Estimating Clothing Comfort Under Dynamic Conditions in the Evaluation of Some Biometric Parameters

II. The evaluation of temperature and electrical resistance of the skin

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Tests on wearing clothes are complex methods of analysis that mainly consist of recordings of physiological reactions in the body. During wearing tests physical parameters of the environment and biometric parameters were measured. Five garments, blouses, were tested under dynamic conditions; the products were worn by 5 subjects, female students. In the performed tests there were determined the following parameters: the skin temperature and the electrical resistance of the skin, under dynamic wearing conditions (repose, effort, recovery). The study demonstrated that the tests of wearing garments under certain conditions, through their complexity, provide a series of information and emphasize certain aspects that cannot be found in the laboratory tests results on textile materials. The performance of these types of tests and the accomplishment of the objectives imply the contribution of complex teams. Only through an interdisciplinary approach can the issues regarding wear comfort be solved.

Keywords: clothing, wear tests, warm environment, dynamic conditions, comfort, evaluation, biometric parameters

The new tendencies which appeared in the cloths study are focused on the cloths' capacity to provide a comfortable wearing; these are caused by the following aspects:

- the continuous development of the new textile types and finishing processes, [1 -5];
- the performances achieved by the new methods of scientific foundation, comfort's testing and evaluation, regarding especially the analysis of the cloths' complex system under the non-isothermal and non-stationary conditions; the possibility to simulate the real conditions in case of wearing the clothing structures, for a broad range of conditions concerning the body as well as the environment;
- the collaboration between different sectors of the textile industry as far as designing and realization of the new products with high performances are concerned [6-10];
- the new concepts regarding the comfort providing at wearing, the cloths' quality and design based also on the body-cloths – environment system (interaction), [11, 13].

The comfort perceived on wearing clothes that are in direct contact with the skin is a complex phenomenon that involves the integration of the following groups of sensations: thermal (warm or cold), wetness, and tactile (contact). The weather conditions, the level of physical activity/load of the individual, his/her physical and biometric status, and the fibre/textile fabric/product properties influence the level of perceived sensations and comfort [14-19].

The skin is a very wide sensitive surface. Three main categories of sensorial receptors are present in the skin: the group of contact receptors; the group of temperature receptors; the group of pain receptors. The group of temperature receptors responds to temperature changes; they are also responsible for the emergence of the chilly/cold sensation, perceived at first at the contact between the skin and several types of fabric (especially the ones with a large contact area). The skin temperature influences the level of the perceived thermal sensations, but there is an impediment that it is influenced by the presence of perspiration; after the evaporation of perspiration, the skin temperature decreases and then increases more slowly than if perspiration were abundant. The combination skin – perspiration (humidity) – sebum generates a very sensitive surface.

Tests on wearing clothes are complex methods of analysis that mainly consist of recordings of biometric reactions in the body. An early supervision of these physiological reactions, at a certain physical charge and under certain climatic conditions, ergometrically shaped, provides precious information on the human body and its status, as well as on the worn clothes. In addition, psychological scales can be used for assessing comfort sensations of wearers in different types of clothing [20-30].

The biometric parameters used in the assessment of the body's thermal solicitation and presented in this paper are [31-39]:

- *the temperature of the skin* (t_{sk}), the temperature measured on the skin surface has great variations on the entire body surface the colder the ambiance is. Thus, we can distinguish:cutaneous local temperature, t_{sk}, measured in a precise point of the body surface and the average cutaneous temperature, t_{sk}, for the entire body surface, which is difficult to gauge but can be appraised by the weight of a certain number of local cutaneous temperatures, according to the surfaces characterised by

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Code of product variant	Item code	Fibrous contents
Ma	G1.1	100% cotton
Mb	G2.2	33% cotton + 67 PES
Mc	H1.3	100% PES Micrell (microfibre)
Md	H5.4	100% PES, non-saponified
Me	H5.5	100% PES, saponified

Table 1
THE TESTED PRODUCT VARIANTS

them. The average cutaneous temperature does not allow by itself the assessment of the physiological solicitation of thermal origin; however, it represents an important criterion in the assessment of the thermal comfort conditions. The most often investigated parts of the body are the ones with greater and more constant temperatures (the forehead, the stern). For the thermal comfort part, the forehead temperature shows values of 31.5 – 33.5°C. In a warm microclimate there is a tendency of increasing skin temperature, levelling the forehead and extremities temperature and showing an active skin vasodilatation, a physiological phenomenon that occurs while the body adapts to heat.

