



## FLEXIBLE PANEL ASSEMBLY TECHNIQUES USED IN THE CONSTRUCTION OF AERODYNAMIC DECELERATOR

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**Abstract:** A combat aircraft is stabilized by the parachute during its dangerous maneuvers such as spin, loss of speed (at low angles of incidence), vibration of the wings (at very high speeds). For the braking on landing of aircraft that have certain operational characteristics, recovery systems are used with the help of parachutes, in which the veil of the main parachute is cross, and the fabric is made of 100% para-aramid yarn. In order to meet the typical design criteria of such a decelerator assembly, related to: stability, operational safety, mass, volume, forward resistance coefficient, shock at opening, a special mechanical-textile processing technology must be used, for which it is necessary to intervene in the flow, especially when sewing - assembly by sewing. The paper presents the achievements of the specialists from INCDTP regarding the types of seams and the subassemblies used for the realization of the drag parachute veil. In order to assemble the para-aramid panels, coats thread brand para-aramid with continuous filament were used. In order to stabilize shape, it was used French seam double top stitch 2x301. Some rows of stitches have been used because the efficiency of the seams for thread and para-aramid materials is lower than those of thread and materials obtained by polyamide or polyester that are used to obtain deceleration systems for other aircraft, with a distinct configuration. The technique used to assemble fabric panels made of 100% para-aramid yarn with a length density of 220dtex/134f coincide with the field of use.

**Key words:** para-aramidic yarn, drag parachute, subassemblies, operational characteristics, supersonic aircraft

### 1. INTRODUCTION

Currently and globally, the approach to speed performance requires new research directions, because not only is the sonic thresholds important, but also the way the aircraft runs on the runway, because the impact with the ground and braking raises equally big problems as big as the flight itself. The first known attempt to use a parachute as a landing brake was made in 1923, using a standard human parachute to reduce the landing path of a Havilland biplane [1].

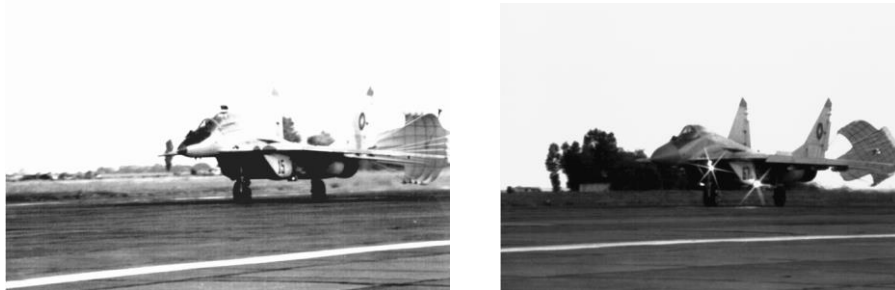
In 1933, systematic studies were carried out at the Aeronautical Institute in Stuttgart, Germany, in order to make a parachute with very good aerodynamic and static qualities. Thus, a parachute with circular slots and a parachute "made of strips" were developed. In 1939, a Junkers W-34 made its first landing using a "strip" parachute as a landing brake. This test, as well as the ones that followed, proved that the parachute is stable, opens slowly and evenly, produces a minimal shock when opened, does not impede the controllability of the aircraft, is a good supplement to the brakes of the landing gear. However, the most important use of braking parachutes came with the construction of high-speed jet aircraft. The loading of the wings of supersonic aircraft resulted in

high landing speeds and long landing distances, which necessitated finding means to reduce runway taxiing. [1,2,3]

Currently, the stabilization of a combat aircraft is done with the help of the parachute during its dangerous maneuvers: spin, loss of speed (at low angles of incidence), vibration of the wings (at very high speeds). For these critical situations, the parachute is disengaged and the aircraft has a normal flight attitude. Braking is performed when the aircraft is in flight, or on landing, to reduce the braking distance, but also to spare the brakes and wheels. The parachutes used as brakes must be very stable, as they must not disturb the control of the aircraft. They must be very strong, but they must develop a shock load at low opening.

