Use of the parachute system for the collective rescue of passengers and aircraft crew

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Abstract: *This study covers the issues of the security system in civil aviation. The relevance of the topic is conditioned by a qualitatively new approach to the design of civil aviation, since the modern equipment has the means intended for rescue directly in the area of contact of an emergency aircraft with the ground. When hitting the ground, as a rule, the lower part of the airframe is crushed, the fuselages break in the centre wing section, and the interior equipment breaking off is very traumatic to passengers, the engines are extremely fire and explosion dangerous, which leads to an emergency situation developing into a catastrophic one. The purpose of the study is to investigate the existing security system of a civil aircraft and develop the modification of aviation equipment with the help of collective rescue systems. Two main areas of application of collective rescue systems in aviation technology are analysed. As a solution to the problem at hand, a modification in the form of a parachute system of collective rescue is proposed. A detailed description of the system operation with the use of the necessary calculations for weight, aerodynamic and similar costs is given. The system under study relates to aviation technology and can be used in the development of transport (passenger, cargo, business class, etc.) aircraft. The proposed modification would significantly increase the level of flight safety due to a preventive measure that would exclude the contact area of the emergency aircraft with the ground.*

Key Words*: flight, aircraft, rescue, safety, system, parachute.*

1. INTRODUCTION

A characteristic feature of modern aircraft (Tu-334, Yak-42, A-310, B-737, etc.) is the low safety of passengers and crew in the emergency event that develops into a catastrophic situation [1], [2], [3], [4], [5]. As a rule (in 80% of cases), an in-flight emergency gives the crew time to make a decision. [6], [7], [8], [9], [10], The development of an emergency situation into a catastrophic one, as a rule, occurs in the area of contact with the ground, which requires increased attention to the safety system [11], [12], [13], [14], [15], [16]. This problem occurs when the aircraft is equipped with only rescue equipment in the area of contact of the damaged aircraft with the ground.

The use of collective rescue systems (CRS) in civil aviation can go in two ways. The first way involves the modification and modernisation of the existing fleet of aircraft. Despite the apparent simplicity in this situation, all the weight, aerodynamic, and other costs need to be summed up, taking into account the differential mass increment of both units and the design of the airframe and systems. For these reasons, despite the fact that this system would meet the requirements of the aviation market, it is necessary to take into account the deterioration of the weight coefficient by weight of an empty equipped aircraft, and, consequently, a decrease in the commercial load or flight range.

The second way allows optimising design decisions taking into account the causal factors of transformation of the external appearance of the aviation complex based on the results of internal design, which is based on the concept of using CRS. However, this requires the identification of new design solutions and features of passenger aircraft equipped with CRS, which in terms of time and material costs corresponds to R&D. It is complex in nature and its implementation would require the involvement of participating bureaus of almost the entire national aerospace complex: aircraft construction, rocket construction, parachuting, aerospace technology, aerospace medicine.

2. MATERIALS AND METHODS

Figure 1 shows the overall schematic of the modified aircraft. The aircraft contains the fuselage, wing, tail, thrust system, and landing gear. The fuselage of the aircraft is equipped with a collective rescue system, consisting of a parachute system attached to the detachable part (module) of the fuselage, a system for separating the rescued modules. The wing is attached to the fuselage through the centre wing section. Before the centre wing section, a module for dividing the fuselage into salvageable and non-salvageable modules is installed.

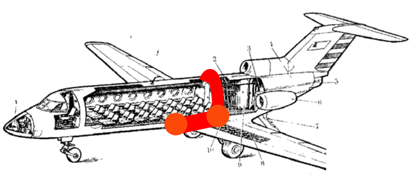

Fig. 1 – Short-haul aircraft

The separation module consists of two fuselage frames, between which a monocoque structural layout is applied. A charge separation system is installed on the outer walls. The parachute system, when folded, is assembled in the fuselage niche. The number of parachutes is determined by the ratio of their dimensions to the dimension of the rescued module. The arrangement of both the detachable part of the fuselage and in non-salvage modules is allowed.

Detachable fuselage modules have an independent control loop. The module is equipped with a rocket engine and a gas-dynamic jet stabilisation and control system.

