Exploring the optimum posture for driver comfort

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Exploring the optimum posture for driver comfort

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Abstract: Published postural angles for driving comfort are based on theoretical
calculations and not observed driving postures. An experiment was conducted to
investigate observed optimum driving postures and positions of the main driving
controls for comparison with available data. New guidelines for optimum
postural comfort have been developed. The recommended range of postural
angles should be used with care because not all people will be comfortable with
the whole range as individuals. Furthermore, inter-relationships between
adjacent joint angles need to be considered. The data also support a strong need
for both horizontal and vertical adjustment in the steering wheel.

Keywords: comfort, design, driving, posture.

Reference to this paper should be made as follows: Porter, J.M. and Gyi, D.E.

1 Introduction

One of the most important contributions that ergonomics can provide to the vehicle design
process is information concerning occupant sizes and their preferred postures. This
analysis dictates the 3D volumes that designers and engineers must endeavour to provide for
the future occupants’ comfort, efficiency and safety. The main aim of this study was to
collect data regarding the preferred postures which subjects adopt given a fully adjustable
car driving package. This was undertaken as part of a larger project (Gyi, 1996). Despite
theoretical work by Rebicic (1969) and Grandjean (1980), there was a need for more data
regarding actual postures that individuals adopt in driving situations and the inter-relationships
between various body angles. An indication of the ranges of adjustments of components of
the car workspace, necessary to satisfy these preferred postures, was also needed.

Rebicic (1969) carried out an analysis of the drivers’ task and theoretically explored
the posture and position of the body which best met the requirements of the driving task,
placing particular importance on the visual demands. Using a biomechanical model of the
body (from distances between joints and mid-range joint angles) and simple geometric
construction, he was able to propose theoretical joint angles for comfort and correct
posture. His belief was that discomfort often arose from poor dimensional arrangement of
the driving workstation rather than from the actual seat itself. Grandjean (1980) based his
calculations on similar assumptions of the positions of the head, feet and hands. There is a
concern that these optimum postural angles may not be as relevant today with cars
increasingly being fitted with such features as power steering, servo-assisted brakes,
automatic gearboxes and cruise control as standard, all of which reduce demands on the
musculoskeletal system.
Reed et al. (1991), following their three-hour driving simulation experiments, concluded that there was a need for detail regarding the actual postures individuals adopt. They felt that there was a dilemma for car seat designers in obtaining a balance between 'prescribing' a seated posture and accommodating a 'preferred' posture. In their experiments, design features such as a contoured backrest (incorporating a lumbar support) increased back discomfort. This was often because it did not allow comfortable pelvic rotation at the backrest angle selected by the subjects, causing them to shift slightly forward and their lower back to lose contact with the lumbar support. They felt designers should consider the design parameters required for the support of preferred postures whilst taking into account the principles of reducing postural stress.

2 Description of the study

Fifty-five paid volunteers were recruited from members of the general public who responded to an advertisement in the local paper. They were carefully selected to include a wide range of percentiles (calculated from Pheasant, 1990) in the dimensions important for car workstation design and to be representative of the car driving population in Western Europe. Other criteria for their acceptance into the study were that they were drivers (one year minimum), they had suffered no musculoskeletal troubles during the last year and they covered a wide range of ages under 65 years. They were instructed to wear clothing and footwear which was comfortable for driving. Table 1 summarizes the anthropometric data most relevant to car seating for the final sample (n=55).

Table 1  Anthropometric data for the sample (n=55).

