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## ERGONOMICS ANALYSIS OF ANTHROPO-TECHNICAL SYSTEMS IN THE ENVIRONMENT OF CATIA PROGRAM

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### **Abstract**

*Every engineer designer when designing the interior of a passenger car must obey certain norms and regulations. When engineer designer introduces innovative solutions of different equipment in the passenger car interior, he must create comfortable conditions for a driver. The article describes the applied issues concerning the interior ergonomics of a passenger car. A designer using CATIA type programs can put the designed model of car interior to work ergonomics analysis for basic service activities of a car driver. A male and female dummies from the European population were created for the purpose of conducting the analysis. The interior of a passenger car was designed and its most important elements were described. The engineer designer having general dimensions of the interior starts analysis which will be a base for the change in cabin dimensions. In this analysis two main positions of a driver were assumed: a sitting position with hands on steering wheel and a sitting position with a right hand holding gear shift stick. It was shown in which areas of the cabin of the passenger car changes in dimensions are necessary and then driver's comfort improvement was shown in percentage.*

**Keywords:** car industry, ergonomics, CATIA, hybrid modeling, cabin interior ergonomics

### **1. Introduction**

On the car market, one may find as many as 100 companies dealing with producing various kinds of cars. Car producing concerns try to lure customers by applying most advanced technologies. Currently, car designers are introducing innovative solutions as regards the placement of usable elements in the cabin of a passenger car. Because of ever increasing technological involvement in the interiors of passenger cars as regards the ergonomics of cabin equipment, the rules of designing such elements change in order to make them more comfortable and fulfill driver's needs. The interior must be designed in such a way that it should make the driver – no matter whether coming from Europe or Asia – feel well. [4]

A designer working with computer aided design programs (CAD) copes with the problem of an ergonomical placement of all elements. The designed machines and workplaces must meet not only the norms and requirements of the safety and hygiene regulations but also be ergonomic. In CATIA V5R19 program a designer may put into practice the above requirements by using *Human Builder* module. The module is used to check previously made three-dimensional model of workplace as regards its ergonomics for the person working there. The engineer designer, may creating a dummy with anthropometrical features in this program and import it into the tested workplace model. By using analysis tools, one may check the interior as regards ergonomics and visibility on the basis of such model. One can also analyze the dummy itself as regards the stress



The test is carried out on the interior of a passenger car that was modeled in a hybrid way with the use of CATIA V5R19 program. The modeled cabin of the car corresponds to actual dimensions and placement of interior equipment elements. The elements include: car roof, dashboard, set of chairs, manipulators inside cabin, doors etc. [2].

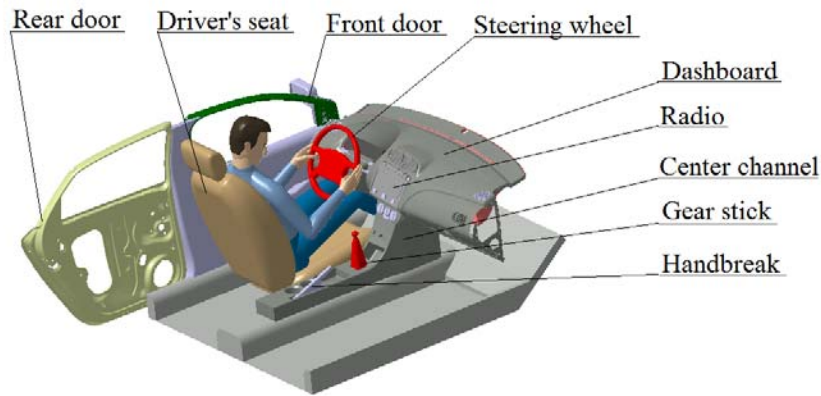


Fig. 2. The hybrid modeled car interior with the analyzed elements

When the designer models the cabin elements, s/he adopts supposed dimensions to place different elements and these dimensions are measured from some characteristic points assumed by the designer. Only at the later stage, after analysis, there occurs a change in basic dimensions and the adoption of placing such element to their usage. The dimensions that may be helpful in percentage analysis of movement range of body parts:

- a) the distance between steering wheel and the sitting driver: the distance will be measured from the centre of the steering wheel surface to the chest – dimension 1,
- b) distance of the chair in XY surface: the distance will be measured from the chair's edge to the sloped floor under pedals – dimension 2,
- c) height of the chair in XY surface: the distance from the chair to the floor – dimension 3,
- d) dimensions of the length and width of placing the gear shift stick: the distance measured from both edges of the floor – dimension 4,
- e) steering wheel leaning angle – dimension 5,
- f) a driver's chair leaning angle – the angle between the backrest and the seat surface – dimension 6.

