University of Patras
Department of Mechanical Engineering and Aeronautics
Division of Design & Manufacturing
Machine Design Laboratory

Diploma's Thesis:

Tribological design of knee joints in mixed lubrication operational regime

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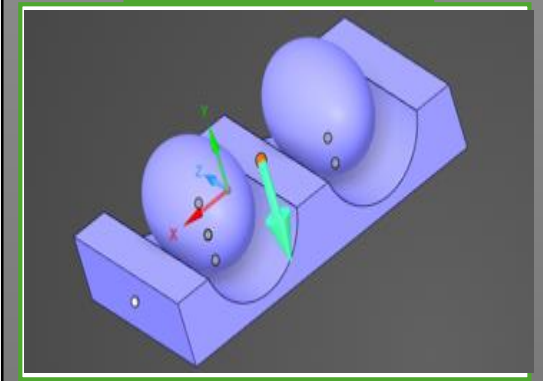
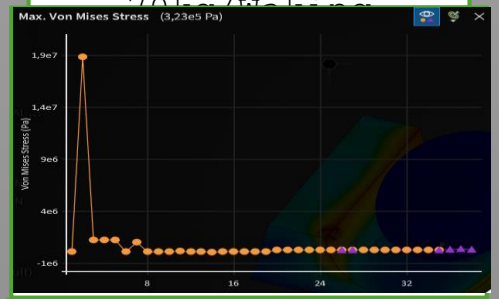
1. Abstract

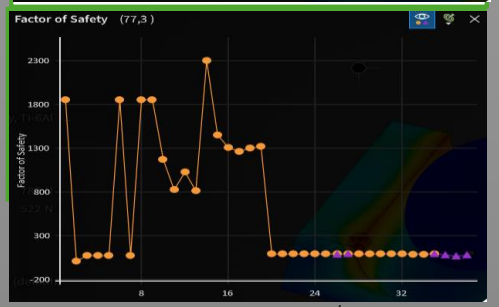
In this paper, the tribological design of an artificial knee joint under mixed lubrication regime is carried out using the finite element analysis (FEA) software ANSYS. The debate on artificial joints has been going on since the beginning of the 20th century and many computational and experimental studies have been carried out over the years. The aim of these has been to optimize their lifetime. Artificial joints find application in cases of people whose natural joint has failed, resulting in an inability to move it or severe pain when moving it. The reason for the failure of each joint (friction between the parts of the joint due to lack of lubricant) makes it necessary to study further the artificial joints and the operating cycle of the natural joint, with a view to the correct replacement of the latter. Initially, general elements of the knee joint were studied, such as the bones involved, the gait cycle, its lubrication and the bio-lubricants that can be used. Then, tools such as the Reynolds equation for hydrodynamic lubrication and the Greenwood and Tripp model were used to understand the roughness of the model, in areas where there is contact between lubricating surfaces, since a mixed lubrication regime exists. The MATLAB programming model was used for the computational process, for the Reynolds model validation, while the ANSYS package with the Discovery application was used for the design and analysis. Thus, analytical diagrams are given for the loading of the model, stress distribution and the robustness of the model and the materials selected during design.

2. The Model



3. Person 70kg/Walking

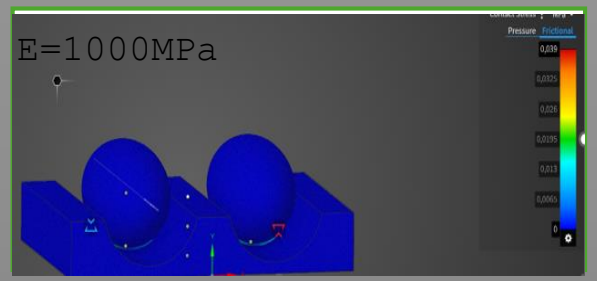




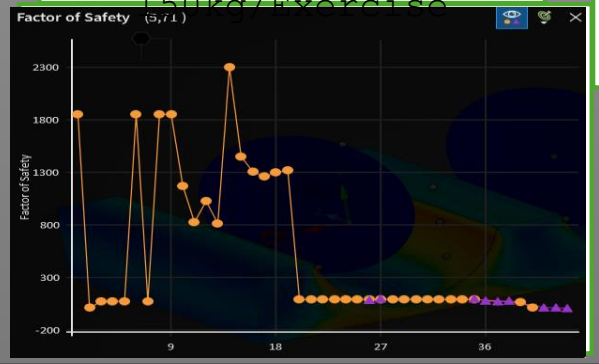
4. Person70 kg/ Other activities

EXCERSICE	VON MISES (MPa)	DISPLACEMENT (m)	FACTOR OF SAFETY
WALKING	0,323	0,00000493	77,3
STAIR CLIMBING	0,696	0,0000091	35,9
RUNNING	1,19	0,0000156	20,9
SQUATING	1,59	0,0000208	15,7
JUMRING AND LANDING	2,39	0,00003125	10,5

5. Modified Tensile Modulus of Tibia



6.Person 150kg/Exercise



7.Conclusions

1) The choice of polyethylene (UHMWPE) and titanium alloy materials gives a robust and reliable artificial joint capable of replacing the natural artificial joint.
2) The model of the artificial joint enables not only simple movement but also light exercise.
3) There is relative displacement of the joint members, but it is so small that it does not seem to cause a problem.
4) With an increase in the elasticity modulus of polyethylene there is an increase in frictional stress, while a corresponding decrease is achieved by reducing it.
5) The strength of the artificial joint depends as expected on the weight of the patient, as in the case of an overweight patient the loads increase significantly resulting in the possibility of failure, especially under exercise. It appears to be possible to meet the needs for people weighing up to 150 kg.
6) The strength of the joint depends on the thickness of the lubricant, as in the simulation it remains constant no problem is observed, in case of a decrease in this the friction will increase resulting in faster wear and an increase in the probability of fracture.