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UAV Drive Units Testing at Pork Tissue

Stanislav Absolon[1]; Hana Havlová[1]; David Hůlek[1]*

[1]Department of Air Transport, Faculty of Transportation Sciences, Czech Technical University in Prague, Prague, Czech Republic

***Corresponding author**: Czech Technical University in Prague, Faculty of Transportation Sciences, Department of Air Transport, Horská 3, 128 03 Prague, Czech Republic, Email: hulekdav@fd.cvut.cz

Abstract

This article deals with the influence of propulsive units of unmanned vehicles on living tissue. More precisely it describes physical tests performed on pork tissue. In the first part of the article, there is a brief description of current situation regarding injuries of people caused by UAV. There are similar tests from other researchers described and given reasons why the tests were made. In the next part of the article, the authors describe the selection of components needed for testing and the entire preparation of the tests from the selection of engines and propellers till the construction of the testing mechanism. Description of the course of the tests and the evaluation of the results follows. The tests were static only. This means that the propulsive units were approaching the test samples (pork leg and ribs) at a very low forward speed. The evaluation of the results is not complete. This is due to the fact that all of the scheduled tests have not been carried out yet neither has the medical injury analysis been finished. It is still a work in progress. The last part summarizes the findings and gives brief plans for further tests.

Keywords

UAV drive testing; testing at tissue; UAV and tissue; UAV testing at tissue; UAV and injury

1. Introduction

Unmanned vehicles are on a global scale one of the most discussed topics including a lot of questions. One of the most frequently asked questions is how to approach unmanned vehicles from a safety perspective and what legislation to apply to their operation. Their use depends on their construction design and on safety risks they may cause to their surroundings. In order to determine how great the risks are, it is necessary to verify in practice what injuries can be caused by unmanned vehicles when clashing with a person. It may not always be an intentional clash. In many cases there may be an operator error or a device malfunction. This article refers to conducted tests of collision of propulsive units and pork tissue. Based on these tests, an assessment of the risks posed by unmanned vehicles is carried out.

2. Current stage

At present, both at national as well as at international level, unmanned vehicles are divided by weight and not according to the components used on UAVs. The draft of the new EU legislation prepared by the EASA counts with division of unmanned vehicles according to the mass and the energy absorbed by the human body on impact. [1] The authors of this article are of the opinion that allocation according to weight is insufficient. In contact of UAV with human body, not only the weight mentioned above, but also the construction type of UAV (multicopter, aircraft, helicopter, etc.), size and

Table 1. Drive units

	Brand	Engine	Propeller	Material	ESC	Battery	Rotation
1	Emax	2280kV	5x3"	Plastic	18A	3S	11475
2		2280kV	8x5"	Carbon	18A	3S	7002
3	Hobby	910kV	12/6"	Wooden	80A	3S	5137
4	King	910kV	8/4"	Plastic	80A	3S	7356
5	Emax	650kV	13/4.5"	Plastic	80A	6S	6045
6	T-motor	920kV	9.5/4.5"	Carbon	18A	3S	7986
7	DJI	400kV	15/5.2"	Plastic	40A	6S	6751

type of propellers, protective elements, types of used materials etc., play their part. Certain consideration of these things is in the division of UAV according to the absorbed energy by the human body. Nevertheless, the authors believe that the distribution should be at least according to the type of construction[2][3].

A few years ago, Danish scientists conducted similar tests to those carried out by the authors of this article. The Danish experiment consisted of mounting the propeller engine on a mobile console that was catapulted onto the pork tissue.[4] The simulation can be considered a dynamic test of interaction between tissue and UAV propeller. This research inspired the authors to carry out the tests described in this article[5].

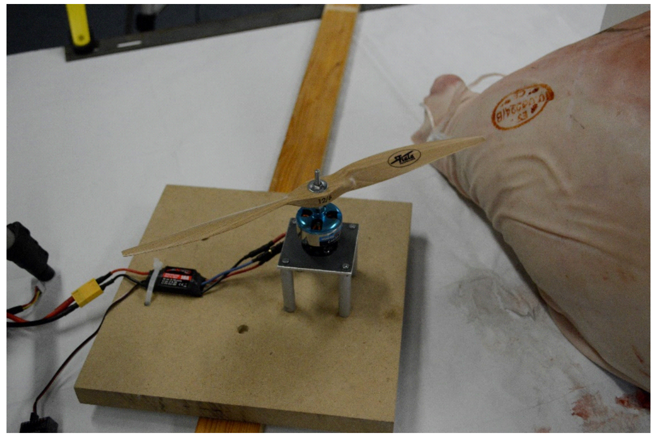

Figure 1. The mechanism with wooden propeller and Hobby king 910 kV engine.

3. Input Test Parameters

For the tests, combinations of drive units were selected to represent a wide range of common UAV and aviation model drives. All tested motors were brushless and powered by lipol batteries. Table 1 lists combinations of electric motors, propellers, propeller material, ESC, batteries and approximate rotation speed per minute.

For the tests, a mechanism, on which the drive unit was mounted, was assembled and subsequently hit a sample of pork tissue. The entire mechanism was assembled from wooden and steel elements (Fig. 1) which guaranteed great rigidity. These tests were just static. After spinning the propeller, the mechanism drew the drive unit by slow motion closer to the test sample. At the moment of impact, the propeller continued to move until it was completely stopped or damaged. The test samples were two. First sample was the outside of the pork leg tissue. The second sample was the inner part of the ribs where the reaction was examined directly on the bones.