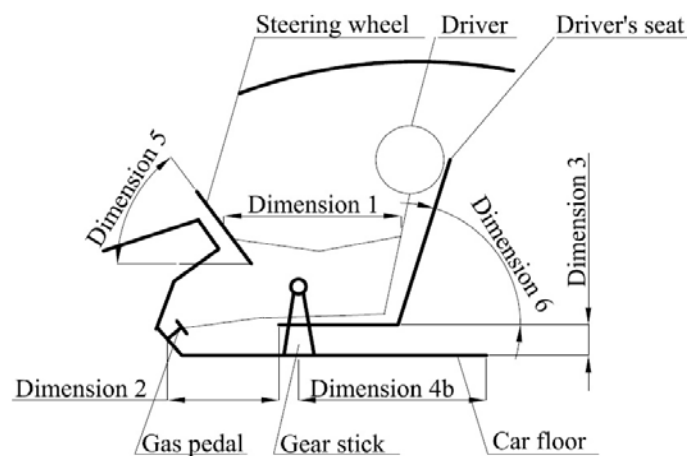


Fig. 3. The car interior dimensions taken for the analysis

Table 1 presents dimensions that were shown as a diagram on Figure 3 thanks to which we can characterize some elements of interior equipment. They play a crucial role in percentage use of a free body part movement. After conducting analysis, the designer should concentrate on these dimensions to create comfortable conditions of driving [3].

Tab. 1. A set of preliminary dimension values taken for the ergonomics analysis of the interior

Dimension number	Value of dimension	
1	330 mm	
2	518 mm	
3	150 mm	
4	a	747 mm
	b	807 mm
5	80°	
6	70°	

#### 4. Analysis of the ergonomics of a car cabin

The analysis of work ergonomics in the interior of a passenger car was carried out on the basis of two imported dummies: male and female ones, whose body part dimensions were defined according to the statistical average of the population i.e. 50 centile dummies that are statistically most often met human dimensions in Europe. Centile measure is a set of statistical dimensions of a human body that reflects the size of a short person (5 centiles), middle-sized (50 centiles) and a tall one (95 centiles) [1].

In these tests the most important positions of the dummy were analyzed as well as the usable area of the car interior. Two tests were conducted after importing the dummy and placing it inside the car in a sitting position:

- a) dummy sitting on a driver's chair and holding steering wheel with both hands – position no 1,
- b) dummy sitting on a driver's chair and holding a gear shift stick with its right hand – position no 2.

During the ergonomics analysis of the cabin the following body parts were taken into account: 1) all levels of freedom 2) the lumbar region 3) chest region 4) neck region 5) thigh region 6) leg 7) toes 8) clavicular region 9) arm region 10) forearm region 11) whole hand (Fig. 4).

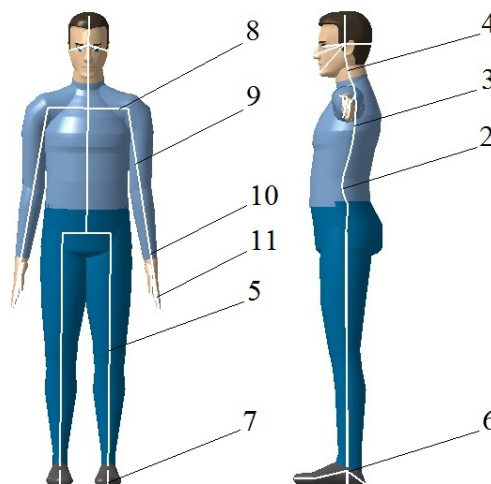


Fig. 4. Body parts taken for the analysis

**Position no 1**

The imported dummy in position no 1 is the most frequent position of a driver sitting inside a passenger car. According to the road code regulations, both hands should be placed on the upper part of the steering wheel, which was also included in the test and checked whether such position for a designed car is comfortable and ergonomic.

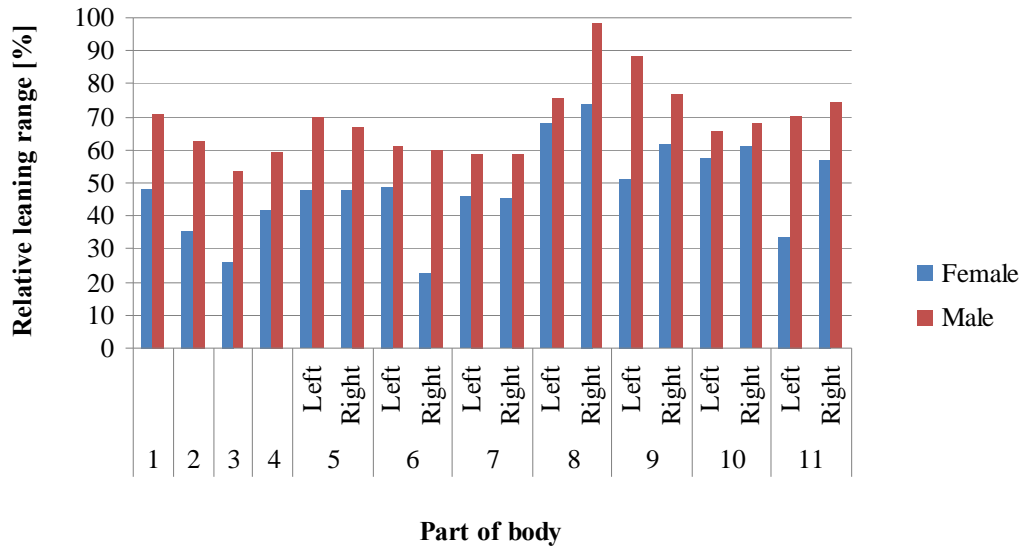


Fig. 5. A comparison of leaning range relative values for men and women for the position no 1

High per cent of the relative of the freedom angle as regards clavicular and arm region may mean that the car cabin was badly designed – the decrease of the usable space which results in lower comfort of the driver.

