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SCIENTIFIC DESIGN OF WORKPLACES

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ABSTRACT
The article presents a research on the sewing process regarding strain and stress. The worker usually performs her / his work in sitting position. The human body is constructed for moving and any position over a longer period of time, regardless of how comfortable it might be, is a forced position and one can say that during the process of sewing the worker sits in a forced position. Such a forced position is even more stressed when the workplace is not ergonomically constructed and the worker at the sewing machine sits in a forced position. The article presents a case study of workplace design for the process of sewing
Keywords: strains and stresses, workplace design, ergonomic design

1. INTRODUCTION
At their workplaces, operators are subjected to stresses induced by different factors in their working environment (physical, psychical and ecological stresses). In the human body, stresses cause physical and psychical strains that depend on the operator's health condition. Work should be organized so as to provide balance between stresses and strains. The disturbance of balance causes tiredness that results in sick leaves, fluctuations of operators, injuries, occupational diseases, handicap and eventually death [1,3].
During sewing, an operator is in a sitting position, thus in a forced position by the nature of the work itself. When the workplace, however, is not designed according to ergonomic principles, stresses experienced by the operator are still higher. Two questions arise here, first whether sewing workplaces are ergonomically designed, and second, if they are not, what are the stresses and strains induced by operators due to incorrect body postures. We are also interested in whether enhanced stresses disturb the balance between stresses and strains. We shall try to answer these questions in the research presented below [2].

2. METHODOLOGY AND RESEARCH RESULTS
The research discusses the re-design of workplaces based on scientific grounds according to the below steps: technological design, engineering design, ergonomic design, physiological design and economic design.The workplace for performing the technological operation of joining side seams of ladies' trousers comprises a sewing machine, a chair, a table at the left from where the operator picks pattern pieces, and a stand at the right for depositing joined pieces (Figure 1).

Technological stresses
The comparison shows that the actual performance of the technological operation meets the standard requirements in almost no point. A new working method should be proposed for this workplace, the workplace should be adequately re-adapted and pattern pieces suitably arranged [4,5].
The technological operation is performed in 0.655 minutes, which is very fast already in the present conditions. The suppression of unnecessary motions, especially the picking up and depositing of the pattern piece with both hands, and the reduction of machine stoppages during sewing, could result in still greater reduction of technological time. The operation time could also be reduced with the replacement of the present machine with the machine with automatic thread clipping.

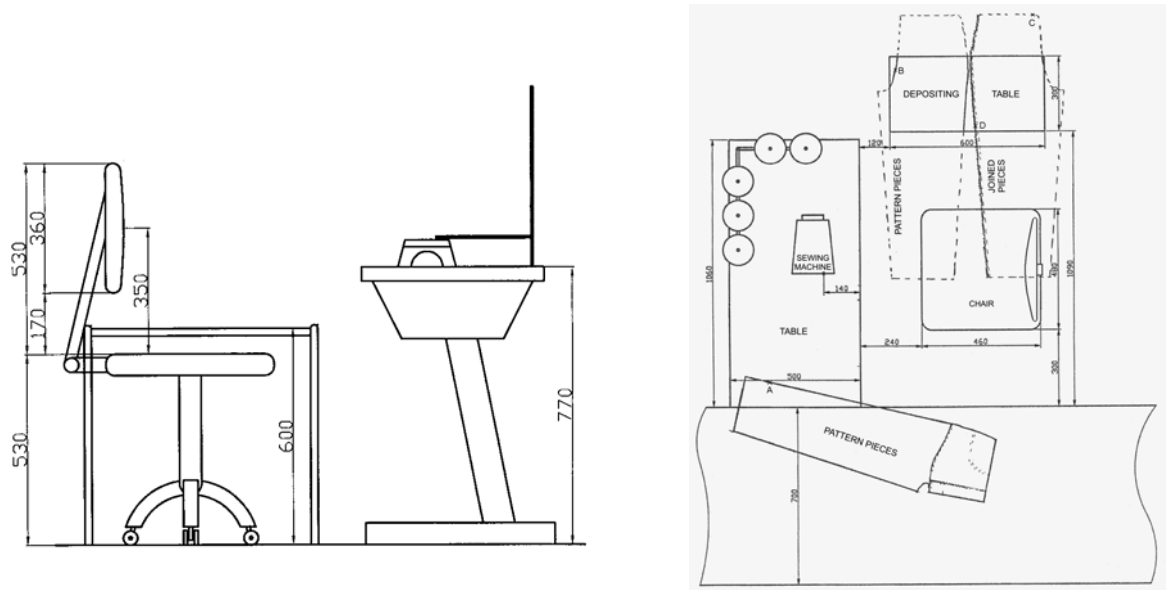

Figure 1. Side view of the workplace and lay-out of the workplace and position of pattern pieces