The following tests are scheduled as dynamic examinations. These tests shall demonstrate the damage to the pork tissue resulting from the impact of the drive unit which will be accelerated. Combining static and dynamic tests plus testing different engines and propellers should provide a comprehensive overview of how an unmanned device can affect the human body.

4. Test Results

A detailed medical analysis of the occurred injuries is still ongoing. For this reason, only the summary of the injuries and their parameters will be given in this chapter. Overall, soft tissue injuries (leg) were less serious than expected by the authors. Figure 2 is an example of a soft tissue injury. As expected, it was found that the bigger propeller and the stronger the engine, the bigger the wound. However, this finding is not surprising. On the other hand, injuries caused by propellers on hard tissues (ribs) have surpassed expectations. The damage was extensive and in one case the bone was so severely damaged the bone marrow was cut out. If the test continued for a while, the bone would be cut through (Fig. 3). Table 2 lists ranges of injuries for individual combinations of engines and propellers.

5. Discussion

A detailed medical analysis of the occurred injuries is still ongoing. Therefore, it not possible to evaluate the injuries from the medical point of view. The initial assessment was made by the authors of this article. Tests show that larger propulsion units cause bigger injuries. It was found that skin and subcutaneous fat provide great protection. However, pork skin is stronger than human. Larger diameters of powerful propellers are able to cut bone without causing greater damage to propellers or engines. The truth remains that bone testing was

Table 2. Overview of injuries caused by different types of engines and propellers

	Engine	Propeller	Material	Sample	Dimensions of injuries [mm]			
					Lenght	Width	Depth	Comment
1.	2280kV	5x3”	plastic	rump	15	1.5	0.1	
2.	2280kV	8x5”	carbon	rump	50	3	0.2	
3.	910kV	12/6”	wooden	rump	55	1.5	0.2	
4.	910kV	12/6”	wooden	ribs	60	10	5	
5.	910kV	8/4”	plastic	rump	40	5	0.1	
6.	910kV	8/4”	plastic	ribs	60	20	5	scratched bone
7.	650kV	13/4.5”	plastic	rump	30	15	7	dirt on large area
8.	650kV	13/4.5”	plastic	ribs	70	30	5	bone cut
9.	920kV	9.5/4.5”	carbon	ribs	66	15	5	scratched bone
10.	400kV	15/5.2”	plastic	rump	50	20	10	
11.	400kV	15/5.2”	plastic	ribs	80	10	8	bone cut

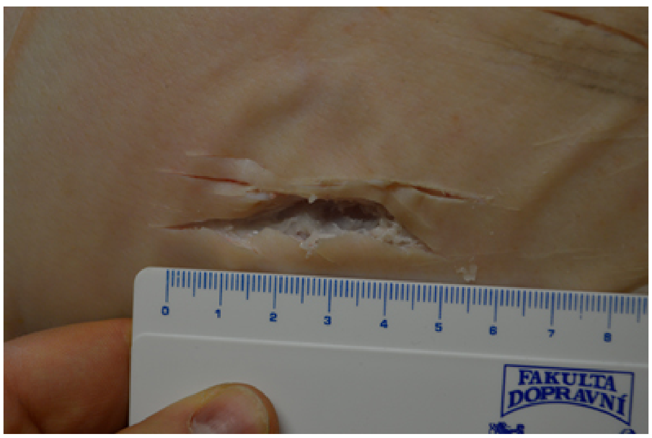

Figure 2. The soft tissue injury caused by DJI 400 kV engine with plastic propeller 15/5.2”.

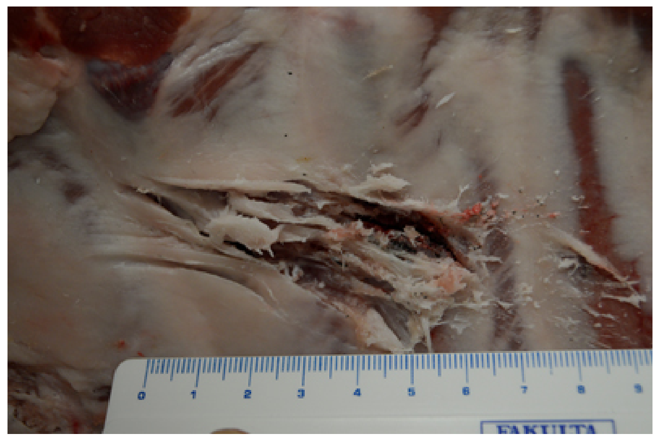

Figure 3. The hard tissues injury caused by Emax 650 kV engine with platic propeller 13/4.5”.

performed with only a small layer of pork tissue. In the real world, the human bones are protected by skin and muscles. It can, however, be said that crashing a rotating propeller with, for example, an upper limb or a skull can cause a chipped, broken bone or a skull fracture. The cutting and traumatic wounds were not clear cuts. The wound was multiple and the tissue was torn. Possible sewing of these wounds would be very complicated and demanding. For detailed evaluation and final conclusions, it is necessary to wait for medical analysis and dynamic tests which will provide a comprehensive overview of how the UAV can be dangerous in a collision with a human body.

6. Conclusion

Given that the project is not yet fully completed, definitive conclusions cannot be made. However, it is clear that unmanned vehicles used for commercial air transport are dangerous to humans and can cause serious injuries. The drive unit capable of cutting the bone may also be mounted on a device which falls, by mass, into a category which is expected to have minor injuries and therefore does not have such safety measures. It is therefore clear that the UAVs should not only be categorized according to the mass, but also the UAV design, the drive type and the protective elements should be taken into consideration.

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