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# 3D modeling of olive tree and simulating the harvesting forces

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**Abstract.** The paper presents the results of the study regarding the influence of shaking forces on olive tree harvesting systems. Shaking forces can be released through several methods. Important is the end result, namely the shaking force and the cadence of shaking speed. Mechanical and automatic harvesting methods collect more olives than traditional methods but may damage the olive trees. In order to prevent this damage, we need to calculate the necessary shaking force. An original research method is proposed to simulate shaking forces using a 3D olive tree model with Autodesk Inventor software. In the experiments, we use different shaking forces and various shaking speeds. We also use different diameters of the olive tree trunk. We analyze the results from this experiment to determine the optimal shaking force for harvesting olives without damaging the olive tree.

## 1 Theoretical considerations

Harvesting through manpower requires employing a large number of people for a limited time period, which could lead to social problems in addition to high labor costs [1, 4]. Due to the economic and social importance of olive trees, it is necessary to use an olive-harvesting robot or an olive-harvesting automatic system, thus eliminating a big number of the human operators, who are employed in large numbers for a limited time, and increasing the speed and the volume of work [2, 3, 5, 11]. In order to use an automatic system for harvesting, we must calculate the necessary force of vibration to shake the olive tree [4, 7, 12].

For this we can use a 3D model of an olive tree based on real dimensions. We use the average diameter dimensions, which is 30 cm at a height of 120 cm in the position of the shaking dispositive and the average density of olive tree wood in raw condition is ρw - 1.09 g/cm3 [5, 8, 10].

## 2 Experimental conditions

Before creating the 3D model, we were traveling in Greece in an olive orchard in region of Halkidiki that was designed to involve planting trees.

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**Fig. 1.** Olive orchard in region of Halkidiki

Afterwards we took measurements of more than 110 olive trees (height, thickness, perimeter and number of branches). The perimeter was taken at 120 cm from sol where is the position of the shaking system and of the vibration forces. Once we measured more than 110 olive trees we determined the average sizes table 1.

**Table 1.** Olive tree measurements.

| Olive tree | Perimeter of olive tree (cm) at high of 120 cm from sol | Height of olive tree (cm) |
|---|---|---|
| 1 | 62 | 353 |
| 2 | 59 | 322 |
| 3 | 67 | 370 |
| 4 | 65 | 341 |
| 5 | 63 | 335 |
| 6 | 68 | 340 |
| … | … | … |
| 112 | 59 | 294 |
| 113 | 58 | 289 |
| 114 | 64 | 296 |
| Average dimensions | 62 | 335 |
| Minimum dimensions | 53 | 258 |

We used this data to create a 3D model. We used one 3D model: figure 2, with two sizes, one with the smallest size we found, and one based on dimensional average.

**Fig. 2.** 3D olive models rendering in Autodesk Inventor.

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Afterwards, we simulated different vibration forces in Autodesk Inventor analysis study, figure 3. The vibration forces were at a high of 120 cm in the olive tree, in positions of the shaking system [6, 9].

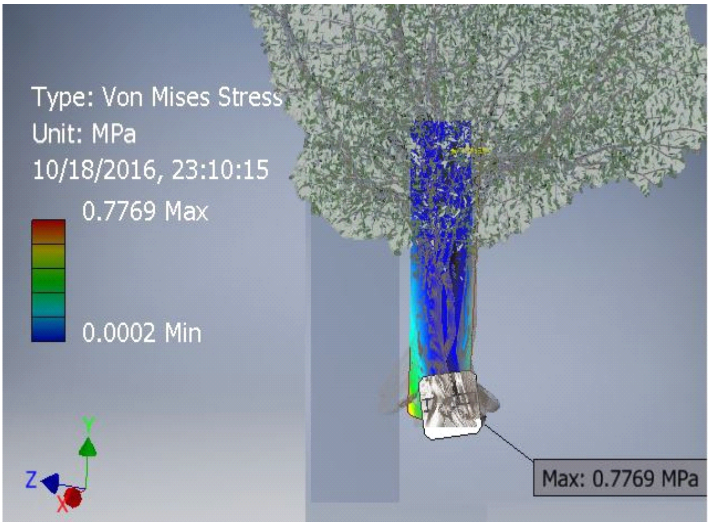


**Fig. 3.** Autodesk Inventor analysis.

## 3 Results and discussions

In order to determine the necessary vibration forces we can use certain software such as Inventor or Solidworks, where we can create the 3D model and simulate the forces. In this case, we used Autodesk Inventor with different vibration forces and statically force, table 2.

All results were satisfactory on highest forces without breaking the olive tree.

**Table 2.** Autodesk Inventor vibration results on olive tree wood.

| Parameter | Minimum value | Maximum value |
|---|---|---|
| Volume | 176715000 $mm^3$ | |
| Mass | 134.303 kg | |
| Von Mises Stress | 0.000176446 MPa | 0.776895 MPa |
| 1st Principal Stress | -0.0196544 MPa | 0.716821 MPa |
| 3rd Principal Stress | -0.648668 MPa | 0.0204877 MPa |
| Displacement | 0 mm | 0.593403 mm |
| Safety Factor | 15 ul | 15 ul |
| Stress XX | -0.132117 MPa | 0.134893 MPa |
| Stress XY | -0.0538508 MPa | 0.233049 MPa |
| Stress XZ | -0.102971 MPa | 0.0967356 MPa |
| Stress YY | -0.622679 MPa | 0.681943 MPa |
| Stress YZ | -0.0697603 MPa | 0.249304 MPa |
| Stress ZZ | -0.296653 MPa | 0.272747 MPa |
| X Displacement | -0.000801034 mm | 0.314307 mm |
| Y Displacement | -0.0455565 mm | 0.0453073 mm |
| Z Displacement | -0.00139634 mm | 0.501298 mm |
| Equivalent Strain | 0.0000000128804 ul | 0.0000634389 ul |
| 1st Principal Strain | -0.0000697494 ul | 0.00000219895 ul |

| | | |
|---|---|---|
| 3rd Principal Strain | -0.000014206 ul | 0.0000145032 ul |
| Strain XX | -0.000014206 ul | 0.0000145032 ul |
| Strain XY | -0.00000579099 ul | 0.0000250616 ul |
| Strain XZ | -0.0000110733 ul | 0.0000104027 ul |
| Strain YY | -0.0000669544 ul | 0.0000733271 ul |
| Strain YZ | -0.00000750186 ul | 0.0000268095 ul |
| Strain ZZ | -0.0000318973 ul | 0.0000293271 ul |

The harvest forces taken into consideration in the present paper were validated by the virtual model simulated in Autodesk Inventor, results being part of a previous paper already presented in another Conference.

The researches will continue by creating a real model of harvesting device with adjustable forces that will confirm or not our presumptions and aloud us to establish closer values for forces closer with the real situation.

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