MICROLIGHT AIRCRAFT APPLICATION FOR LARGE-SCALE MAPPING OF SMALL TERRAIN AREAS

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ABSTRACT:

Here questions of topographic use of microlight aircraft for purposes of mapping and revision of toporgaphic maps and planes for scales 1:500 - 1:10000 are considered. Besides description of construction of special double-engined microlight aircraft is presented, its detailed technical performances, conditions of exploitation and topographic use are given. References of a special airsurveying and other topographic equipment are presented (together with flytests' results).

1. INTRODUCTION

The problem to increase efficiency and improve aerial survey methods for mapping and revision of topographic maps and plans for small areas, and to obtain digital terrain information used, for instance, for geoinformation systems and cadastres of various types, is related to the employment of microlight aircrafts.

The use of microlight aircrafts is reasoned by possibilities to attain more efficiency of aerial surveys owing to:

- lower costs of microlight aircraft service comparing with conventional carriers;
- possibility of having the basing of flight-survey team closer to the place of work;
- simplicity of the vehicle service and maintenance; absence of strict requirements to the choice of a taking off-landing area as to its dimensions and pavement;
- low speed (60 kmph) and altitude enabling us to avoid forward motion compensation while taking photographs, and to have a better view while visual image interpretation to see all changes on the ground and to overfly objects, if it is necessary.

All the above-said has been provided by the studies and experiments carried out [1-4].

Nevertheless we find it reasonable to continue improvement of the method based on employing microlight aircrafts. The improvement can be accomplished in three ways:

1) to improve the design of the carrier;
2) to enhance fields of its applicatiion;
3) to equip microlight aircraft with new technical means.

2. DESIGN IMPROVEMENT OF THE CARRIER

The requirement to increase load-carrying capacity of microlight aircraft and to improve the reliability of conducting flights on them, including flights over woody, water and built-up areas, gave rise to the idea of a two-engined carrier. In accordance with the technical requirements worked out at TsNIIGAiK, the "DeltaKom" Research and Production Association has developed and designed a two-engined prototype of the MDP-AM updated microlight aircraft (fig. 1).

MDP-AM consists of a flexible wing with a soft skin and undercarriage with a power unit.

The wing design is of a "floating" cross-piece type and includes a supporting frame, cable tension members, a lavsan-type skin, and an anti-diving device. The wing design provides for its adjustment during the flight.

Motorcarriage consists of horisontal and vertical trusses, folded and frontal ninepins, undercarriage, seats for the pilot and an operator. Hinge-joint of the vertical truss allows folding of the motorcarriage for installation and removal of the wing and decrease of sizes for transportation and storage.

In front of the pilot's place there is an instrument board which consists of aneroid altimeter VD-10, rate-of-climb indicator VR-5, an indicator of airspeed US-250, magnetic compass KI-13.

The power unit consists of two engines RMZ-640 with two propellers. The engines have been updated to increase their power and reliability. The design provides for independent performance of the engines and reciprocal displacement of axes caused by vibration. One of the engines is equipped with a generator.

For aerial visual interpretation there is a place equipped for a topographer to replace the camera intended for this purpose. The developed micro-light aircraft was tested in various conditions of performance, including that with one operating engine.

Microlight aircraft MDP-AM is intended for use in mapping and revision of topographic maps and plans of large scales (such as 1:500 - 1:10000). Here flights are fulfilled in day-time over built-up and unbuilt-up territories by the visual flight regulations. For taking off and landing it is possible to use landing areas with an artificial covering and ground areas with a soil stregth not less than 0,6 kg/cm. Admissible altitude of airfield above sea level is 2000 m.

MDP-AM has the following technical features:

- wing-span - 10.54 m;
- length - 4.4 m;
- hight - 3.7 m;
- area of wing - 19.6 sq m;
- track of undercarriages - 1.6 m;
- pressure in tyres- 2.2 kg/cm;
- max. take-off mass - 410 kg;
- mass of construction -210 kg;
- fuel mass - 22 kg.

The main technical features of the power unit are as follows. RMZ-640s are 2-cylinder, two-stroke carburettor air-cooled engines of max.power 29 kW. Fuel consumption is 15 litres per hour. Engine lubrication is in composition of the fuel. System of ignition is electronic, in- contact. Starting device is manual. The first engine has a gear, the second one - a belt-drive. Total propellers thrust is 170 kg (115 - the first one, 110 kg - of the second engine).

