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SIMULINK BASED BIODYNAMIC MODEL FOR THE HUMAN ARM SUBJECTED TO VIBRATION

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Abstract

Every machine generates some vibration when it's in working mode. It is clear that such vibration can be effectively transmitted to the human arm cause adverse effects. The objective is to investigate the vibration transmission from the human arm. Some injuries caused due to the mechanical vibration transmitted to human arm while driving vehicle or operating heavy machine. To develop a human hand arm biodynamic model and to investigate the biodynamic response (BR) in the six degree of freedom (DOF) of the human- hand arm system (HAS). The model is based on the second order mass-spring-damper system. In this study presents the biomechanical models considering the masses, stiffness, and damping of the finger, palm-wrist-forearm, and upper-arm and corresponding to different modes of vibration. To study a possible ways to for reducing the health-hazards of hand due to vibration by using the isolator and gloves. Matlab-Simulink based on this model to determine the effect of vibration transmits from driving vehicle or operating machines. This results are discussed the view-point of the vibration response behaviour of the hand arm that are presented in the Matlab-Simulink

Keywords: Biodynamic of hand-arm vibration, ergonomics, hand-arm models, Anti-vibration gloves and isolator.

1. INTRODUCTION

Nowadays, in daily life, the human arm is exposed to different mechanical vibrations occurs during travelling through vehicles or heavy handling machinery. The long term contacted hand tool vibration causes damage in the joint are wrist, elbow and shoulder disorders. The major component of upper extremity musculoskeletal disorders (MSD). A remain major occupational diseases for further life. The vibration disbursed in numerous substructures of the hand arm device uncovered to vibration. On this study a six degree-of-freedom (DOF) of human hand arm system (HAS) mechanical model, to research the biodynamic response (BR) characteristics of the hand arm system. The hand arm model with isolator and gloves is simulated in Matlab - Simulink software program to assess rms acceleration values at segments of hand-arm gadget. Ren G. Dong and Jennie H. Dong [1], a few reported driving-point biodynamic responses (DPBRs) models have shown such good agreements between modelling predictions and experimental data as those observed. While the suggested low order models have proven quite terrible agreements with the experimental records, the excessive-order models commonly yield excessive static deflections attributed to their low stiffness parameters rakheja et al. The three-DOF version defined in yields a deflection of 9.37 mm between the hand and handle in the Z_h-axis below a 50 N push pressure, which is taken into consideration to be unrealistic and could make it difficult to assemble a hand–arm simulator. The proposed 4-DOF model is quite simple for fabrication of a hand–arm simulator, even as the 5-DOF model can offer extra records at the distributions of the biodynamic responses. This take a look at advanced two models for simulating the disbursed biodynamic responses of the hand–arm gadget exposed to vibration in zh-axis. Ren G and Dong, John Z. [2], biodynamic of the hand-arm system is an essential foundation not only for the future standardization of the measurement, evaluation, and assessment of hand-transmitted vibration exposure, but also for the developments of better tools and anti-vibration devices. The advanced biodynamics based on the biodynamic stresses and deformations has been initiated and many studies can be conducted in this direction. The new biodynamic concept and the newly developed methodologies also provide many opportunities for studying the driving-point biodynamic responses distributed on the hand.

Ren G. Dong et al [3], study investigated the biodynamic response (BR) distributed at the palm of the hand subjected to a random vibration. The palm BR value is frequency-specific. Under the test conditions of resonant frequency usually falls in the frequency range of 20 to 50 Hz. Due to the resonance frequency range corresponds to the most vibration transmission and absorption to the hand arm system through the palm. This sort of resonant frequency variety coincides with the dominant vibration frequencies of many percussive tools. This resonance may additionally for that reason have some affiliation with vibration-induced injuries or problems within the wrist-arm machine among people using percussive equipment. Growing the effective palm pressure generally increases the resonant frequency and will increase the significance of the biodynamic response and vibration transmission. The influence of the implemented pressure on the biodynamic response is more stated in the middle-frequency range (40-200 hz). A person with a massive hand-arm length probably famous a huge palm biodynamic response at the low frequencies (<40 Hz). Although not always statistically significant, this person may also produce large BR values at frequencies above 300 Hz. However, he/she may present low BR values in the middle-frequency range

