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KINEMATICS OF THE LANDING GEAR SYSTEMS OF AIRCRAFT

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Abstract: *The mechanisms best represented in aircraft design are the bar mechanisms. They are mostly part of the landing gear and of the command systems for aircraft space positioning and for changing flying conditions. The current article is a review of bar mechanisms with reference to the landing gear of aircraft as well as a kinematics functional analysis with software assistance.*

Keywords: *mechanisms, landing gear, software analysis*

1. INTRODUCTION

Mechanisms are mechanical systems for transmitting and changing the motion and forces of one or several moving bodies as well as the constraint forces of other bodies; it is the kinematic chain where one kinematics element is fixed [1].

The mechanisms best represented in aircraft design are the bar mechanisms. They are mostly part of the landing gear and of the command systems for aircraft space positioning and for changing flying conditions. [2, 3].

The landing gear is the aircraft component which ensures taxiing in good conditions, prior to takeoff and after landing as well as during parking, see figure 1.1 and 1.2.

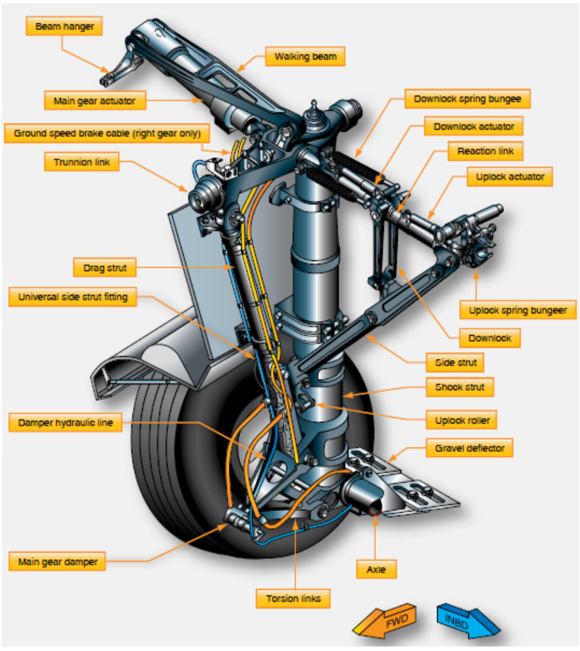

Fig. 1.1 Main landing gear components [5]

Fig. 1.2 Aircraft landing gear [5]

Mostly due to aerodynamic reasons, the majority of modern aircraft exceeding the speed of 350 km/h are equipped with retractable landing gears. The diverse designing requirements turn the design and construction of a retractable landing gear suitable for certain aircraft into complex, difficult tasks. The need of such requirements has led to an increasing number of constructive variants for the design and building of retractable mechanisms as well as to a more systematic approach, - see figures 1.3 and 1.4.

Fig. 1.3 Lockheed Martin Landing Gear - F 16 [6]

Systematization has been used for studying retractable mechanisms, one based on specific classification criteria which emphasize the ranking of these technical systems. Thus, the landing gear can be worthy of being considered a complex system, falling into three categories or subsystems: a *drive mechanism* which is mainly made of a subassembly with the piston in oscillating cylinder and pneumatic or hydraulic drive; a *main mechanism* which supports the gear wheel by means of the undercarriage leg operated by the undercarriage strut; a *wheel spinning mechanism* which can often be studied separately from the other subassemblies.

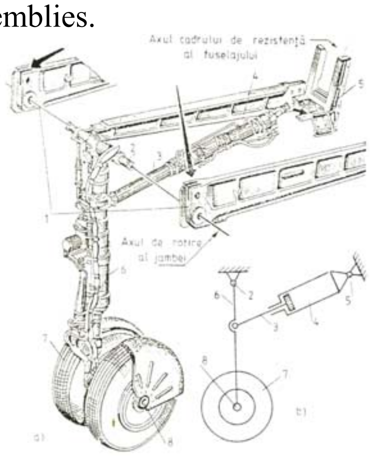

Fig. 1.4 Design of a retractable landing gear [1]

Figure 1.4 shows the following: *1-strut bracing girders, 2-strut rotation axis, 3-actuator rod, 4-strut retraction actuator, 5-assembly for attaching the actuator to the fuselage/wing, 6-landing gear strut, 7-landing gear wheel, 8-axis of the landing gear wheel.*

The most frequently used landing gears are the ones with folding bracing strut, see figure 1.5. The main advantage of this retraction mechanism is that it occupies relatively little space in the fuselage after retraction.