<table>
<thead>
<tr>
<th></th>
<th>sample n = 55 mean (SD)* range</th>
<th>males n = 28 mean (SD) range (percentile)</th>
<th>females n = 27 mean (SD) range (percentile)</th>
</tr>
</thead>
<tbody>
<tr>
<td>stature (mm)</td>
<td>1707 (111)</td>
<td>1792 (79)</td>
<td>1619 (59)</td>
</tr>
<tr>
<td></td>
<td>1475–2002</td>
<td>1645–2002 (8–99)</td>
<td>1475–1753 (2–99)</td>
</tr>
<tr>
<td>weight (kg)</td>
<td>74 (16)</td>
<td>78 (11)</td>
<td>70 (19)</td>
</tr>
<tr>
<td></td>
<td>38–125</td>
<td>58–104 (8–99)</td>
<td>38–125 (2–99)</td>
</tr>
<tr>
<td>sitting height (mm)</td>
<td>900 (53)</td>
<td>937 (36)</td>
<td>861 (36)</td>
</tr>
<tr>
<td></td>
<td>783–1018</td>
<td>855–1018 (6–99)</td>
<td>783–932 (3–99)</td>
</tr>
<tr>
<td>buttock knee length (mm)</td>
<td>605 (43)</td>
<td>622 (37)</td>
<td>586 (41)</td>
</tr>
<tr>
<td></td>
<td>524–692</td>
<td>554–692 (9–99)</td>
<td>524–663 (6–99)</td>
</tr>
<tr>
<td>knee height (mm)</td>
<td>522 (40)</td>
<td>548 (34)</td>
<td>494 (23)</td>
</tr>
<tr>
<td></td>
<td>444–627</td>
<td>493–627 (5–99)</td>
<td>444–551 (2–97)</td>
</tr>
<tr>
<td>hip breadth (mm)</td>
<td>380 (39)</td>
<td>371 (21)</td>
<td>388 (50)</td>
</tr>
<tr>
<td></td>
<td>297–512</td>
<td>321–410 (9–96)</td>
<td>297–512 (2–99)</td>
</tr>
<tr>
<td>arm length (mm)</td>
<td>737 (60)</td>
<td>708 (49)</td>
<td>713 (33)</td>
</tr>
<tr>
<td></td>
<td>637–910</td>
<td>710–910 (3–99)</td>
<td>637–770 (2–98)</td>
</tr>
</tbody>
</table>

* SD = Standard Deviation. † Percentile value for British adults (Pheasant, 1990).

A highly adjustable driving rig was constructed for the experimental work (see Figure 1). Criteria for its construction were the following:

Figure 1  The experimental driving rig.

(1) A wide range of sizes of subjects (1st percentile females to 99th percentile males) could be accommodated in either extremely flexed or extended driving postures. A 3D human-modelling CAD system called SAMMIE was used to aid these calculations. For more details of this system, the reader should refer to Porter et al. (1993 and 1996).

(2) The steering wheel and pedals were easily fully adjustable in order to satisfy the above, within the constraints of the design.

(3) The positions of the controls could be easily measured from a fixed reference point and converted to the standard SAE packaging dimensions (Figure 2 and SAE Handbook, 1985).

(4) The workstation, i.e. the floor, steering wheel and pedals, would be adjustable around the seat. The seat itself was also adjustable in tilt, backrest angle and lumbar support.

(5) The pedals, gearbox and steering wheel all incorporated some realistic force to allow subjects to mimic the movements of driving, whilst watching a driving video.

(6) The seats could be replaced quickly and easily as necessary.
Following the driving simulation, each subject's driving posture was measured whilst semi-depressing the accelerator, placing the hands on the steering wheel and looking ahead as though they were driving on a road. Joint markers had already been positioned on the anatomical landmarks (7th cervical vertebrae, acromion, lateral epicondyle, ulnar styloid, greater trochanter, lateral condyle and lateral malleolus) to aid the measurement through clothing. The positions of the joint markers were checked and the postural angles were then measured on the subject's right-hand side with a goniometer. The average of three readings was recorded. Postural angles were defined as follows, adapted from Grandjean et al. (1983), Bridger (1988) and Bhatnager et al. (1985):

(i) **Neck inclination**: The angle between the vertical and a line from the 7th cervical vertebrae to the auditory canal.

(ii) **Trunk-thigh angle**: The angle between a line from the acromion to the greater trochanter and a line from the lateral condyle to the greater trochanter.