The device works as follows. In the event of an emergency that develops into a catastrophic situation, the command to separate the salvaged module from the fuselage comes either from the pilot, or from the ground, or from automation, etc., through the control system. In this case, the pyrotechnic system burns through the fuselage outer wall along the contour of the separation between the frames. In order to ensure the safety of passengers and vital units, the frames are made of wall frames. In the rear non-separable module, there are wardrobes, luggage compartments, toilet, etc.

For example, the passenger short-haul aircraft Yak-40 [5], [7], contains a fuselage with doors for boarding and disembarking passengers in the tail section of the aircraft, a straight wing, vertical and horizontal T-shaped tail, a three-engine thrust system located in the tail section of the aircraft and tricycle landing gear arrangement.

3. RESULTS AND DISCUSSIONS

The disadvantage of such a layout scheme is the low safety of passengers and crew in the event of an emergency, which is associated with the equipment of the aircraft with means that provide rescue in the area of contact of the emergency aircraft with the ground [17].

The standard exit is blocked during an emergency landing. When hitting the ground, as a rule, the lower part of the airframe is crushed, the fuselages break in the centre wing section, and the interior equipment breaking off is very traumatic to passengers, the engines are extremely fire and explosion dangerous, which leads to an emergency situation developing into a catastrophic one [18].

As a means of preventing this phenomenon, the aircraft can be modified by equipping with a parachute collective rescue system (see Fig. 2), which is another measure for the safety of passengers, crew and cargo in case of an emergency event [2]; [19]. It is possible to equip a mainline aircraft with a parachute CRS, but this requires an expense of 5% to 7% of the take-off mass for its installation, which is commensurate with the mass of the target load, in the case of saving the entire aircraft as in Fig. 2. It is rational to break down the aircraft and minimise the mass of the salvaged module [20], [21], [22], [23].

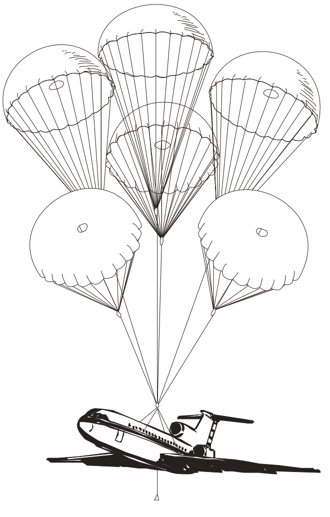

Fig. 2 – The system of collective rescue of passengers and crew of the long-haul aircraft

With the help of a brake parachute, an auxiliary engine and two sets of flaps, the detachable cabin is stabilised in accordance with the flight conditions determined by the dynamic-pressure transducer. The parachute system opens automatically with a barostat (Fig. 3). Simultaneously with the activation of the charge and the activation of rocket engine, the emergency transceiver and flashing beacon are activated at the signal of the control system to facilitate the rescue operations of the crew [24], [25], [26], [27], [28].

To soften the impact when landing, the cabin has a shock-absorbing system. The cabin has everything necessary to ensure the life of the crew and protection from the influence of the external environment, including an emergency oxygen system. The cabin can be ejected at zero speed and at zero altitude. When any of the two ejection handles located on the central control panel of the cabin are activated, the following operations are automatically performed [2], [3], [5]:

- both crew members are attracted to the seat backs by the seat belts and are held in this position by the inertia lock of the seat belts;
- the emergency oxygen system and the cabin pressurisation system are activated;
- the rocket engine turns on;
- simultaneously with the ignition of the rocket engine, the shaped charge that separates the capsule from the aircraft is detonated;
- after about 0.6 seconds, the stabilising parachute is released and the rocket engine is turned off;
- when the capsule descends to an altitude of 4500 m, the main rescue parachute is released. If the ejection speed exceeds 555 km/h, the release of the parachute is delayed until the negative longitudinal overload is less than 2.2 g;
- after 3 seconds after the opening of the main parachute, the pneumatic shock absorber is filled with air.