**Position no 2**

During driving a driver must take off one of his hands from the steering wheel to change into higher or lower gear. Such activity means also a temporary leaning of some body part that was analyzed for the position no 2.

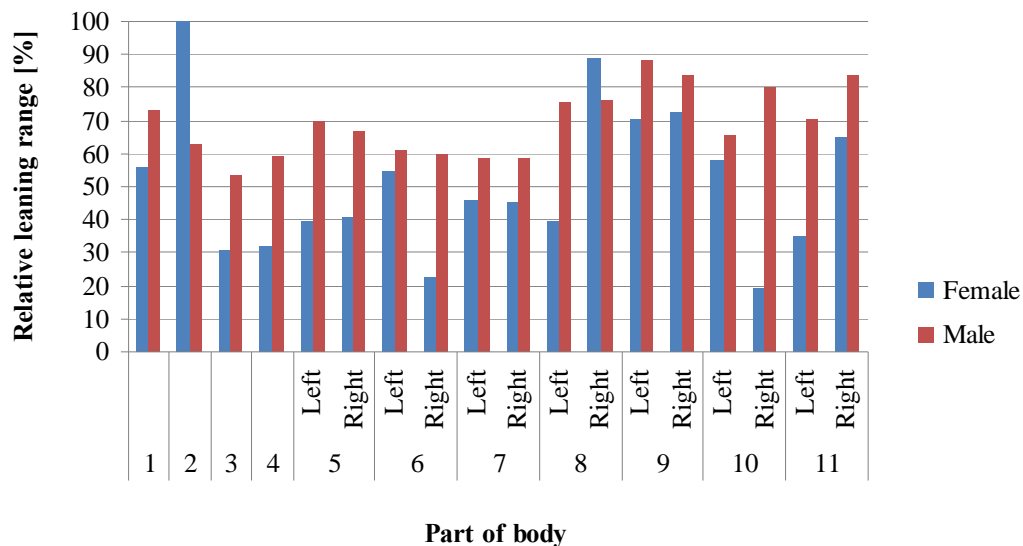


Fig. 6. A comparison of leaning range relative values for men and women for the position no 2

When analyzing the obtained results for the position no 2, one can notice that women show an extreme leaning of clavicular region which may result from bracing with all body. A similar

behavior but regarding whole hand can be observed among men, which probably is a result of grasping tight the gear shift stick and consequently gives a very high value of the relative degree of freedom.

## 5. Improving ergonomics in the modelled interior of a car cabin

When analyzing position no 1, one can see differences between percentage DOF range for men and women. By changing dimension no 1 by 50 mm, we can notice a percentage decrease of the angle range by 20% for clavicular and arm region. When we change dimension no 3 by 40 mm, we can observe a percentage decrease of angle range for clavicular region by 15%. If we change these two dimensions, we can achieve a considerable improvement of comfort for both sexes. If we change the leaning of the steering wheel by 5°, the designer will get a decrease of the angle range for clavicular region by 10%. When we change dimension no 1, dimension no 2 will get automatically adjusted by 30 mm as these two dimensions are correlated. To solve this problem, we may change dimension no 6 by 10° which will result in a better comfort for forearm and arm region.

*Tab. 2. A set of final dimensions taking into account conducted analysis*

Dimension number	Value of dimension	
1	430 mm	
2	548 mm	
3	190 mm	
4	a	767 mm
	b	877 mm
5	85°	
6	80°	

With women, the clavicular region is leant at 89%, which means that the gear shift stick is too far from the driver. They need to lean their bodies to reach it. The change of dimension no 4a by 70 mm and dimension no 4b by 20 mm will result in an automatic decrease of the percentage leaning of clavicular region by 15%. When analyzing angle range in percents for men at agreed changes, we can see a decrease of angle range by 10% for arm region and 20% for forearm region.

## 6. Summary

The present work presents modeled interior of a passenger car. Before starting the analysis, some selected elements from the car cabin were measured. Two analyses of work ergonomics for basic service activates of the driver of the car were conducted. The results obtained during the analysis shown that geometrical condition of car cabin are inadmissible as far as the driver's comfort is concerned. After the analysis, the cabin was remodeled and as a result a 15% decrease of the movement range for all body parts was achieved.

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