Worldwide, two types of braking parachutes are known, namely:

- for braking and controlling the aircraft during flight, known as the approach parachute.
- for braking the aircraft on landing, known as the landing brake parachute (fig.1).



*Fig. 1: Deceleration at landing*

This type of parachute is used, along with aerodynamic and mechanical devices (flaps, aerodynamic brakes, spoilers, lift destroyers, attack flaps), to brake the aircraft during taxiing on landing, producing the highest braking force at speed at which the plane reaches the ground, when the brakes are practically ineffective. In addition to a reduction in landing distance, the system ensures increased safety in flight in hazardous conditions (for example during landing with brakes not acting), during unsuccessful take-offs, during forced landings on short runways, on icy or wet runways. The typical design criteria for a drag parachute are [1,2]:

Operational safety of the system - the most important criterion. A technical reserve of at least 31 consecutive landings for space shuttle landings and a high rate for airborne troops must be provided.

Mass and volume are considered important. The parachute system is about 5% of the weight of the air vehicle (for light vehicles) and 3-4% for vehicles with a mass greater than 1000 pounds (454 kg). A complete recovery system shall include the buoyancy, positioning and restraint assembly and shall have  $10 \pm 2\%$  of the total mass of the air vehicle. [1,4].

Stability is the main selection criterion for the system. Drag parachutes, drag-deceleration parachutes require a high level of stability, a requirement that automatically eliminates many parachutes that have a high coefficient of resistance to advance (so-called solid parachutes) [3,5,6]. For a final lowering parachute, a small diameter, i.e. a small mass and volume, is required, even if the stability leaves much to be desired (oscillation angles of  $\pm 10^\circ$ ). For a very fast descent, the large oscillation can be eliminated by using a parachute beam [2, 3, 7].

The coefficient of resistance to high advance is very important in the selection of downhill parachutes [1, 2]. A good evaluation is also determined by the efficiency of the mass  $(C_x S)_0 / M_p$ , which shows how much of the resistant surface  $(C_x S)_0$  is produced on the mass of the parachute  $M_p$ .

The reduced opening shock is an important criterion for the selection of parachutes without delayed opening, where the delay device controls the force-time ratio for the parachute opening

process.

Increasing potential is important in design [1, 3, 5]. A smooth landing requires a lowering speed, which in turn increases the size of the parachute and at the same time increases the mass and volume of the parachute assembly.

All these features have been taken into account for the design of the drag parachute of the MiG 29 Sniper aircraft and, in addition, special attention has been paid to the types of assemblies of the component subassemblies.