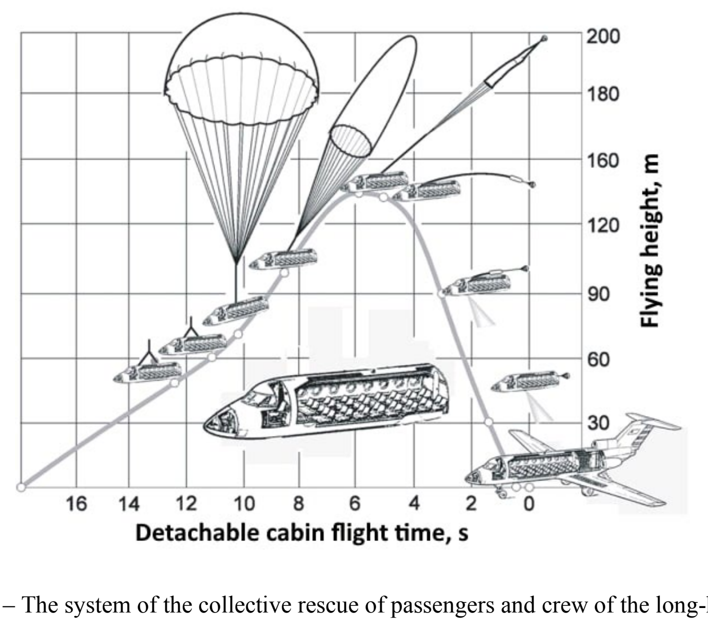

Fig. 3 – The system of the collective rescue of passengers and crew of the long-haul aircraft

The pneumatic shock absorber absorbs the impact energy when the capsule lands. For landing on the water, the capsule has inflatable pontoons [29], [30]. The cabin of the aircraft has a device that is activated underwater and automatically separates the capsule from the aircraft when it reaches a depth of 4.5 m [2]. The pontoons push the capsule to the surface of the water and set it in the correct position. The separation of the central module of the fuselage is conditioned by the structural and power layout, the scheme of technological division, the aerodynamic and energy layout of the units and systems of the aircraft and provides a reduction in the mass of the salvaged module to 25-30% of the take-off weight of the aircraft [31]. The use of CRS for such aircraft organically fits into their concept and does not require additional weight costs based on the weight summary, or leads to their minimisation.

Crew members do not have individual parachutes. In the event of an emergency, the module is separated from the aircraft by means of a directional explosive charge that cuts the panelling along the contour, and with the help of a rocket engine, the module is separated from the aircraft. The use of a rocket engine is not necessary when the flight heights are sufficient for the opening of parachutes, while the separation is performed by aerodynamic forces. When separating the tail section of the aircraft, which combines the wing, tail, fuel tanks, thrust system, etc., there is a cabring moment, due to which the nose module is separated along the trajectory directed forward upwards [32]. This would happen due to the aircraft rotation relative to the centre of mass through aerodynamic, inertial, and mass forces.

Low flight altitudes require a rocket engine to be installed for separation. The air conditioning system in the module cabin maintains pressure at high altitudes, corresponding to an altitude of 2400 m.

With the help of a brake parachute, an auxiliary engine and gas-dynamic jet control and stabilisation system (or sets of flaps), the detachable cabin is stabilised in accordance with the flight conditions determined by the dynamic-pressure transducer. The parachute system opens automatically with a barostat. Simultaneously with the activation of the charge and the activation of the rocket engine, an emergency transceiver and a flashing beacon are activated at the signal of the control system to facilitate operations to rescue the crew and passengers. The analysis of aviation accidents for 1990-2000 shows that in 58 cases out of 100 the CRS could have saved passengers and crew members from emergency situations during cruising flight modes.

Thus, the exclusion of the zone of contact of the damaged aircraft with the ground, as the most dangerous part of the flight, due to the use of the collective rescue system would lead to a change in the requirements for the design of the aircraft and auxiliary units, calculated cases. As a result, the new structural and parametric appearance of passenger aircraft would allow qualitatively improving flight safety.

4. CONCLUSIONS

Thus, the analysis of aviation accidents for ten years shows that in 58 cases out of 100, the SCS could save passengers and crew from disasters in which the development of an emergency situation into a catastrophic one occurred in cruising flight modes. It is possible to equip a long-haul aircraft with a parachute CRS, which requires spending from 5-7% of the take-off weight of the aircraft on it. The separation of the central module of the fuselage is conditioned by the structural and power layout, the scheme of technological division, the aerodynamic and energy layout of the units and systems of the aircraft and provides a reduction in the mass of the salvaged module to 25-30% of the take-off weight of the aircraft. The conducted inferential research of the use of parachute systems of collective rescue in civil aviation creates the possibility of significant promotion of Russian aviation equipment in the international market and its implementation abroad based on a qualitatively new approach to ensuring safety in civil aviation.

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