(iii) **Arm flexion**: The angle between the vertical and a line from the acromion to the lateral epicondyle.

(iv) **Elbow angle**: The angle between a line from the acromion to the lateral epicondyle and a line from the ulnar styloid to the lateral epicondyle.

(v) **Knee angle**: The angle between a line from the greater trochanter to the lateral condyle and a line from the lateral malleolus and the lateral condyle.

(vi) **Ankle angle**: The angle between a line from the lateral condyle to the lateral malleolus and a line parallel with the foot.

3 Discussion of the results

3.1 Ranges of postures

Actual observed postures were compared with recommendations from the literature (Table 2). Knee angle and foot–calf angle were very similar to the theoretical recommendations of Rebifse (1969) and Grandjean (1980). However, generally subjects preferred to sit with a smaller trunk–thigh angle than previously recommended. Neck inclination, arm flexion, and elbow angle were greater than the ranges of any previous recommendations.

<table>
<thead>
<tr>
<th></th>
<th>Rebifie (1969)</th>
<th>Grandjean (1980)</th>
<th>observed postures (n=55)</th>
<th>95% confidence limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>neck inclination</td>
<td>20-30</td>
<td>20-25</td>
<td>30-66</td>
<td>29-63</td>
</tr>
<tr>
<td>trunk-thigh angle</td>
<td>95-120</td>
<td>100-120</td>
<td>90-115</td>
<td>89-112</td>
</tr>
<tr>
<td>knee angle</td>
<td>95-135</td>
<td>110-130</td>
<td>99-138</td>
<td>103-136</td>
</tr>
<tr>
<td>arm flexion</td>
<td>10-45</td>
<td>20-40</td>
<td>19-75</td>
<td>16-74</td>
</tr>
<tr>
<td>elbow angle</td>
<td>80-120</td>
<td>-</td>
<td>86-164</td>
<td>80-164</td>
</tr>
<tr>
<td>foot-calf angle</td>
<td>90-110</td>
<td>90-110</td>
<td>80-113</td>
<td>81-105</td>
</tr>
<tr>
<td>wrist angle</td>
<td>170-190</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
3.2 Inter-relations between postural angles

Considering the inter-relations between postural angles for the whole sample, there were only two significant (positive) correlations; they were between trunk-thigh angle and knee angle (correlation coefficient 0.3721, p<0.01) and between arm flexion and elbow angle (correlation coefficient 0.7698, p<0.001). The former would be influenced by limitations in the flexibility of the hamstring muscles, such that the preferred trunk-thigh angle is dependent on knee angle. For example, Table 3 shows that none of our subjects who drove with a comparatively large knee angle (125-136°) had a small trunk-thigh angle (89-96°). It is likely that it is very uncomfortable for a tall person to sit upright and stretch out their legs to operate the pedals within the constraints of the design of the rig; they would need to increase knee flexion in this instance. The rig was designed to simulate realistic postures for cars, not the upright postures possible in vans, buses and trucks. Table 3 also illustrates that if the driving workstation of a car were designed around the middle range for preferred trunk-thigh angle (97-104°) and knee angle (114-124°), only 29% (n=16) of the sample would be able to sit in their preferred driving posture.

3.3 Posture, body size and gender

A more 'open' posture was generally preferred by males with consequently significant differences in arm flexion and elbow angle, and trunk-thigh angle approaching significance (Table 4a). This 'open' posture was also more a reined posture supported by significant (p<0.001) gender differences in seat back angle (L40), seat angle (L42) and seat tilt. The question arose as to whether this was a body size or a gender difference. This was further investigated by selecting a sub-sample of subjects (male and female) of mid-range sitting height. This sample (n=32) was selected to be a range from the lowest male sitting height (855 mm) to the highest female sitting height (932 mm), and consisted of 13 males and 19 females. Table 4b shows the significant differences between these males and females, supporting the view of a sex difference in trunk posture (trunk-thigh angle, L40 and L42) but not in arm posture. It is outside the realms of this research to suggest reasons for this.