(50–200Hz).The palm tissue contact stiffness likely plays an important role in determining the BR value at frequencies above 20 Hz. The apparent stiffness in the middle-frequency range is correlated with the essential resonant frequency of the gadget and the (BR) values in a large frequency range. R. G. Dong and a. W. Schopper [4], evolved to one at a time degree the vibration energy absorption (VEA) into the fingers and into the palm. This study that the finger vibration energy absorption is extensively much less than the palm vibration absorption at low frequencies (<25 hz). The vibration energy absorption values are similar below excitations within the (250–100 Hz) frequency variety. The finger vibration absorption at excessive frequencies (=100 Hz) is nearly independent of the hand-handle coupling situation. The coupling situations affect the vibration energy absorption into the arms and the palm very otherwise. The finger vibration energy absorption values recommend that the frequency weighting exact inside the cutting-edge may additionally underestimate the effect of excessive frequency vibration on vibration-brought about finger problems. M. Kalra and s. Rakheja [5], The feasibility of the flexi force sensors changed into assessed by way of evaluating the palm and hands' biodynamic responses obtained from the two strategies. Flexi force sensors had been set up on an instrumented deal with to degree the palm and handle take care of interface dynamic forces. The measurements had been carried out with four subjects grasping and ranges of large-band random vibration. The palm and finger impedance responses measured with thin film and flexi force sensors confirmed very good traits with the reference values acquired from the instrumented handles. Robert g. Radwin and thomas j. Armstrong [6], research has established that hand device vibration might also have a quick time period effect on tactility and ought to be considered in destiny vibration exposure hints. The quick-term outcomes of power hand device vibration on deep feel tactile sensitivity. Five subjects operated a simulated hand device the usage of a work/rest responsibility cycle. Tactile sensitivity reduced with growing frequency after working a simulated hand tool for 30 min the usage of a weighted acceleration, indicated by falling ridge threshold shifts. No shift was located for growing ridge thresholds. Seeing that tactile sensitivity decreased with increasing frequency among 0 Hz and 160 Hz, it become concluded that loss of tactility become no longer in all likelihood the purpose of multiplied grip force, as shown in a preceding take a look at, considering grip pressure outcomes were lowest at 160 Hz vibration, where tactility loss changed into best. Ren g. Dong and daniel e. Welcome [7]. The weightings derived from three energy methods have been in comparison with the frequency weighting. Primarily based at the comparisons, this study expected that the total strength absorption of the complete hand–arm system is likely to be correlated with subjective sensation or discomfort. But, if the weight approach cannot yield correct predictions of the vibration-prompted problems in the human arm, the hand and palm strength strategies are not likely to yield extensively higher predictions. The finger VPA is a vibration measure between un weighted and weighted accelerations. The palm VPA method may also have some value for studying the problems within the wrist–arm machine. Ren g. Dong and daniel e. Welcome [8], the distributed driving point mechanical impedances vary significantly with the unique vicinity of the hand, the vibration path, and the individual.

