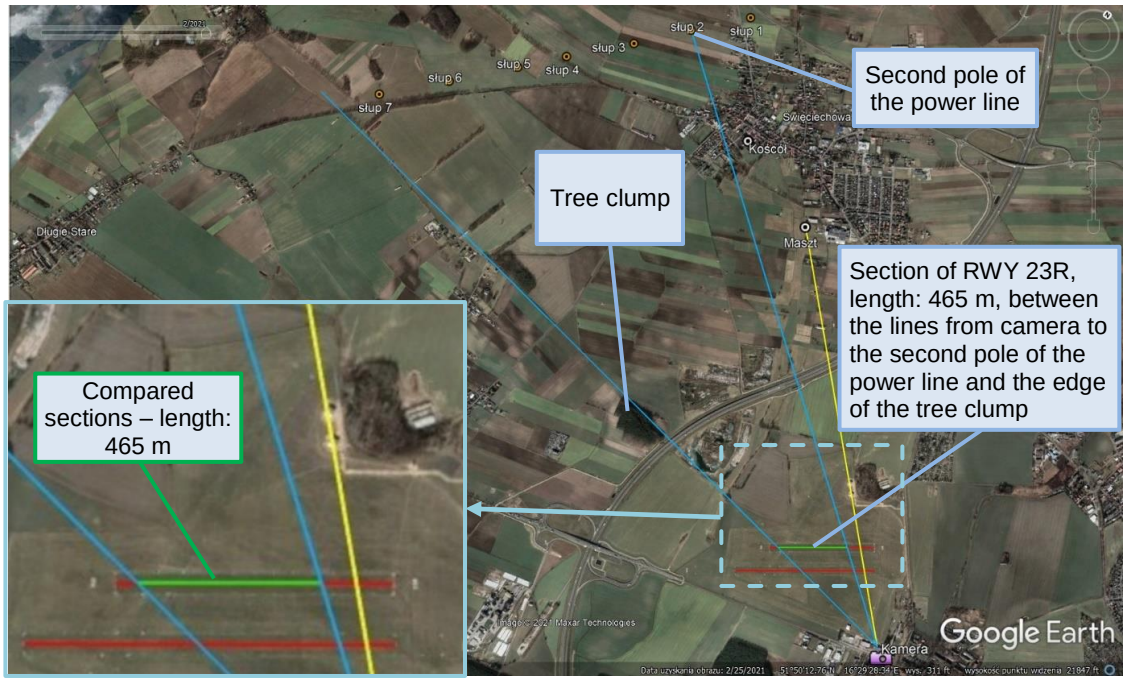

Fig. 31 Sketch for the purpose of airplane speed calculation during take-off from EPLS [source: Google Earth, videos of airplane take-off].

The results of the average airspeed (Vav) calculations are shown in the table below.

No.	Take-off	Distance [m]	Time [s]	Speed [kt]	Remarks
1.	EPLS 1st flight	465	15,4	Vav = 58,7	Aircraft flight test
2.	EPLS 2nd flight	465	16,16	Vav = 55,9	Departure to EPZP
3.	EPZP	465	16	Vav = 56,49	Accident flight

The calculated airspeed values are subject to distance reading error due to distortion of the camera lens and the distance measurement in Google Earth. The EPLS aerodrome image is from Google Earth and was captured in February 2021.

Despite the indicated factors affecting the calculated average airspeed values, they are similar to the results presented in Section 2.1.1 for the accident flight. Therefore, they could be used to evaluate three take-offs performed by the same pilot.

During the first take-off, the airplane reached its highest speed. However, its take-off mass was 80 kg lower than that in flight #3.

During the second take-off, the characteristics of the airplane climb (steep climb section like in flight #3 were similar to the characteristics of the third take-off. The average airplane speeds were similar as well. The take-off mass of the airplane was 53 kg lower than the mass in the third take-off.

In flight #3, the take-off mass of the airplane was close to the MTOM. A detailed analysis of the flight is outlined in Section 2.1.1.

The comparison of the three take-offs shows that the calculated airspeed values (Vśr) were in line with the values specified in the AFM airplane for the relevant phase of the take-off.

2.2. Aircraft

2.2.1. Engine

The engine visual inspection performed directly after the accident showed that the engine was in a condition, which allowed its further examination.

The engine examination was performed at the Institute of Aviation in Warsaw.

The examination determined that:

- no engine seizure occurred;
- all main components of the engine were operative and in good mechanical condition;
- the damage detected was a result of the collision of the engine with the ground and the fire.

The condition of the spark plugs, whose faces were covered with velvety-black coating, was a subject of concern. During the last periodic maintenance, the spark plugs were cleaned of the residue. Their condition and the color of the face surface were checked

after the engine test runs. The color of the spark plugs did not deviate from the standard. The engine worked for approximately 2 hours after the last maintenance.

Despite the fact that the spark plugs were operative, the velvety-black color of the residue is a typical sign of an engine running on a rich fuel mixture. The combustion rate of this type of mixture is very low which could prolong the time of the combustion that could have lasted even during the exhaust stroke. That could have caused the exhaust backfire and black smoke coming out of the exhaust pipe visible in the footage, as well as a decrease in the engine power during climb.

The rich mixture may have been caused by opened choke valve. However, as a result of the destruction of the airplane structure and broken control cables of the choke valve, the springs mounted on the carburetors caused the valve levers to return to the initial (closed) position (Fig. 32). The throttle levers were in different positions (left carburetor - slightly open, right carburetor - more open). The choke valve lever, which should have been located in the cockpit, was not found, it has probably burned down. As a result, it was impossible to determine the reason and the method of enriching the mixture.