Microlight aircraft MDP-AM has the following flight characteristics:

- speed range - 60-80 kmph;
- cruising speed - 72 kmph;
- speed to climb with max. take-off mass - 1.2 m/s;
- max. time in flight - 2.1 h;
- required length of taking-off and landing runway - 150 m.

Using MDP-AM it is necessery to remember limitations connected with its technical and exploitation features. Max. admissible exploitation overloadings must not be higher than 2.0 g (positive) and 0.6 g (negative). Max. admissible angle of bank - 30°. Max. windspeed while taking-off and landing: head-wind - 10 m/s; fair-wind - 2 m/s; side-wind - 5 m/s. As flight experiments show, taking-off and landing in these conditions don not reqire super pilot's efforts or any use of special flying-techniques. Time of continuous engine work in take-off-regime - 1 min. Max. admissible temperature for cylinder heads is 200° C. Admissible air temperature: -15°C - +30°C. Admissible relative air humidity is up to 98%.

To meet requirements of comfort it is necessary to have a closed cabin to protect the pilot from air flows and rain. The cabin should provide a good view of the terrain and be comfortable for an topographer in cases of visual interpretation and reconnaissance flights.

3. ENHANCEMENT OF MICROLIGHT AIRCRAFT APPLICATIONS

The researches of microlight aircraft application were related to the employment of such carriers for aerial surveys aimed at large-scale mapping of small areas in the form of topographic plans [1,4]. However, in this case the use of microlight aircrafts is significantly limited as so far their flights are impossible over urban areas (vast built-up territories). In this connection some ways to enhance fields of microlight aircraft application are suggested.

First, it is advantageous to use microlight aircraft not only for aerial surveys, but also for visual interpretation and reconnaissance flights i.e. here we speak about microlight aircraft application for the purpose of revision of topographic plans and maps of 1:500-1:25000 scales. Experimental flights and technical and economical estimations have provided the possibility of successful solution of this problem [2].

Secondly, as microlight aircrafts is equipped with two engines they are allowed to conduct airsurvey, reconnaissance and interpretation-aimed flights over built-up areas in contrast to microlight aircrafts with one engine which is prohibited to fly over such territories according to the flight regulation in force.

In the process of experimental flights the tests of microlight aircraft were carried out. Here a possibility of carring out of horizontal flight with one working engine and two members of crew were presented. Loading here is higher than 40 kg. Carring out of horizontal flight is possible when only the first or the second engine operates and there is a surplus of engine power, providing possibility of climbing with a rate not less than 0.5 m/s (fig. 1). MDP-AM flights of the two man crew and with airsurvey equipment are possible. In the process of test flights serviceability of microlight aircraft with positive and negative (to -10° C) temperatures was tested.

But a number of short comings, connected with constructive features of the aircraft were revealed. For example

increased vibration of one engine, because of moving joint of gear box of this with a shafe of air propeller. It is also difficult to start the engine when temperature of free air is under 0° C. When two engines work, a high level of noise is created; it gives some problems when flying over urban areas.

4. RETROFITTING OF THE CURRENTLY EMPLOYED MICROLIGHT AIRCRAFTS

The equipment designed for aerial photography includes a pendulum inged dampedsuspension of the camera, a mechanical strip finder, a control device and a vacuum pump (fig. 2).

Pendulum hinged damped suspension of the camera permits to orient optical axis of the camera vertically with admissible angles of tilt of motorcarriage during flying, and to exclude the drift, to define value of the drift and to crab it into the wind, moving camera around vertical axis to minimize angle of drift.

Pendulum hinged damped suspension consists of a maunting ring where sockets for semiaxes of the camera are positioned. This ring is joined a cardan ring on lateral axis, and the cardan ring in its turn is joined with the turret by forward axes. All hinged joints have bearings, and to reduce free vibrations are supplied with hydraulic dampers. Turret ring is joined through four angle rollers on the frame, in corners of which four rubber shock-absorbers are placed; through them a frame is adjusted on cross-beams of the MDP-AM lower truss with staples. On the turret ring rocking on bracket draught, it fixes to itself, joins turret ring with rocking ring of viewing, providing their equal angle moovings.