- *electrical resistance of the skin*, the thermoregulation possibilities are also characterised by the prompt production of perspiration. The strong subcutaneous irrigation and the production of perspiration increase the electrical skin conductibility and thus modify the electrical resistance of teguments. In the thermal comfort area, perspiration is reduced; at the upper end of this area, with the increase of air temperature, the electrical conductibility of the skin increases progressively and in parallel, so it is indicated to measure the electrical resistance of the skin in different skin areas under the conditions of a low or average strained microclimate [40-42].

Experimental part

The tests on wearing clothes were based on the following standards: determining the production of metabolic heat, SR ISO 8996/1990; assessing the thermal requirement through biometric measurements, SR ISO 9886/1992; thermal ambience (machines and methods of measuring physical units), SR EN 27726/1996; assessing thermal stress of working people according to the WBGT index (wet temperature and globethermometer), SR EN 27243/1996. Experimental tests were carried out with the cooperation of Public Health Institute, “Labour medicine” section. The clothes used during the wearing tests comprised 5 variants of female blouses, for the warm season (summer).

The model was designed out of five different items, of class cotton type and silk type; the tested variants are presented in table 1.

The tests were carried out during the summer period, in a specially designed room under the following circumstances: air temperature t_a = 25.4 – 27°C; relative air humidity φ= 57 – 79%; air currents speed v_a = 0.04 – 0.21m/s. These characterize a warm and wet environment, without any air currents; also, there was no influence from sunbeams. The subjects were five female students. For each subject, it was also determined a corporal mass index IMC (or a Quetelet - IQ index), establishing the relationship (equation 1):

$$IMC = IQ = M / T^2,\ [kg/m^2], \qquad (1)$$

where M – is the corporal mass, [kg]; T – is the height of the body, [m].

It is considered that normal values for this index range between 22 – 25kg/m². For the five subjects, the IMC values range between 16 – 20.45kg/m², so these are part of underweight persons (table 2). Previously, a psychological exam was carried out, determining the types of dynamic-energetic reactivity (tempers), according to Gaston Berger’s survey, because it is known that temper can also influence cardio-vascular and breathing reactions etc. (these are an expression of neuro-vegetative reactivity). Three elements of characterising reactivity types (tempers) were considered: emotional, active, secondary/primary. The conclusions of the psychological exam were: all subjects are emotional (except one) and active; four out of five have impetuous tempers (passionate and choleric), are active, passionate persons, fighters, who want to be successful and obtain rapid and susceptible achievements, who feel easily and quickly affected and irritated by unpleasant events. The emotional, active and primary subjects can have stronger and abrupt reactions, thus having the possibility to react more often and through increasing the electric conductibility of the skin, frequent or/and abundant perspiration.

The physiologic experiment on subjects was carried out under dynamic conditions and comprised three distinct stages: repose and accommodation, effort and repose, and anticlimax. The length of each period has to be chosen according to the destination of tested products and envisaged aim. The physical effort was carried out on a cycloergometer (KE11).