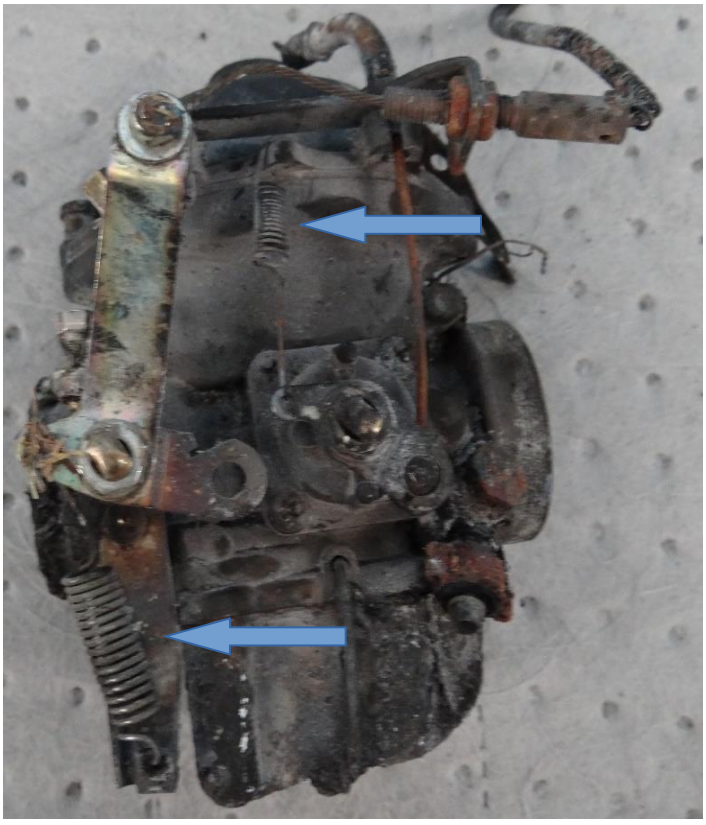

Fig. 32 Carburetor view from the choke valve control lever side [source: PKBWL analysis].

Analysis of the recordings from the CCTV cameras shows that a puff of white smoke/fog appeared one second after a puff of black smoke.

This phenomenon may have been caused by the fact that when the engine operates on a rich mixture, temperature of the fuel-air mixture is rapidly reduced even to the water freezing point. This is due to heat extraction from the flowing air stream and from

the flow channel walls. At some point, the water vapor condensed during this process escaped along with the exhaust gases in the form of a cloud of white fog visible behind the aircraft. Piston engines with float-type carburetors are most likely to produce such a phenomenon. The contributing factor was the use of automotive fuel, which generally contains more water than aviation fuel.

Symptoms of abnormal operation of engine caused by rich mixture were visible during the take-off (the pilot did not define the problem with engine in his report). However, the calculated flight parameters show that the engine and the entire powerplant met the requirements specified in the AFM.

3. CONCLUSIONS

3.1. Findings

1) The aircraft had a valid Certificate of Airworthiness.
2) Periodic engine maintenance was performed by qualified mechanics in a timely manner.
3) Periodic maintenance on the airframe and propeller was not performed in 2020 and 2021.
4) The aircraft was registered in Italy as an ultralight aircraft with authorized mass up to 472.5 kg, while the actual authorized mass of this aircraft (MTOM) was 600 kg.
5) The aircraft has been registered by CAA for permanent residence in Poland.
6) The pilot held a PPL(A) and SEP(L) rating valid until 31 May 2021.
7) The pilot held a valid medical certificate.
8) ATOM was close to the MTOM; the center of gravity was within the specified limits.
9) Pilot failed to gain the speed necessary to make an emergency landing after the aborted take-off.
10) The pilot made a turn during take-off, which is prohibited in the AFM. The turn was made at low altitude and with bank angle excessing that allowed for the aircraft.
11) The airplane was destroyed as a result of the collision with the ground and the fire.
12) In the past the aircraft sustained a fire during refueling. However, the details of the damage and its possible consequences have not been documented.
13) The flight was planned as a private tourist flight.
14) The pilot maintained radio communication with the EPZP flight coordinator.
15) The rescue action was initiated by the flight coordinator.
16) The examination of the engine did not reveal any damage that could have occurred prior to the accident that could have affected its operation.
17) The analysis of the flight parameters calculated for the accident flight and the comparative analysis of the two previous flights showed that in all three cases, the parameters corresponded to those specified in the AFM.
18) During the accident take-off, symptoms of engine abnormal operation occurred due to a rich fuel mixture, which likely caused the pilot to abort the flight, but had no noticeable effect on the flight parameters.

3.2. Causes of accident

The cause of the accident was bringing the aircraft to stall and spin due to the following pilot errors following the decision to land downwind:

- **failure to gain an appropriate speed for emergency landing;**
- **making a 180º turn at a low altitude prohibited in airplane flight manual;**
- **exceeding the maximum allowable bank angle when making a turn.**

Contributing factors:

- Aircraft mass close to MTOM;
- Wind direction pushing the aircraft to the left at the final stage of the turn.

4. SAFETY RECOMMENDATIONS

PKBWL has not proposed any safety recommendation as a result of the investigation.

5. ATTACHMENTS

None.

THE END

Investigator in charge

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