The two essential resonances of the hand-arm system in the three guidelines are observed in a wide frequency. The impedance of the hand is usually dispensed on the palm underneath a sure frequency with the specific frequency transition relying at the vibration course. The impedance at the hands turns into comparable or better than that at the palm at better frequencies. While the impedance along the take care of longitudinal axis is typically the smallest, the impedance alongside the forearm course is normally the most important. The impedance of every direction within the plane vertical to the cope with longitudinal axis is basically unbiased of vibration direction at excessive frequencies (>250 Hz), which shows that the hand tissues near the touch interface are worried inside the reaction at such frequencies. John E. Speich and Liang Shao [9]. Authors have advanced a version for the human arm and hand as they interact with a telemanipulation device and experimentally determined the model parameters for 1-DOF and 3-DOF telemanipulation system. The version provides an extra spring and damper to the mass–spring–damper model generally used to symbolize a human and better approximates the dynamics of the human while interacting with the manipulators used on this observe. The model and parameters have been determined from experimental data taken from a telemanipulation machine with a single translational degree-of-freedom. Additional information turned into taken from a system with three actuated degrees-of-freedom, and a fixed of model parameters changed into decided for each direction of motion. Each set of model parameters presented in this paper is for the unique grip type and hand/arm orientation used in the course of interaction with every precise telemanipulation system; but similar sets of parameters using this human model might be received for interaction with other telemanipulation structures and haptic interfaces. The model can be used to design and analyze manipulate architectures for telemanipulation systems. Jennie h. Dong and Ren G. Dong [10], 5 degrees-of-freedom model of the hand–arm system with finger and palm-side driving factors is used to estimate the absorbed strength disbursed in finger, hand back, palm–wrist, palms, and shoulder and systems beyond the shoulder. Predicting the absorbed power disbursed in various substructures of the hand–arm device exposed to vibration is proposed. The vibration power absorptions further suggested that vibration exposure would generally pose a better danger of developing fingers issues than exposure to vibration at other frequencies. The vibration power absorption was discovered to be mostly dispensed within the arm and shoulder when operating low-frequency tools, consisting of rammers. The power absorption become normally focused within the hands and hand when working high-frequency equipment, which include grinders. The major resonances of the hand–arm system had been intently pondered in vibration energy absorption dispensed within the hands. Whereas the finger vibration power absorption become found to be correlated with unweighted acceleration measured on many equipment, the vibration power absorption disbursed within the palm–wrist–arm machine became correlated with the ISO-weighted acceleration. These may want to provide better know-how of a number of the findings of the reported physiological and epidemiological studies. The proposed local energy approach confirmed a promising capacity for evaluation of exposure dosage, and related to fitness outcomes. Although further studies are critical to don't forget the contributions due to major influencing elements and to enhance the hand–arm system models. S. Kazi, a et al. [11], 2-DOF and 3-DOF biomechanical model have been advanced to derive the vibration transmission characteristics of the hand-arm. The human hand and arm vibration has been investigated in phrases of biodynamic responses. The 2 and 3-degree of freedom (DOF) models of human hand-arm were offered. Analyses of this biomechanical model was accomplished to apprehend the model deflection patterns of the human hand arm system (HAS). The deflection patterns due to masses on the hand, the forearm and the top-arm, similar to different modes of vibration, were analyse regarding the vibration behavior of the hand-arm. Behaviour of the hand-arm models are implemented and tested inside simulation environment and the corresponding results are offered. It's far taken into consideration as a form of 'input' to the system. The effects of vibration reaction between the two-dof and 3-dof even as for the duration of white noise vibration exposure the hand-arm system. Comparisons of the responses of the vibration behaviour in hand-arm that the same agreement between 2-DOF and 3-DOF outcomes within the resonance frequencies had being finished. It's miles mentioned that outcomes for the first two modes of vibration 2-DOF of the device converged to 27.77 Hz and 41.65 Hz whereas 13.8 Hz and 35.5 Hz for the 1st and 2nd modes of 3-DOF respectively. A random inputs force become implemented within the range of 3 N to -2 N. The most displacement of hand motion in 2-DOF located is about 0.0031 m at 3.4sec and 0.006 m at 9sec respectively. Ren G. Dong, Subhash Rakheja [12], 5 degree-of-freedom (DOF) model with a fixed of constraints proposed. 3 units of mechanical impedance statistics measured on the fingers and palm of the hand have been used to look at the validity of the proposed approach. This study is confirmed that the maximum dependable technique for the modelling of the biodynamic responses disbursed at the arms and the palm of the hand is to create the model using the experimental records one after the other measured at the fingers and the palm. To approximately estimate the distributed responses from the total response using the proposed modelling method with appropriate model constraints. This study also demonstrated that if only the magnitude or real part of the total response is available, its corresponding phase angle or real part can be estimated using the available information using the modelling method. However, the reliability of the estimated distribution varies with the available information. Whereas the reliability of the estimation with the magnitude alone is comparable with that estimated with both the magnitude and phase of the total response, the estimated response is less reliable when only the real part of the mechanical impedance is used. The estimated response distributed at the palm is generally more reliable than that distributed at the fingers.

E. Weston et al .[15] analyzed the office seat and tablet device for the comfort. 20 subjects were analysed during the typing task on a desktop computer and touch screen tablet in two chairs for an hour each. The effect of seat, device and their interaction were analyzed during the analysis. Heart rate variability was observed as a response parameter.L. Roseiro et al. [16] examined the experience level of the vibration induced in the cycle driver and the motor driver hand. From the study, it has been concluded that vibration level inducted during the driving on stone road was exceeding the limit. Various types of road nature, type of bicycle and the operators were examined observed during the investigation.Miroslavet al. [17] improved the vehicle design. The effect of fore and aft vibrations areexamined using electrro-hydraulic simulator. The experiments were executed with and without inclination. The observationsshows that the human body response like a non linear system under the vibration. S. Rahmatallaet al. [18] has analysed the impact of vibration on the seat to head transmissibility. The newmethodology of multiple inputs and multiple output for the whole body vibration system was deployed for the analysis. The response was computed in terms of transmissibility. The observation shows that the sitting posture and arm position were the most affecting parameters. V. Kumar and V. Saran [19] examined the impact of reading format on reading activity under the uni-axial whole body vibration. 30 male subjects were analysed during the reading activity for the vibration range 0-20 Hz. The research findings were helpful for the passenger read during the journey. A. Rhimi et al [20] observed the prolonged static posture of the car driver. The basic aim of their work was to find out the improved design parameters of the car seats that might reduce the impact of discomfort generated during the driving. FEM model were employed to carry out the investigation.

2. FORMULATION OF EQUATIONS OF MOTION FOR THE HAND MODEL

2.1 Human are Biodynamic Model:

Fig.1 shows the biomechanical model of the hand arm system subjected to the vibration. There is two vibration reduces materials are using isolator and gloves material with different vibration isolation effects on six segments of hand.