Mechanical strip finder consists of a balance frame, showing vertical plane in the flight along a strip and also angle drift-turn of the camera. Rocking-finder is joined by draught bar with a frontal plug, which helps to change frame viewing, turning the plug along the route line during flying and correspondingly, turn angle of air camera around vertical axis.

Panel of the camera drive unit is in front of the pilot at an accessible distance that permits him to control airsurvey.

For convenience in exploitation all the mounting devices for the aircamera, vacuum pumps, drive unit on a lower horizontal truss of the MDP-AM motorcarriage, that provides an exploitation of a complete set without their removal in preparating of flights not related to airsurveys and also folding up of motorcariage and removal of the wing.

Vacuum-pump situates on a frame of pendulum suspension and in removing of camera is not removed. Supplying of a pump is joining through disconnected part.

AFA-TE-type mapping air cameras now mounted on microlight aircrafts were developed some decades ago and do not meet the nowaday requirements as to resolution, distortion, relative aperture, and compatibility with satellite systems. We find it reasonable to develop new flight compact air cameras with improved measuring and imaging features of their performance to meet all the above-mentioned requirements.

In details, new camera must have small weight (not much then 30-40 kg), small power-volume (not much then 150 W), high quality objectives (lens) with view angle 120°, 85° and 55°, relative aperture not less than 1/4,5, standard

distortion not much than 5 mkm, resolwing power not less than 40 lp/mm. Taking low speed of a carrier forward motion compensation may be absent. Together with it a possibility of connection with airborne satellite system GPS must be provided.

Practical experience in aerial photography with use of microlight aircrafts shows that photographic flight stripping is complicated because of the carrier's low weight. In order to overcome the problem it is necessary to construct artificial ground targets in a case of poor-contour terrain. On the other hand the problem of attaining high quality of aerial photography can be solved by using navigational satellite systems. In this connection the next step suggested is to equip microlight aircrafts with a geodetic satellite system to determine coordinates of photograph projection centers. However, thorough researches needed to study the influence of flight slope of the micro-light aircraft when piloting on the stability of satellite signals reception and the accuracy of positioning by a navigational system.

Thus, designed microlight aircraft serves as a carrier of operative mapping and revision of maps and planes on small urban areas (to 20 sq. km), regional zones of intensive building of cottages and country houses, villages, developing industry, coal, mining and other objects, (some oil fields) and also in regions of extremal situations, when up-to-date information about the region condition is urgently needed.

Microlight aircrafts designed for reconnaissance flights and viusual interpretation are equipped with a videocamera and a microphone to survey terrain objects to be interpreted and to have sound records of their characteristics.

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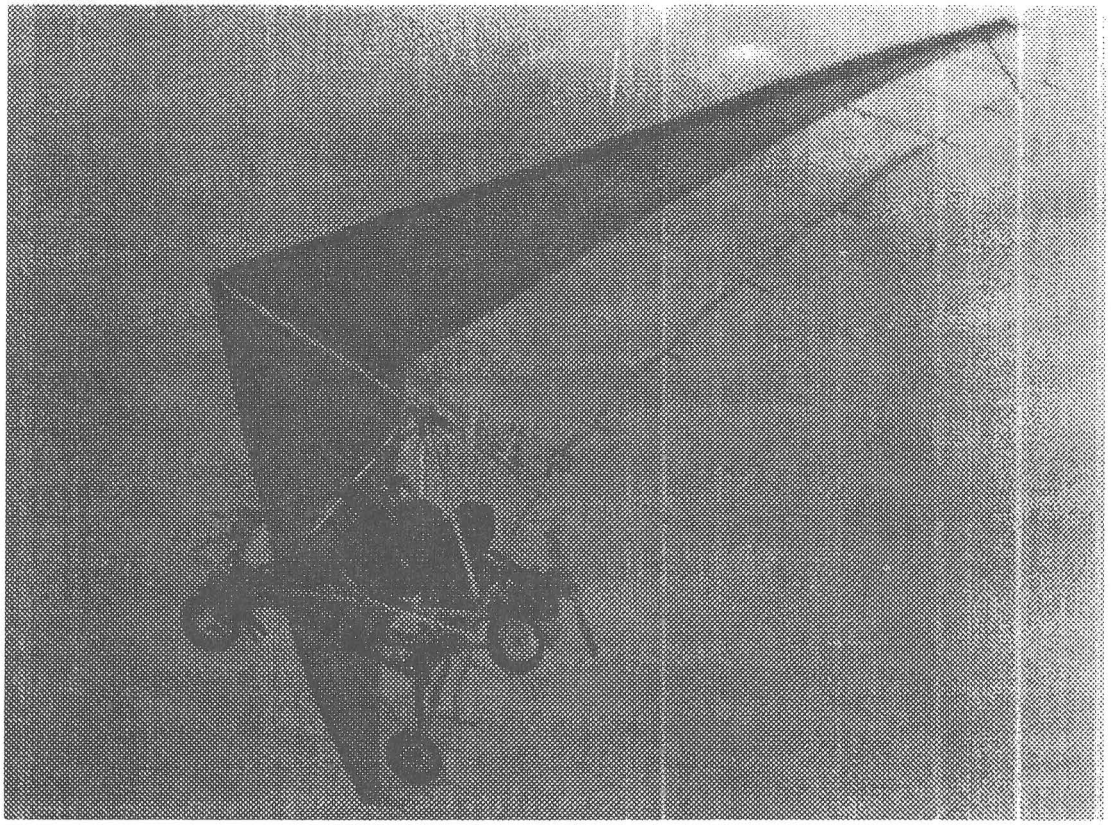