Ecological stresses

The mean value of normal effective temperature was NET=22,9 °C. The comparison of measured and calculated values with the standard or proposed ones shows that the illumination of the material at the workplace as well as the illumination of the workplace and wider working area exceed the proposed values and meet the norm. The calculated value of noise was compared to the allowed value. The calculated noise level is 78.34 (dB), which is still within the allowed values.

Physiological stresses

The results obtained with the OWAS method (Figure 2) show that corrective measures should be taken of the below postures:

- 1.2 bent posture, the bent is greater than 15°,
- 2.2 one or both upper arms are active and below the level of shoulders,
- 4.1 sitting,
- 5.2 head inclined towards the stomach above 30°.

Anthropological measures of operators were compared to the dimensions of tables, chairs and tools (Table 1). Dimensions of the inspected workplace are totally unsuitable. All measures must be corrected to suit operator's anthropological measures.

Psychological stresses

It is evident from the inspection of work and talks to the operator that she is subjected to stressful situations during her work:

- she works as on a conveyor belt and is continually under stress endeavoring to finish enough pieces to provide work also for the next operator;
- work is standardized, which causes additional psychical stress;
- work is monotonous, operations are short and repeated.

Proposal for an ergonomically designed workplace

Based on scientific findings, the ergonomic design of the workplace is proposed considering the results of the workplace analysis and the comparison of the results with the required or standard values.

Technological design

Within the scope of technological design, a proposal was made for a new working method in accordance with optimal working methods for guiding the pattern piece. The length of the seam in this operation is considerable (about 100 cm), the edges of the pattern piece are straight for some time and

then curved, and the pocketing must be caught into the seam during the same operation. Such an operation is almost impossible to be performed without stopping the sewing machine. Therefore, two sewing methods are proposed for each garment side (left and right) between which the operator stops the machine.

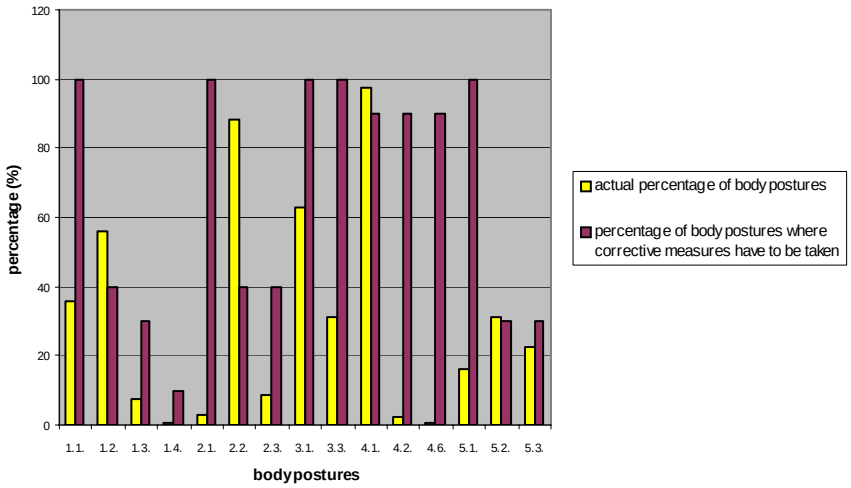

Figure 2: The histogram of the OWAS measuring method applied at the inspected workplace

Table 1: The comparison of actual workplace dimensions with the required workplace dimensions (according to OWAS)

Workplace dimensions	Actual dimensions (mm)	Required dimensions (mm)
Height of the working table	770	780+45+20=845
Height of the chair	530	430+45+20=495
Dimensions of the chair	480X460	450X400 (max.)
Dimensions of the chair support	360X420	220X300 (minim.)
Distance of the chair support center from the seating area	350	220
Height of the table for depositing pieces	600	600
Distance of the sewing needle from the edge of the working table	140	300

Engineering design

The present sewing machine does not have the automatic thread clipper. This device, however, is a prerequisite if optimal working methods of guiding pattern pieces are to be introduced. We suggested the replacement of the present special sewing machine with a special sewing machine JUKI MO-3916-FG6 with automatic thread clipping. This machine also has the pneumatic device for removing the cut thread at the beginning and end of the seam, as well as a pneumatic device for removing cloth clippings cut by the knife during the sewing process. This reduces the amount of dust at the workplace. The workplace is cleaner and tidier.