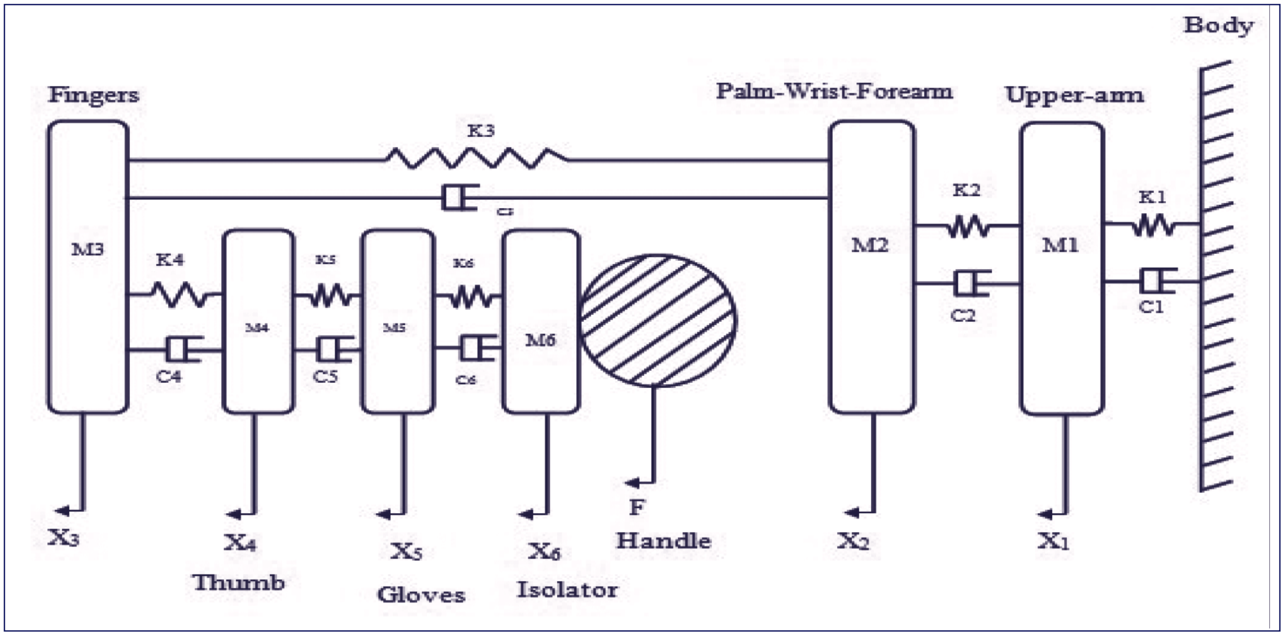


Fig.1. Mathematical model of 6-DOF finger-hand-arm system with isolator and gloves

2.2 Calculation for equation of Motions (EOM) for the hand Model:

The equations of motion of the human arm

$m_1 x_1 + k_1 (x_1) + c_1 (x_1) + k_2 (x_1 - x_2) + c_2 (x_1 - x_2) = 0$ (1)

$m_2 x_2 + k_2 (x_2 - x_1) + c_2 (x_2 - x_1) + k_3 (x_2 - x_3) + c_3 (x_2 - x_3) = 0$ (2)

$m_3 x_3 + k_3 (x_3 - x_2) + c_3 (x_3 - x_2) + k_4 (x_3 - x_4) + c_4 (x_3 - x_4) = 0$ (3)

$m_4 x_4 + k_4 (x_4 - x_3) + c_4 (x_4 - x_3) + k_5 (x_4 - x_5) + c_5 (x_4 - x_5) = 0$ (4)

$m_5 x_5 + k_5 (x_5 - x_4) + c_5 (x_5 - x_4) + k_6 (x_5 - x_6) + c_6 (x_5 - x_6) = 0$ (5)

$m_6 x_6 + k_6 (x_6 - x_5) + c_6 (x_6 - x_5) + F = 0$ (6)

Their (x, x, x) the angular displacement, velocity and acceleration vectors at hand joints. (m_1, m_2, m_3, m_4, m_5, m_6) are masses of upper-arm, palm-wrist-forearm, fingers, thumb, isolator, gloves. (k_1, k_2, k_3, k_4, k_5, k_6) and (c_1, c_2, c_3, c_4, c_5, c_6) are respectively the stiffness and damping coefficients of the shoulder, elbow, wrist joints element. (F) the force vector due to external excitation [13,14].

2.3 Calculation for [M], [K] and [C] matrix for the hand Model:

To derived equation of motion describing the dynamics of the controlled system is as follows.

$[M]\{x\} + [C]\{x\} + [K]\{x\} = [F]$ (7)

[M] = Mass Matrices {x} = Acceleration
[K] = Stiffness Matrices {x} = Velocity
[C] = Damping Matrices {x} = Displacement
[F] = force vector due to external excitation.