Table 3 Preferred ranges of trunk-thigh and knee angles (n=55).

<table>
<thead>
<tr>
<th>Degrees</th>
<th>Trunk-thigh angle</th>
<th>Knee angle</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>89-96</td>
<td>97-104</td>
</tr>
<tr>
<td>Knee</td>
<td>103-113</td>
<td>7</td>
</tr>
<tr>
<td>Angle</td>
<td>114-124</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>125-136</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>15</td>
<td>29</td>
</tr>
</tbody>
</table>

Table 4a Preferred posture (in degrees) by gender.

<table>
<thead>
<tr>
<th></th>
<th>Males (n=28) mean (SD)</th>
<th>Females (n=27) mean (SD)</th>
<th>Significance of t</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neck inclination</td>
<td>47 (8)</td>
<td>44 (8.5)</td>
<td>not significant</td>
</tr>
<tr>
<td>Trunk-thigh angle</td>
<td>101 (6)</td>
<td>99 (5.2)</td>
<td>0.1&gt;p&gt;0.05</td>
</tr>
<tr>
<td>Knee angle</td>
<td>121 (8.1)</td>
<td>117 (8.6)</td>
<td>not significant</td>
</tr>
<tr>
<td>Arm flexion</td>
<td>50 (2.4)</td>
<td>40 (2.8)</td>
<td>p&lt;0.01</td>
</tr>
<tr>
<td>Elbow angle</td>
<td>128 (20.3)</td>
<td>113 (17)</td>
<td>p&lt;0.01</td>
</tr>
<tr>
<td>Foot-calf angle</td>
<td>93 (6.4)</td>
<td>92 (5.3)</td>
<td>not significant</td>
</tr>
<tr>
<td>L40</td>
<td>18 (3.2)</td>
<td>14 (3.8)</td>
<td>p&lt;0.001</td>
</tr>
<tr>
<td>L42</td>
<td>94 (3.8)</td>
<td>91 (3.9)</td>
<td>p&lt;0.001</td>
</tr>
</tbody>
</table>

Table 4b Preferred posture (in degrees) of sub-group by gender.

<table>
<thead>
<tr>
<th></th>
<th>Males (n=13) mean (SD)</th>
<th>Females (n=19) mean (SD)</th>
<th>Significance of t</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neck inclination</td>
<td>49 (9.3)</td>
<td>43 (9)</td>
<td>0.1&gt;p&gt;0.05</td>
</tr>
<tr>
<td>Trunk-thigh angle</td>
<td>104 (6.5)</td>
<td>98 (5.6)</td>
<td>p&lt;0.01</td>
</tr>
<tr>
<td>Knee angle</td>
<td>120 (7.6)</td>
<td>116 (8.7)</td>
<td>not significant</td>
</tr>
<tr>
<td>Arm flexion</td>
<td>47 (12.9)</td>
<td>39.9 (15.4)</td>
<td>not significant</td>
</tr>
<tr>
<td>Elbow angle</td>
<td>122 (18.8)</td>
<td>115 (17.7)</td>
<td>not significant</td>
</tr>
<tr>
<td>Foot-calf angle</td>
<td>92 (6.1)</td>
<td>92 (5.1)</td>
<td>not significant</td>
</tr>
<tr>
<td>L40</td>
<td>19 (3.1)</td>
<td>13 (4.1)</td>
<td>p&lt;0.001</td>
</tr>
<tr>
<td>L42</td>
<td>95 (4.1)</td>
<td>90 (4.2)</td>
<td>p&lt;0.001</td>
</tr>
</tbody>
</table>

The significant positive correlations between arm flexion and elbow angle with stature, sitting height, buttock knee length, knee height and upper limb length (Table 5) also confirms that taller subjects (mainly males in this sample) prefer to drive with their arms outstretched.

Table 5 Correlation coefficients (Pearson's r) for postural angles and anthropometric measurements (n=55).