Ergonomic design

Dimensional changes (required dimensions) – look at Table 1

Physiological design

From the measurement analysis of the workplace it is evident that:

- thermal environment is adequate – no changes necessary,
- illumination meets the standards – no changes necessary;
- the contrast of the working table when dark materials are sewn is too big; the working table should be of a bit darker color as presently so as to reach a suitable contrast either when light or dark materials are sewn;
- the inclination angle of the head α and the inclination angle of the eyeballs β are unsuitable: they are remedied by lowering the seat and correcting the posture of the operator;
- the noise does not exceed the allowed values – no changes necessary;

- there are no hazardous chemicals at the workplace - no changes necessary;
- mechanic vibrations are slight - no changes necessary.

Economic design

The savings per unit S_1 and savings per year S_N are calculated from:

$$t_{1o} = 0{,}66\,\text{min};\ t_{1n} = 0{,}60\,\text{min};\ C_w = 0{,}15\ €/\text{min};\ Z_N = 750 \cdot 249 = 186.750\ \text{pieces/year}$$

$$S_1 = (t_{1o} - t_{1n}) \cdot C_w = 0{,}009\ €/\text{piece};\ S_N = 186.750\ \text{pieces/year} \cdot 0{,}009\,€/\text{piece} = 1.680{,}75\,€/\text{year}$$

With the introduction of a new quicker sewing machine with automatic thread clipping additional 0,05 min, i. e. 0,0075 €/piece can be obtained, which amounts, together with savings due to corrected working methods to 0,0165 €/piece. The number of pieces per year is increased to 203.682.

3. DISCUSSION AND CONSLUSIONS

In the sewing process stresses are induced by anthropometric measures (body postures, body measures), working tasks, working environment, and work organization. One common point to all workplaces in the process of sewing is the stress induced by the forced position of the operator, because due to the nature of work the operator is in a sitting position for the whole time. The stress is still greater because workplaces are not adequately designed, i.e. adapted to operator's measures. A detailed analysis of the workplace showed that:

- the workplace is badly designed or not designed at all: the operator selects the method of performing a sewing operation by herself, as she thinks it best;
- ecological stresses met the allowed or required values, with the exception of the excessive contrast between the working surface and the pattern piece;
- the results obtained by the OWAS method and the comparison of operator's body measures with the dimensions of the workplace showed that the operator's posture was not in accordance with ergonomic requirements;
- the nature of the work itself makes the work stressful: the work psychically affects the operator.

It is clear from the above discussion that the proposed re-design of the workplace reaches its goal. We are further convinced that the workplace meets ergonomic requirements if we compare the photograph showing an operator during sewing at a non-redesigned workplace (Figure 3) with the photograph of an operator sewing at a re-designed workplace (Figure 4).

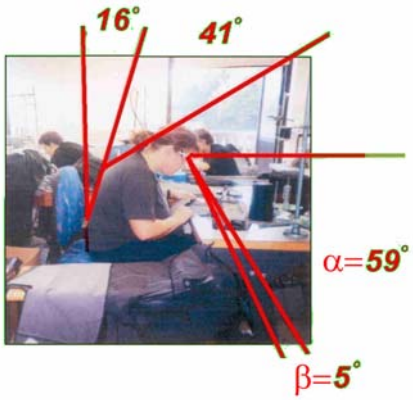

Figure 3: Operator in her posture during sewing at a non-redesigned workplace

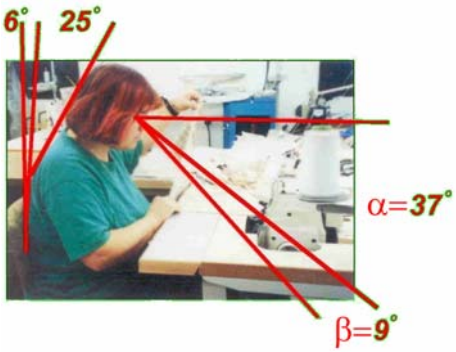

Figure 4: Operator in her posture during sewing at an ergonomically designed workplace

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