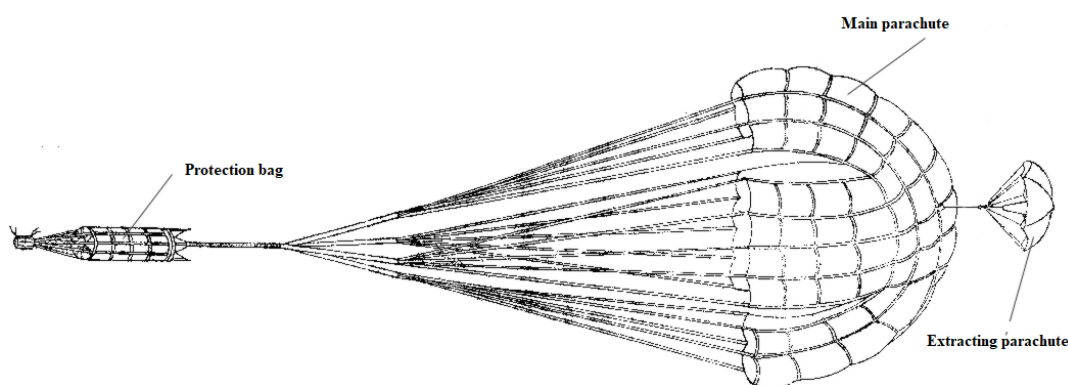
## 2. MATERIAL AND METHOD

### 2.1 Materials used to make the main parachute canopy

For landing braking of aircraft with certain operational characteristics (wingspan - 11 - 12 m; length with LDPE arm - min. 17m; height - min. 4m; wing surface - 38 sqm; with single or double control; 2 turbojet engines) with water injection during landing); engine mass - 980 kg; empty aircraft mass - 10900kg; maximum take-off mass - 18500kg; combat load - 3000 kg; maximum flight speed - 2.3M, ground - 1300km / h; take-off speed - 220km / h; landing speed - 235 km / h, equipped with cannon-type weapons, bombs or ground-to-air weapons; medium-range missiles, etc.) are used used cruciform braking parachutes made 100% para-aramid yarn fabric because it must meet the following requirements:

- temperature resistance developed behind the aircraft engines: min. 260 ° C;
- maximum force that the veil must withstand: 7500 daN;
- resistance to difficult weather conditions;
- resistance to joining by sewing: min. 60% of the value of tensile strength;
- small mass and volume, determined by the aircraft configuration.

The diagram of the braking parachute assembly from the aircraft recovery system component is presented in **Fig.2**.



*Fig. 2: Diagram of the braking parachute assembly*

The specialists from INCDTP designed and made a woven structure made of 100% para-aramid yarn with a length density of 220dtex/f134 and which presents the physical-mechanical characteristics presented in **table 1**. The images obtained by scanning electron microscopy are present in **Fig.3**.

This fabric has been tested for seaming to determine how it will break. To assemble the para-aramid panels, it was used coats thread brand para-aramid with continuous filament - needle

size 140/22 and Pfaff 2235 sewing machine with Ecodrive servomotor. It was also used French seam double top stitch 2x301, to stabilize shape.

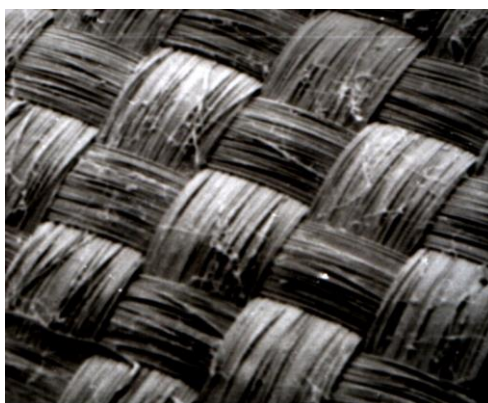
The configuration of the MIG21 Sniper supersonic aircraft requires the use of a High-Tech yarn with a temperature resistance of at least 300 degrees Celsius, which is proven only for the para-aramid yarn. It is well known that the restrictions imposed on the woven structure are also due to the aerodynamic configuration.

The 2x301 stitch is the only one that can be used, given the restrictive control of the overall permeability. Also, this type of seam ensures that the strength of the stitch is maintained (60 percent of the value of the breaking strength of the fabric) without affecting the aircraft's attitude when landing.

These results were obtained for the first time in Romania, all the results being strictly used for supersonic aircraft with  $V_{taxi}$  of 350km / h and cruising speed of 2.2M

*Table 1: The physical-mechanical characteristics of the fabric obtained at INCDTP*

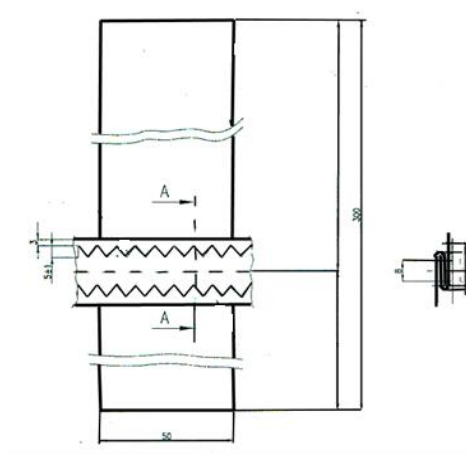
Characteristics	Values
Mass, g/mp	88
Tensile strength, daN U/B	309/308
Elongation at break, % U/B	8.4/6.2
Slip resistance of yarns, daN U/B	37/40
Tear resistance, daN U/B	60/55



*Fig. 3: Electron microscopy images for the obtained fabric (40X magnification)*

A zig-zag seam was applied over the two-needle seam, a p-aramid yarn, the thread used for both types of seams being Nm 40/3 -100% Kevlar para-aramid. The type of joint used for joining the panels and making the seams is shown in **Fig. 4**, and the physical-mechanical characteristics of the subassemblies used in the assembly are presented in **table 2**.