Mass matrix

$$\{m\} = \begin{bmatrix} m1 & 0 & 0 & 0 & 0 & 0 \\ 0 & m2 & 0 & 0 & 0 & 0 \\ 0 & 0 & m3 & 0 & 0 & 0 \\ 0 & 0 & 0 & m4 & 0 & 0 \\ 0 & 0 & 0 & 0 & m5 & 0 \\ 0 & 0 & 0 & 0 & 0 & m6 \end{bmatrix} \quad (8)$$

Stiffness matrix

$$\{k\} = \begin{bmatrix} (-k2-k1) & k2 & 0 & 0 & 0 & 0 \\ k2 & (-k2-k3) & k3 & 0 & 0 & 0 \\ 0 & k3 & (-k3-k4) & k4 & 0 & 0 \\ 0 & 0 & k4 & (-k4-k5) & k5 & 0 \\ 0 & 0 & 0 & k5 & (-k5-k6) & k6 \\ 0 & 0 & 0 & 0 & k6 & (-k6) \end{bmatrix} \quad (9)$$

Damping matrix

$$\{c\} = \begin{bmatrix} (-c2-c1) & c2 & 0 & 0 & 0 & 0 \\ c2 & (-c2-c3) & c3 & 0 & 0 & 0 \\ 0 & c3 & (-c3-c4) & c4 & 0 & 0 \\ 0 & 0 & c4 & (-c4-c5) & c5 & 0 \\ 0 & 0 & 0 & c5 & (-c5-c6) & c6 \\ 0 & 0 & 0 & 0 & c6 & (-c6) \end{bmatrix} \quad (10)$$

Force vector matrix

$$F = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ f \end{bmatrix} \quad (11)$$

3. CALCULATION OF MASS, DAMPING COEFFICIENT AND STIFFNESS MATRIX

Fig. 2 (a).Semi ellipsoid axes shows that the lengths of each segment to be taken in the human hand arm. Again, let (a_i, c_i) denote the short and long b_i semi axes of an ellipse. Fig.2 (b) truncated ellipsoidal is the ellipse at some distance z from its centre and complete the figure by circle segment having the same tangent as the ellipse at the point of fusion. Rotate figure around the long axis to produce a spheroid ellipsoid.

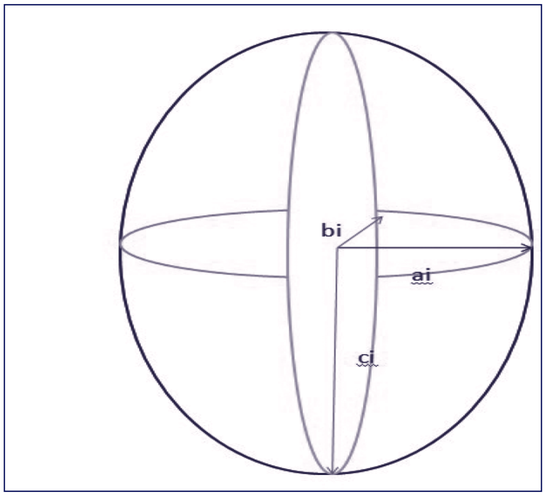


Fig.2. (a) Semi Ellipsoid axes

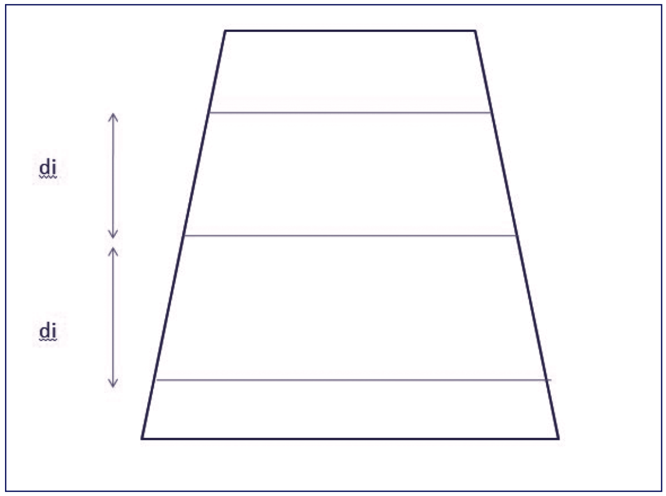


Fig.2. (b) Truncated ellipsoidal

Sr. No.	Parameter	Measurements (cm)			
		Male1	Male2	Female1	Female2
I	Age	26	24	25	24
II	Weight (kg)	68	75	54	56
L1	Standing height	172	174	158	164
L2	Upper arm length	30	32	27	27
L3	Upper arm width	10	12	9	9
L4	Upper arm Circumference	31.42	37.7	28.27	28.27
L5	Elbow width	8.6	10.5	8.4	9.5
L6	Elbow circumference	27.02	32.98	26.38	29.85
L7	Forearm length	25	29	25	26.5
L8	Forearm width	8.5	9.5	7.5	8
L9	Forearm circumference	27.9	29.84	23.56	25.13
L10	Wrist width	5.6	5.75	5.4	6
L11	Wrist circumference	17.6	18.06	16.96	18.85
L12	Hand length	10	11.5	9.5	10
L13	Hand thickness	2.9	3.25	2.5	2.5
L14	Hand width	9	10	8.5	8
L15	Finger length	9	10	7	8
L16	Finger width	3.5	2.5	2	2
L17	Finger circumference	6.91	7.85	6.28	6.28
L18	Thumb length	7	7.2	7	7.5
L19	Thumb width	2.35	3	2	2.5
L20	Thumb circumference	7.38	9.42	6.28	7.85
L21	Gloves length	20	22	18	19
L22	Gloves width	12.5	12.5	9	9
L23	Gloves thickness	5	5	3.5	3.5
L24	Isolator length	11	11	11	11
L25	Isolator width	3.5	3.5	3.5	3.5
L26	Isolator circumference	11	11	11	11