Fig. 1. The Microlight aircraft MDF-AM in its flight with one engine operated

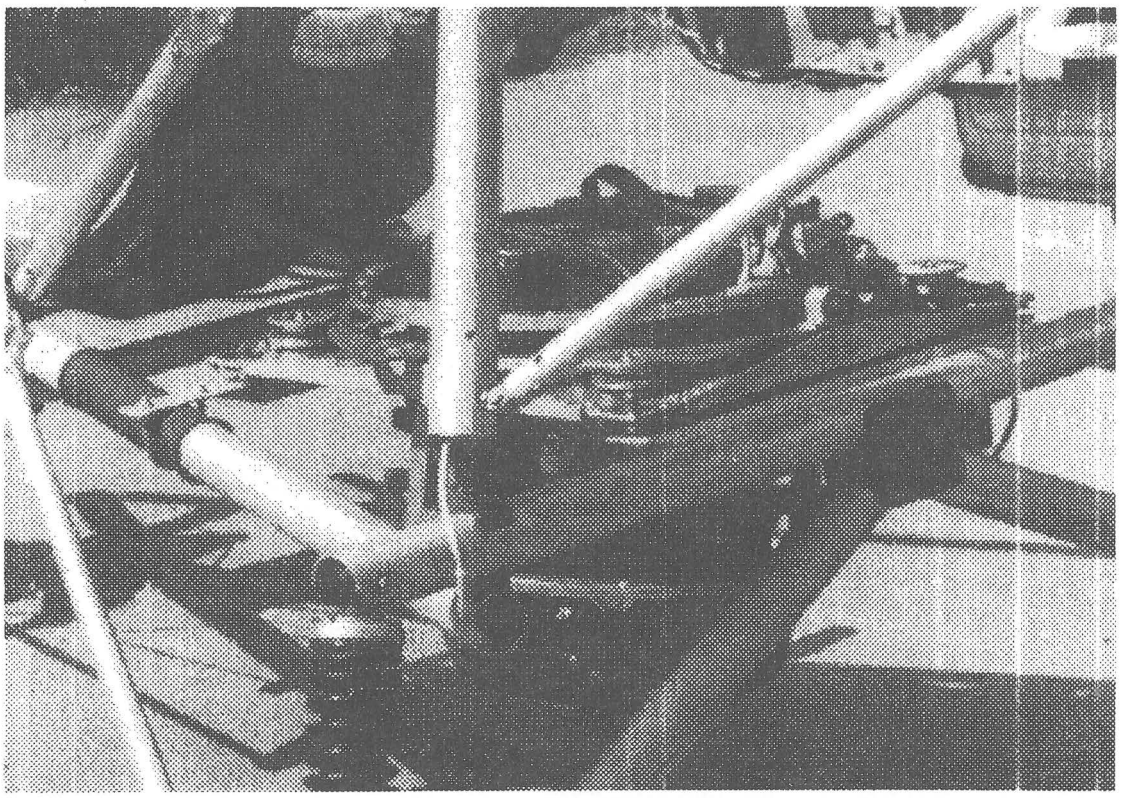

Fig. 2. The camera mounting is damped against vibration and is fully adjustable for in-flight drift compensation