Several rows of stitches were used because the efficiency of the seams for thread and para-aramid materials is lower compared to those of thread and materials made of polyamide or polyester which are used to make deceleration systems for other aircraft, with a different configuration (for example MiG 21-LanceR). The small elongation of the thread and implicitly of the fabric determines a reduced capacity of the assembly to take over the shock loads, therefore the length of the resistance seams, on the para-aramid fabric was increased by approx. 15% compared to polyamide or polyester. In all the samples taken, the joint was made without any technological problems.[6]



**Fig. 4:** The type of joint

The panels joined by sewing were tested in the accredited laboratories within INCDTP.

**Table 2** Physico-mechanical characteristics of the subassemblies used to join the panels

<b>Subassembly</b>	<b>Characteristics</b>
Para-aramid tape 25-1000 S.T.2 (90851)	Width, mm: 25±1; Mass, g/m : 11,5; Breaking resistance, min, daN: 1000; Elongation at break, min, % 3,5
Para-aramid strap 43-5500 S.T.3 (90852)	Width, mm: 48±2; Mass, g/m : 52 Breaking resistance, min, daN: 5500 Elongation at break, min, % 3,5
Para-aramid thread Nm 40/3 S.T.4 (90853)	Length density, Nm: 40/3 Breaking resistance, min, daN: 9 Elongation at break, min, % : 5
Para-aramid thread Nm 40/3 S.T.5 (90854)	Length density, Nm: 20/3 Breaking resistance, min, daN: 15 Elongation at break, min, % : 5

### 3. RESULTS

The results obtained after testing the joint of the panels with dimensions of 5 cm X 30 cm are presented in **table 3**, compared to the tensile strengths of the finished fabric.

**Table 3** Comparative values of the tensile strengths of the finished fabric and the joined panels

<b>Characteristics</b>	<b>Values</b>	
Mass, g/mp	U	B
Tensile strength, daN	309	308
Breaking elongation, % U/B	8.4	6.2
Tensile strength of fabric, joined by two-needle stitching, with zig-zag stitched tape, daN	235	228

It can be appreciated that:

- the assembly will be able to withstand the shock loads that will occur during taxiing of the aircraft, although the tensile strengths of the fabrics joined with zig-zag stitching, compared to the tensile strengths of the fabric without joining are 24% lower in warp and with 26% in the weft.[8,9]



- during the strength tests, it was found that in all the tests the fabrics broke near the joint, which is important because it is preferable for the fabric to break instantly, at a certain value (even small, but sufficient to take over the overall shock load) rather than slipping long before breaking, as an area of airflow may occur during operation and the parachute may not open. The phenomenon is particularly dangerous, because it can occur at any time and not being a clear break, it cannot be noticed in time by the personnel in charge of the maintenance of the recovery system with the help of the parachute.

#### 4. CONCLUSIONS

The technique developed by INCDTP specialists and used to assemble fabric panels made of 100% para-aramid yarn with a length density of 220dtex/134f corresponds to the field of use, the whole recovery system with the help of the parachute having the ability to withstand the shock loads that will occur during taxiing on the runway of the aircraft when it is in the landing configuration.

Breaking the fabric exactly at the joint eliminates the possibility of air leaking during the operation of the recovery system, which could lead to the main parachute not opening. In addition, this clear rupture can be noticed immediately by the personnel in charge of parachute maintenance.

#### ACKNOWLEDGEMENTS

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