Table.1. Measurement of Human hand model parameter of subjects.

Table 1. Shows the anthropometric measurements of two males and two females subjects used for experimentation.

3.1 Calculation for M, K and C matrix

Calculation of Mass, Stiffness and Damping Coefficient is required to obtain the biodynamic responses of an each segment.

3.1.1 Mass Matrix Calculation of 6-DOF

In this table.1 to taken an anthropometric parameter are applied in the give formula

$$M_i = \frac{M * V_i}{\sum_{r=1}^{n} V_r} \quad (12)$$

V_i = Volume of i[th] segment = 4/3(π *a_i*b_i*c_i), (a_i, b_i, c_i are the semi axes of the ellipsoid), n = Total number of segments, M = Total body mass.

The above equation (12) division of Masses into the 6 subjects for 6 degrees of freedom and calculated and tabulated in Table.2.

3.1.2 Stiffness Matrix Calculation for 6DOF

(a) Moment of Inertia of the segments.

$$I_i = \log \frac{2-\left(1-\frac{d_i}{c_i}\right)}{1-\frac{d_i}{c_i}} \quad (13)$$

d_i= Half length of the truncated ellipsoid, c_i = Semi-axes of the ellipsoid.

(b) Elastic module of bone and tissues.

$$E = \sqrt[2]{E_t * E_b} = 13.06 \frac{MN}{m^2} \quad (14)$$

E_b = Elastic Modulus of Bone (22.6 GN/m^2), E_t = Elastic Modulus of Tissue (7.5 kN/m^2).

The above equations (13), (14) are substitution in the equation (15) to determine the expression for axial stiffness (S_i) of the ellipsoid and table (3) shows below.

$$S_i = \frac{\pi * E * ai * bi}{ci * Ii}, \frac{KN}{m} \quad (15)$$

$$s_i = (11164.277) * \frac{ai * bi}{ci}, \frac{KN}{m} \quad (16)$$

The above equation (16) division of stiffness in of 6 subjects for 6 degrees of freedom and calculated and tabulated in Table.3.

Parameter (kg)	M1	M2	M3	M4	M5	M6
Male 1	0.6912	2.9028	0.0048	0.0017	0.3403	0.0104
Male 2	0.8847	4.1146	0.0097	0.0042	0.3744	0.0104
Female 1	0.4031	2.4043	0.0017	0.0017	0.1484	0.0104
Female 2	0.4059	2.3354	0.0019	0.0043	0.1567	0.0104

Table.2 Mass element distribution by segments of 2 male and 2 fem subjects.

Parameter (K.N/m)	K_1	K2	K3	K4	K5	K6
Male 1	74661.8	56387.9399	5594.7535	2085.1025	3218.65	8340.4
Male 2	83994.6	62082.0329	9101.4619	3835.9767	6208.7168	8340.4
Female 1	53756.5	42204.3676	3222.8307	1638.3	3170.5856	8340.4
Female 2	54129	41081.9459	2819.569	2071.536	6910.4386	8340.4

Table.3 Stiffness element distribution by segments of subjects.

3.1.3 Damping Coefficient Calculation for 6 DOF.

The damping ratio of i[th] segment is given.

$$\beta i = \xi i * \sqrt[2]{Si * Mi} \quad (17)$$

ξ_i = Damping constant of the i[th]segment (0.3841 N-s/m), β_i = Damping ratio of the i[th] segment, S_i = Stiffness of the segment (kN/m), M_i = Mass of the segment, (kg).

The above equation (17) division of damping coefficient in of 6 subjects for 6 degrees of freedom and calculated in the table.3.

Parameter (N-sec/m)	C_1	C_2	C_3	C_4	C_5	C_6
Male 1	18.1736	11.6386	0.4049	0.1105	0.1499	5.588
Male 2	21.8078	14.1668	0.7379	0.225	0.3191	5.588
Female 1	11	8.0544	0.1858	0.078	0.1328	5.588
Female 2	11.8582	8.0202	0.1838	0.1043	0.2371	5.588

Table 4. Damping element distribution by segments of 2 male and 2 female

4. SIMULINK MODEL

Simulink is a MATLAB-based graphical programming environment for modeling, simulating and analyzing multidomain dynamical systems. Its primary interface is a graphical block diagramming tool and a customizable set of block libraries. Simulink for the human arm with gloves and isolator are developed in the block model and showing below fig.3. The simulation of hand arm system model constructed from the equations (1),(2),(3) and their two integrate equations (4) and (5) are gloves and isolator characteristics to the hand-arm system model. The basic elements of the simulink blocks are as given in table 5.