<table>
<thead>
<tr>
<th></th>
<th>Ankle angle</th>
<th>Arm flexion</th>
<th>Elbow angle</th>
<th>Knee angle</th>
<th>Neck inclination</th>
<th>Trunk-thigh angle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stature</td>
<td>0.3573 **</td>
<td>0.4333 ***</td>
<td>0.0104</td>
<td>0.0373</td>
<td>0.0363</td>
<td>0.0363</td>
</tr>
<tr>
<td>Weight</td>
<td>0.0534</td>
<td>0.2104</td>
<td>-0.0069</td>
<td>0.2355 a</td>
<td>-0.3072 *</td>
<td>0.000</td>
</tr>
<tr>
<td>Sitting height</td>
<td>0.2100</td>
<td>0.3138 *</td>
<td>0.4844 ***</td>
<td>0.0065</td>
<td>0.0024</td>
<td>0.00</td>
</tr>
<tr>
<td>Buttock knee length</td>
<td>0.3210 *</td>
<td>0.2759 *</td>
<td>0.3169 *</td>
<td>0.0078</td>
<td>0.0878</td>
<td>-0.1487</td>
</tr>
<tr>
<td>Knee height</td>
<td>0.0228 a</td>
<td>0.3097 *</td>
<td>0.3866 **</td>
<td>0.0974</td>
<td>0.1230</td>
<td>0.0412</td>
</tr>
<tr>
<td>Hip breadth</td>
<td>-0.0110</td>
<td>-0.00298</td>
<td>-0.0911</td>
<td>-0.0944</td>
<td>-0.4322 ***</td>
<td>-0.4322 ***</td>
</tr>
<tr>
<td>Upper limb length</td>
<td>0.0250 a</td>
<td>0.3338 *</td>
<td>0.3958 **</td>
<td>0.0872</td>
<td>0.1603</td>
<td>-0.0219</td>
</tr>
</tbody>
</table>

N.B. n=0.1>p>0.05, *p<0.05, **p<0.01, ***p<0.001.
The preferred driving posture of taller subjects (mainly males) was with arms outstretched (as indicated previously) and the steering wheel position higher and further away in relation to their body. This is shown in Table 6 with significant positive correlations between arm flexion and steering wheel distance from the body (L53-L11), and the height of the steering wheel in relation to the body (H17-H30). There was a negative correlation between trunk-thigh angle with the height of the steering wheel in relation to the body. In other words the larger the trunk-thigh angle the lower the steering wheel position in relation to their body. As expected, both trunk-thigh angle, knee angle and neck inclination positively correlated with seat angle (L42) and seat back angle (L40), also shown in Table 6.

Table 6 Correlation coefficients (Pearson’s r) for postural angles and H-point dimensions (n=55).

<table>
<thead>
<tr>
<th></th>
<th>L53-L11</th>
<th>H17-H30</th>
<th>L40</th>
<th>L42</th>
</tr>
</thead>
<tbody>
<tr>
<td>ankle angle</td>
<td>0.1416</td>
<td>0.1717</td>
<td>0.0984</td>
<td>0.2063</td>
</tr>
<tr>
<td>arm flexion</td>
<td>0.4873  ***</td>
<td>0.3195  *</td>
<td>0.1707</td>
<td>0.1648</td>
</tr>
<tr>
<td>elbow angle</td>
<td>0.6812  ***</td>
<td>0.1175</td>
<td>0.1212</td>
<td>0.1179</td>
</tr>
<tr>
<td>knee angle</td>
<td>0.0879</td>
<td>-0.1685</td>
<td>0.2687  *</td>
<td>0.2783  *</td>
</tr>
<tr>
<td>neck inclination</td>
<td>0.0605</td>
<td>0.0461</td>
<td>0.2829  *</td>
<td>0.3239  *</td>
</tr>
<tr>
<td>trunk-thigh angle</td>
<td>-0.0995</td>
<td>-0.4182  ***</td>
<td>0.5198  ***</td>
<td>0.3729  **</td>
</tr>
</tbody>
</table>

N.B. a=0.15, b=0.05, *p<0.05, **p<0.01, ***p<0.001.