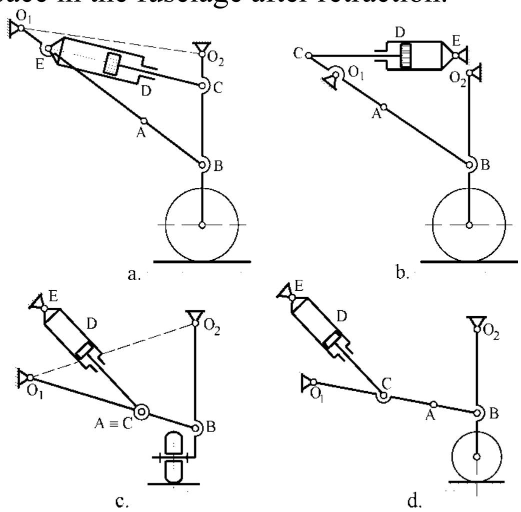

Fig. 1.5 Kinematics diagram of the landing gear with folding bracing strut

From the structural point of view, as shown in figure 1.4 and as previously mentioned, these mechanisms are made up of the drive system (hydraulic or pneumatic) and a four-bar mechanism 4R, O_1ABO_2, which is the main mechanism of the retraction system.

All cases clearly demonstrate that the design of the drive mechanism can be done only if certain requirements are met.

One of these requirements is to determine the extreme positions of the elements of the mechanism when the gear is out or retracted. It is a follow-up of the synthesis of the main mechanism of the landing gear. The synthesis will be performed in such a manner that, during its functioning, the mechanism will not reach singular positions.

2. KINEMATICS THEORY

Figure 2.1 shows a kinematics diagram of a drive mechanism of the landing gear in which three consecutive positions are presented and the following notations are made $O_1A= r$, $O_1E= d$.

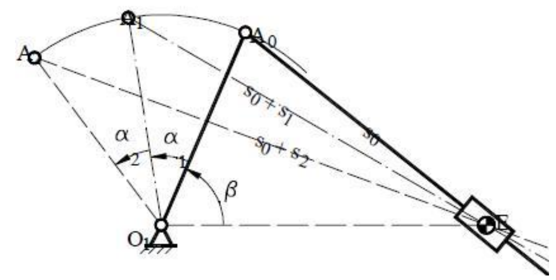

Fig. 2.1 Kinematics diagram of a mechanism with oscillating cylinder for three consecutive positions

Parameters s_0, s_1 and s_2 are known and determine the piston path for all three consecutive positions. Angles α_1 and α_2 determine the position of the balancer related to the initial position.

The landing gear must show certain advantages and meet certain requirements such as: a minimum number of force elements, a minimum number of mobile elements and joints, no deformity of subassemblies and joints, high reliability, minimum resistance to forward motion, landing shock absorption, reduced weight, easy maintenance, and the best braking capacity.

3. KINEMATICS ANALYSIS OF THE LANDING GEAR

We have used Artas SAM 6.1sofware for the kinematics analysis of the landing gear. It is interactive software for design, analysis, synthesis and optimization of plane mechanisms. The software package includes a numerical preprocessor and a post-processing analysis with animation and graphic display of parameters. SAM 6.1 also includes a set of instruments such as design and modeling of mechanisms, CAD interface, and optimization of mechanisms, post-processing and analysis of results, [4].

We propose for analysis a plane mechanism of the landing gear (a constructive solution for both the front strut and the main struts), of the oscillating cylinder type, as shown in figure 3.1.

The mechanism is according to a set of mandatory requirements: supporting points 1 and 5 (the slideway) are at the same absolute altitude, element/bar 3 (the strut) is initially perpendicular to the ground. The component elements have the characteristics in table 3.1.