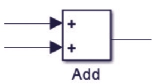
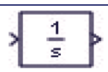
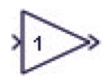
Blocks	Description	Blocks	Description
	• Add and subtraction, main operation is to add or subtract two element s and gives output. • At least two inputs required and it gives single output.		• Display signals generated during simulation • The output in the form of graph.
	• The Integrator block outputs the value of the integral of its input signal with respect to time.		• Gain block is basically scales the input and gives output.

Table 5. Simulink blocks.

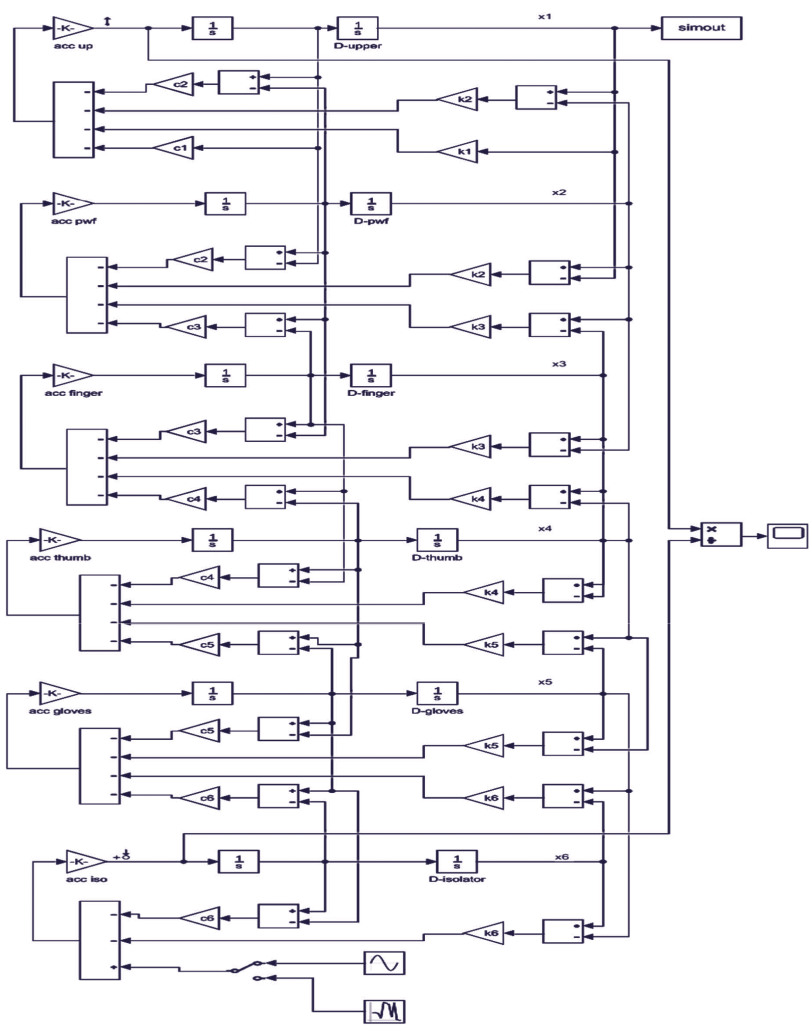


Fig.3. Simulink block diagram of human arm model.

The input is given to the system form sine wave. This sine wave is connected to the add/sum block. The add/sum block performs addition or subtraction on its inputs. This block can add or subtract scalar, vector, or matrix inputs. The gain block is connected to the sum block. The gain block generates its output by multiplying its input by a specified constant, variable, or expression. Further, a gain block is connected to the integrator. The Integrator block outputs the value of the integral of its input signal with respect to time. To pass through the signal, we have a closed switch. After getting signal the addition block performs add/subtraction. After that the signal complete loop, we get acceleration from this process. To convert this acceleration into velocity, we have to connect one integrator block. After this, we need displacement signal so, we have to connect one more integrator after that the velocity integrator. To achieve output signal in the form of a graph, we have connected scope after this integrator block.

4.1 Simulation Results

The input sine wave signal is given to the handle after that there is decreases acceleration in the linearly form handle to upper-arm are shown fig. 4 and fig.5.

