Static Structural analysis of the 'Robotic Physiotherapeutic Device'

In order to perform static structural analysis of the 'Robotic Physiotherapeutic Device', first, the 3D structure of the device is modelled with the proper dimensions using CATIA (Version 5). Finite element method is employed for performing static structural analysis of the designed model. Linear tetrahedron mesh is used in the static structural analysis process. A simulation is performed to analyse the effect of the loading (static) conditions in the structure of the device. The Von Mises stress, principal stress, structural deformation value of the device structure due to application load is computed from the simulation process. The selected simulation parameters are provided in Table XI. Properties of the materials (i.e., aluminium and steel), used in the static structural analysis process is shown in Fig. 20. Fig. 21 shows the boundary conditions which are set for static structural analysis of the designed model. In the Fig. 21, 'yellow' arrows signify applied load and 'blue' arrows signify restraints (support).

TABLE XI
SIMULATION PARAMETERS

Parameter	Value
Material of the 'Base' Part	Steel
Material of the 'Cage' Part	Aluminium
Applied load on the 'Base' Part	1000 Kg.
Applied load on lower part of the 'Cage'	20 Kg.
Applied load on lower part of the 'Cage'	60 Kg.
Direction of the applied force/load	Perpendicular to the surface

Material	Steel
Young's modulus	20394.324kgf_mm2
Poisson's ratio	0.266
Density	7.86e-006kg_mm3
Coefficient of thermal expansion	1.17e-005_Kdeg
Yield strength	25.493kgf_mm2

Material	Aluminium
Young's modulus	7138.014kgf_mm2
Poisson's ratio	0.346
Density	2.71e-006kg_mm3
Coefficient of thermal expansion	2.36e-005_Kdeg
Yield strength	9.687kgf_mm2

Fig. 20. Material Properties.

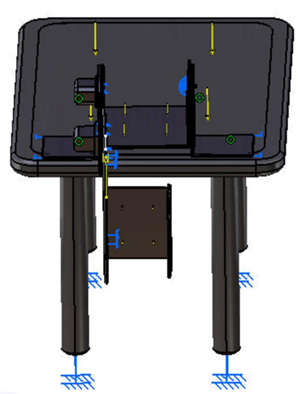

Fig. 21.Boundary Conditions set for the static structural analysis process.

While using the designed 'Robotic Physiotherapy Device', a patient is supposed to seat/lie on the 'base' and put his leg into the 'cage'. So the 'cage' part will carry the weight of a patient's thigh, leg, and toe. To be more specific, the upper part of the 'cage' will bear the weight of the thigh, and the lower part of the cage will bear the weight of the leg and toe. The average weight of a complete leg (i.e., thigh, leg and toe), thigh, leg, and toe are 17.55 kg., 11.12 kg., 5.01 kg., and 1.38 kg., respectively [47]. Considering dynamic load (i.e., the load generated in the structure while it is in motion) as three times of the static load, we apply 60 kg and 20 kg as loads at the upper and lower parts of the cage, respectively, for structural analysis.

The base part will carry the weight of the patient and other parts of the 'Robotic Physiotherapeutic Device'. The average weight of an Indian person is 65 kg [25]. Assuming one or two people may also sit on the 'base' while a patient is doing exercise using the device and dynamic load three times as the static load, the applied load on the base is set as 1000 kg. for the structural analysis process.

Fig. 22 describe the overall static structure analysis report obtained by the performed simulation process, and the design appears to be good as per the obtained stretch value of the report.

Entity	Size
Nodes	16372
Elements	51759

ELEMENT TYPE:

Connectivity	Statistics
TE4	51759 (100.00%)

ELEMENT QUALITY:

Criterion	Good	Poor	Bad	Worst	Average
Stretch	51413 (99.33%)	346 (0.67%)	0 (0.00%)	0.098	0.567
Aspect Ratio	37362 (72.18%)	13970 (26.99%)	427 (0.82%)	19.557	2.291

Fig. 22. Overall static structure analysis report.

Von Mises stress is characterized as a quantity used to determine whether a given material will yield or fracture. According to the von Mises yield criteria, a material will yield if the von Mises stress is equal to or less than the yield limit of the same material (under simple tension). The simulation results show that the Von Mises stress and primary stress generated in the device's structure as a result of the load application are lesser than the material's yield strength.