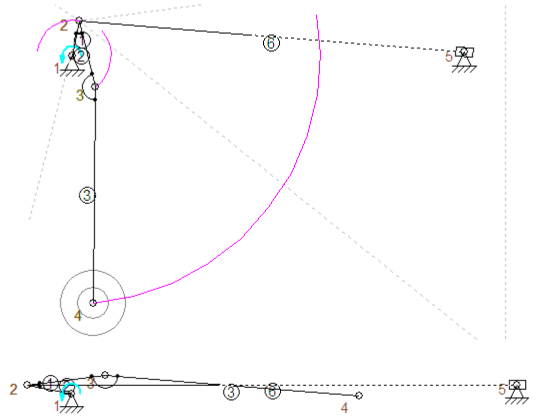

Fig. 3.1 Kinematic diagram of a landing gear

Table 3.1 Characteristics of the landing gear

Element	Value
Element 3, the strut	560 mm
Element 6, bracing strut actuator	970 mm
Element 1, strut spur	100 mm
Node 1 rotation angle	900

Figure 3.2 highlights the variation of absolute motion of node 4 (wheel axis) and nod2 2 (strut spur) while figure 3.3 highlights the speed of these nodes.

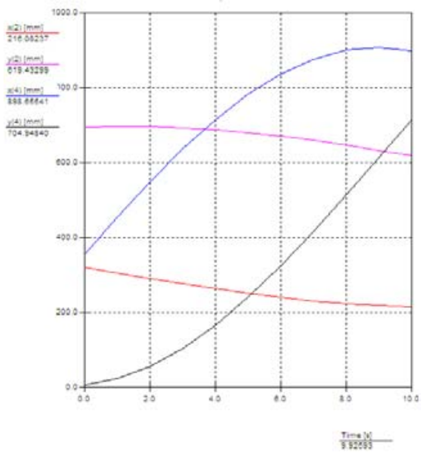

Fig. 3.2 Motion of nodes 2 and 4

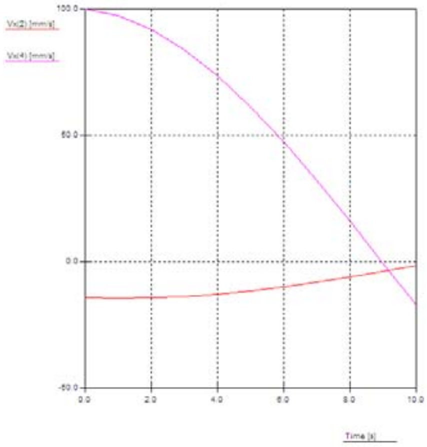

Fig. 3.3. Speeds of nodes 2 and 4

Figure 3.4 highlights the motion of nodes 2 and 4.

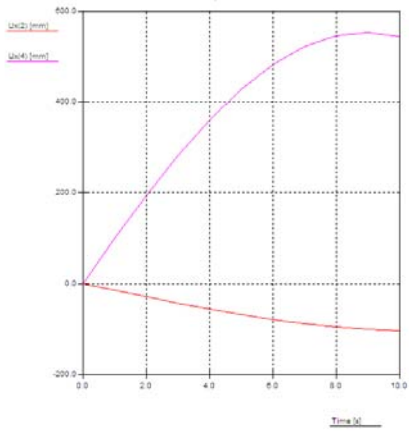

Fig. 3.4 Absolute motion of nodes 2 and 4

Table 3.1 Motion values for nodes 2 and 4

Nr: [-]	Time [s]	Ux(2) [mm]	Ux(4) [mm]
0	0.000	0.000	0.000
1	1.000	-14.322	98.716
2	2.000	-28.719	193.318
3	3.000	-42.796	281.214
4	4.000	-56.168	359.991
5	5.000	-68.468	427.490
6	6.000	-79.357	481.858
7	7.000	-88.539	521.605
8	8.000	-95.760	545.641
9	9.000	-100.822	553.305
10	10.000	-103.588	544.388

4. CONCLUSIONS & ACKNOWLEDGMENT

The kinematics of the mechanisms which are part of the command system of the landing gear needs to be subject to a rigorous dimensional study in order to prevent occurrence of inappropriate phenomena through kinematic parameterization.

The software method allows design and parameterization of the landing gear mechanism at a reliability level similar to the one of studies on the real models.

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