3.4 Driving package

The subjects' preferred positions of the controls were recorded from the driving rig and converted to H-point values (SAE Handbook, 1985). These values (Table 7) were directly compared with actual vehicle dimensions from a sample of 32 well-known cars. The observed maximum values with reference to the H-point calculated from the rig exceeded these vehicle dimensions, implying that at present no car on that list will fit all users comfortably. For example, for the measurement L53 (H-point to heel point), one subject required 889 mm, meaning that he would comfortably fit in only 2 out of 30 well known cars. In support of this, a recent questionnaire survey by the Vehicle Ergonomics Group (Petherick, 1996) found that 43% of drivers for a large service company were not comfortably accommodated in their company car. This postal questionnaire was sent to 450 company car drivers with a 61% response rate (273 subjects).

As another example, the mean H17 (floor to steering wheel centre) measurement on the rig was 628 mm but 26 out of 30 cars had an H17 measurement higher than this, implying that there is a need for a lower steering wheel position. It may be that the steering wheel is fixed high to ensure leg-room particularly in subjects who prefer a more upright posture. This will have a knock-on effect of making more leg-room available in the back seat. Larger subjects, both males and females, also preferred the steering wheel further away from the body than these cars.

Table 7 Driving rig dimensions from the sample.

<table>
<thead>
<tr>
<th></th>
<th>L11</th>
<th>L40</th>
<th>L53</th>
<th>H30</th>
<th>H17</th>
</tr>
</thead>
<tbody>
<tr>
<td>driving rig values</td>
<td>437.7</td>
<td>15.9</td>
<td>738</td>
<td>301.1</td>
<td>627.8</td>
</tr>
<tr>
<td>maximum</td>
<td>602</td>
<td>25</td>
<td>889</td>
<td>335</td>
<td>689</td>
</tr>
<tr>
<td>minimum</td>
<td>322</td>
<td>5</td>
<td>577</td>
<td>283</td>
<td>580</td>
</tr>
<tr>
<td>standard deviation</td>
<td>47.61</td>
<td>4</td>
<td>67.49</td>
<td>11.28</td>
<td>23.99</td>
</tr>
</tbody>
</table>

The distance of the steering wheel from the subject (L53-L11) was found to be significantly positively correlated with all measured anthropometric dimensions for males and females (apart from knee height), with the larger subjects preferring the steering wheel further away from the body (Table 8). The height of the steering wheel from the body (H17-H30) for females was significantly positively correlated with all anthropometric dimensions measured, the larger females preferring the steering wheel to be higher. Males with larger stature and sitting height also preferred the steering wheel higher in relation to the body. Stockier females, as implied by larger hip breadths and weights, appeared to sit more upright, as shown by significant negative correlations between hip breadth and weight with seat angle (L40) and seat back angle (L42).

3.5 Validity of the work

The validity of the data regarding posture and the positions of the controls from a static driving rig must be considered. The measurement of postural angles using anatomical landmarks is a crude measure, but care was taken to check the marker positions and the actual measurements were repeated three times to obtain an average. Also, it is likely that subjects do adopt different postures due to the constraints imposed by different vehicles in order to obtain optimum visibility of the road, ease of reach to the controls and driving comfort. Inevitably, compromises will have to be made and these are all also affected by unique conditions such as a worn-out foam in the car seat lowering the eye level and the cluch biting point affecting stretch to the clutch. This is difficult to control for when measuring both static and dynamic postures in different vehicles. Rebiffe (1969) and Grandjean (1980) both based their analyses of a comfortable driving posture on the theoretical analysis of the driving task. In the light of this, the optimum postural angles for driving obtained by subjects using a standardized car seat on the driving rig must also be a good estimate. However, further work is needed to determine how much an individual's posture varies with different vehicles and in different driving situations. The fact that there was no restriction in headroom space on the rig however does mean that these optimum postures may not be achievable in many current vehicles, for example tall subjects driving with an upright backrest.