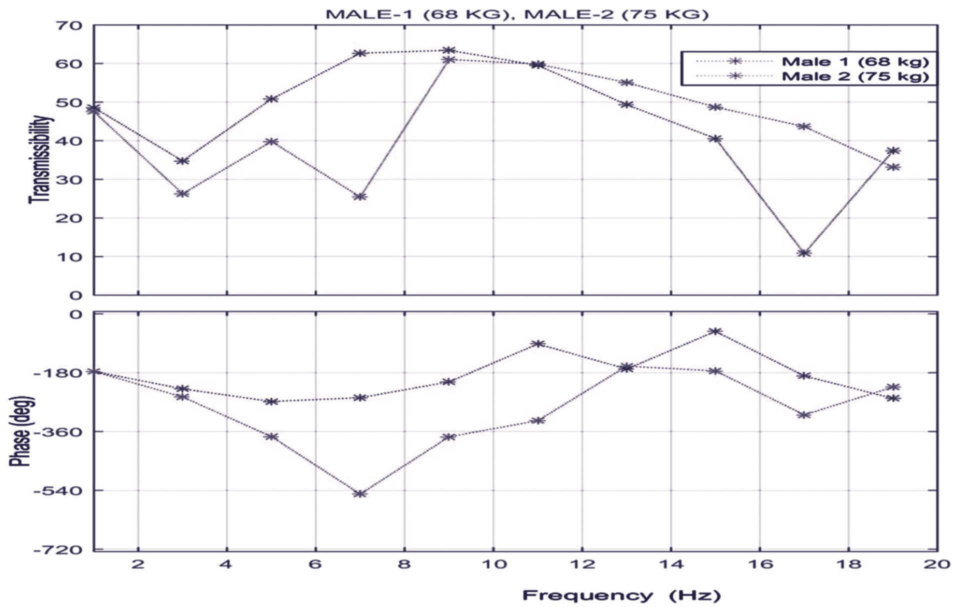


Fig.4. Transmissibility of male-1 and male-2.

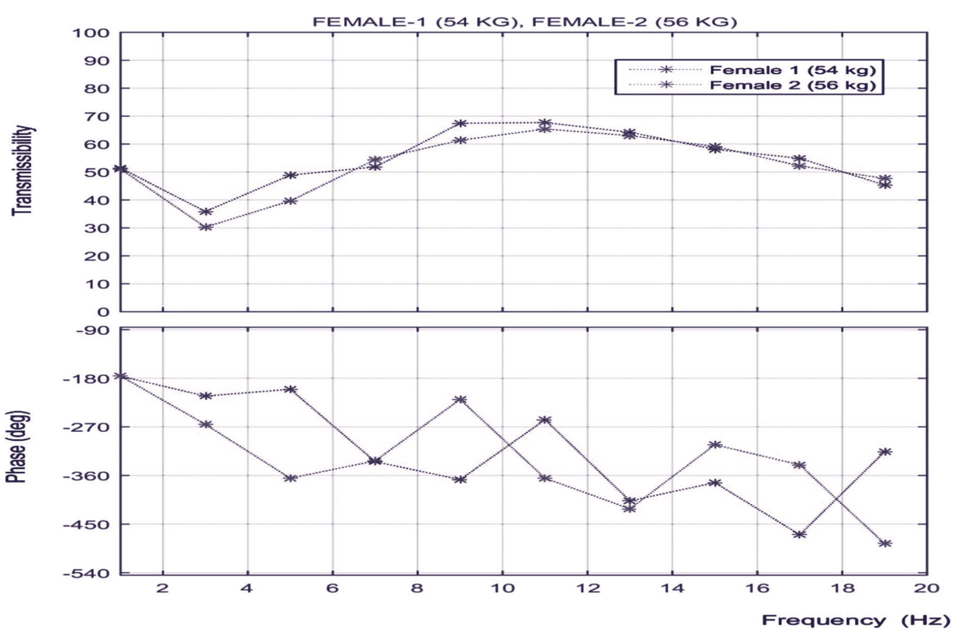


Fig.5. Transmissibility of female-1 and female-2.

5. CONCLUSION

The human arm vibration has been investigated in terms of biodynamic responses. The six degrees of freedom model of human arm have been presented. This biomechanical model was carried out to understand the hand arm system model deflection patterns of different segments in terms of acceleration responses. It different deflection, velocity and acceleration patterns can be observed due to masses hand, forearm, fingers, upper arm at different mode of vibration. It different deflection, velocity and acceleration patterns can be observed due to masses hand, forearm, fingers, upper arm at different mode of vibration. Anti vibration materials such as isolator and gloves to reduces the vibration. Under different condition the simulation of model was done in MATLAB-SIMULINK and behaviour of acceleration amplitude was recorded. The present model will help the industry to take care of the human operator and provide the better safety.

The presented work will help the industry to critically observe the impact of vibration on the operator or human arm. After analysing the impact and its nature, the industry can take the corrective action to avoid the damage. The study will help the automobile industries and other industries to design the work station which will minimize the impact of vibration on human arm. The study will also significantly help to improve the life style of the operator or driver in their working environment.

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