FOOTPRINT: NONLINEAR MODEL OF PRESSURE DISTRIBUTION

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INTRODUCTION

The aim of the study is to find realistic visco-elastic model of the foot. Change of foot shape and the pressure distribution between the foot and its surroundings are effects of the response to their mutual interaction [1]. To detect the changes in the foot shape and its surroundings we defined a calculation model reflecting the material viscose-plasticity of the imprint substance in two steps. MODEL I – for small deformations, and MODEL II for major deformations using the second order theory, i.e. considering geometric non linearity. Foot shape was detected by MRI technology for leg with load applied and without applied load.

METHOD

Using a preloaded spring device to apply load on the leg we achieved axial load strength of the leg of 1G. Foot shape was detected using MRI scans in states with load applied and without applied load.

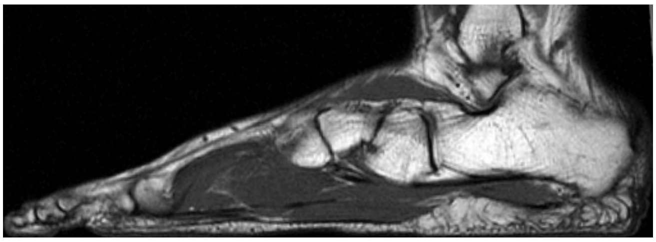

Figure 1: MRI scan of loaded foot

Basic mechanical features of the imprint substance PHASE 1 were ascertained by the dependency of the imprint depth of the testing role on time. We used MODEL I of viscose-plasticity, and J2 condition of plasticity. In the SIFEL program for small deformations < approx. 3%, and geometric linearity, counting in MKP (FEM), we achieved the required material parameters. Using these we calculated the applied load field between the foot and the imprint substance. Using the ADINA MODEL II program for major deformations and geometric non linearity we simulated the experiment and the resulting material parameters better fitted the calculated dependency on measured courses.

RESULTS AND DISCUSSION

Result is the calculation of pressure distribution between the foot and its surroundings – the imprint substance. Picture no. 1 visualizes the calculation of pressure distribution of the foot and the imprint substance for MODEL I. MODEL II better accepts the characteristics of fast solidifying material, including major deformations. Table 1 contains the resulting calculated values of the material parameters.

- E = 4800 [Pa] - Young´s flexibility module
- k = 600 [Pa] - yield limit
- H = 2000 [Pa] - stabilization module
- a_0 = 4.2e-005 - viscosity ratio determining the scale of viscous deformation
- a_1 = 1.53 - viscosity ratio determining dependency on achieved tension
- a_2 = 0.5 - viscosity ratio determining dependency on time
- ν = 0,49 - Poisson´s factor

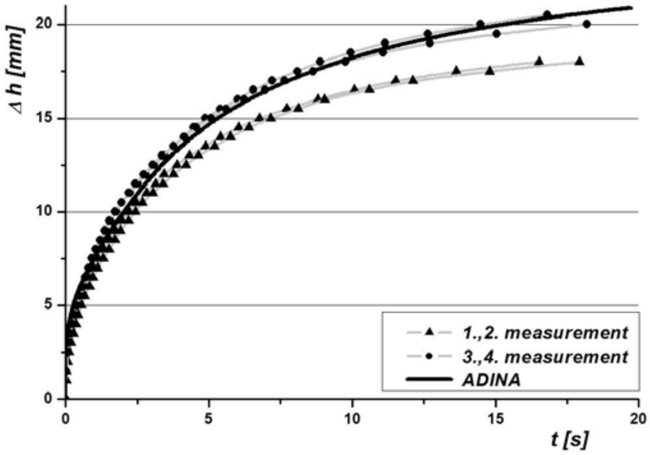

Figure 2: Detection 3, 4 –water concentration I – MODEL II, Detection 1, 2 –water concentration II – no model

CONCLUSIONS

For the foot – surroundings mutually interactive elements, it is needed to further detect the mechanical characteristics of the foot surface as a viscose-elastic material, which changes its final shape and characteristics as a result of load applied from inside – for example weight force, and from outside – pressure reaction field [4]. That is a task for a further stage. We didn´t find this methodology published in literature. Generally it is expected to use the models to determine material responses to applying load in orthopedics, shoe manufacturing industry, rehabilitation, forensic area etc.

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