5 Recommendations and conclusions

(1) New guidelines for optimum postural comfort are presented (Table 1), although not all people will be comfortable with the whole range of postures as individuals. Subjects generally preferred a smaller trunk-thigh angle than recommended by Rebiffe (1969) and Grandjean (1980) and with their arms more extended. The latter could be due to the
effects of power steering and smaller steering wheel diameters in newer cars. Knee angle and foot-calf angle were very similar to the above authors’ recommendations.

(2) Tall subjects (all males in our sample) preferred a more ‘open’ and reclined posture than the females. This could be due to a constraint of the rig, which limited the maximum seat to floor height to a level which was realistic in cars thereby limiting knee flexion in long-legged drivers. In the case of females, the rig was able to comfortably accommodate greater flexion at the knee and consequently the smaller trunk–thigh angle required by their more flexed optimum posture. On the other hand, there is some evidence that there may be sex differences in the postures people adopt. Other factors also influence the choice of backrest angle (and so trunk–thigh angle), including headroom, sight lines to the instruments and the road, fit of the backrest profile and location of the seat belt. In these cases, drivers with short backs would benefit from a more upright backrest than drivers with long backs.

(3) At present, it is highly likely that car drivers, especially those at the greater end of the extremes of anthropometric dimensions, have to compromise their preferred driving position in order to fit many cars on the market today. Although there is some evidence of a halt in secular growth of human stature in the industrialized societies of Europe and North America, the stature of adult populations as a whole are thought to continue to increase for the next two decades (Pheasant, 1996). This has implications for the distribution of cars in the world-wide market, such that it is important to have available the most relevant, recent anthropometric data for the population to aid design.

(4) The data also support a need for both horizontal and vertical adjustment in the steering wheel in order for individuals to obtain their optimum postures, particularly with respect to arm flexion and elbow angle.

(5) Careful use of recommended postural angles for comfort is advocated. Individuals will not be comfortable throughout the whole quoted ranges. It is suggested that designers use the range of calculated SAE dimensions shown in Table 7, to enable a variety of postures and sizes to be accommodated.

(6) The design of vehicles with the consideration of people issues such as their predicted size, preferred postures, age and their space requirements should be promoted at the concept stage. This method has been simplistically termed designing from the ‘inside-out’ (Porter and Porter, 1996), with the ideal approach being to consider the styling, engineering, legislation and ergonomics concurrently.

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Modelling and optimal control of transport flows in megapolis

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Abstract: The problem of modelling and optimal control of transport flows on a traffic net of a large town is investigated in this paper. The main elements of mathematical description of a city’s transport net are formulated, and the base parameters influencing the traffic are introduced. A mathematical model of traffic flows on net is described; in addition, structure of traffic flow’s composition according to the different types of vehicle is taken into account essentially. Formulations of different optimal control problems of flows and approaches to their solvability are given. Processes of flows ramification on alternative traffic net sections are formalized, and models of traffic movement are considered according to the different optimal criteria. The algorithms are tested on the example of the Moscow traffic net and are based on energetic process estimation.

Keywords: fuel consumption, optimal control problems, traffic flows, traffic flow density, traffic flow intensity, traffic net graph.


1 Introduction

The intensive increase in number of the automobile fleet in large cities is one of the results of economic reforms in Russia while there is practically invariable configuration and length of traffic net.

In spite of a quite low level of automobile saturation in megapolises such as Moscow (Figure 1) and St. Petersburg (about 250 automobiles per 1000 persons), average speed of traffic flow movement in daytime decreased to 18–20 km/h on main roads. For example, on the Moscow traffic net there are at least 25 sections where traffic jams are constantly formed and traffic flows become uncontrollable.

Further numbers of vehicles are increasing the automobile fleet while factors suppressing development of the traffic net (economic, architectonic, ecological) can strain the situation.

The solution lies in development of strategic management in traffic flows of large cities in the following directions:

References