Evaluation of the biometric indices

The following biometric indices were measured in the performed tests: the skin temperature which was measured using an electrothermometer, in three different areas: forehead (t_F), stern (t_S), back – spine (t_c); and the electrical resistance of the skin (Rep), expressed in Ohm, which was measured using a “Reograph” comprising an ohmmeter with transistors. The measurements were carried out in the following manner: for the repose period (after 10 min), effort after 5 and 10 min and for the anticlimax period after 5 respectively 10 min. The average values of the skin temperature (forehead $\overline{t_F}$, sternumm $\overline{t_S}$ and respectively spinem $\overline{t_C}$) and the electric resistance of the skin ($\overline{R_e}$), for the five product variants and different

Subject	Age (year)	Height T (m)	Corporal mass M (kg)	Corporal mass index IMC (kg/m²)	Corporal surface SC (m²)
S1	25	1.61	53	20.45	1.55
S2	22	1.62	42	16.00	1.41
S3	23	1.71	54	18.47	1.63
S4	23	1.60	47	18.36	1.46
S5	23	1.55	45	18.73	1.40

Table 2
THE SUBJECTS USED IN THE EVALUATION

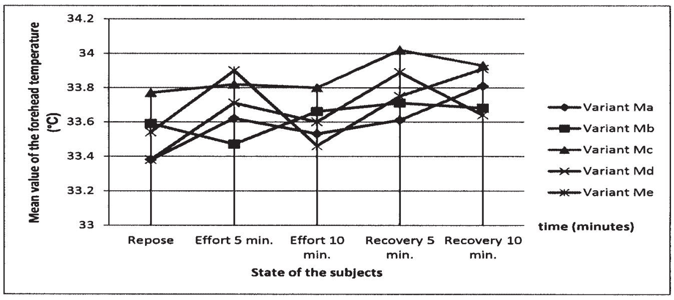

Fig. 1. Average temperature of the forehead $(\overline{t_F})$

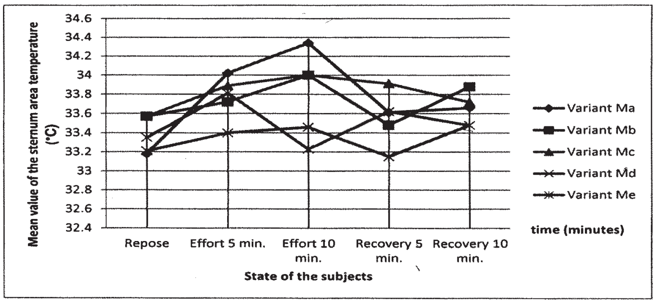

Fig. 2. The variation of the sternum area temperature $(\overline{t_s})$

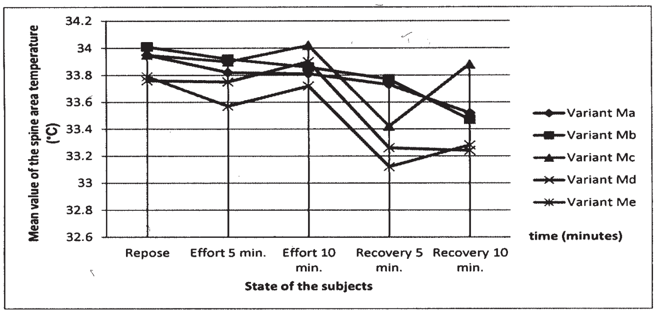

Fig. 3. The variation of the spine area temperature $\overline{t_c}$

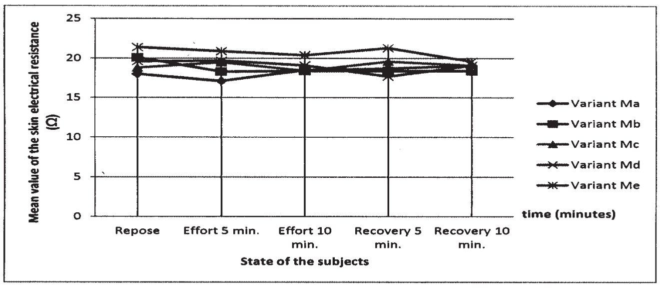

Fig. 4. The variation of the skin electrical resistance $(\overline{Rep})$

states of the body (repose, after 5 and respectively 10 min of effort and recovery after 5 min , respectively 10 nin), are presented in figure 1.

There can be ascertained that $\overline{t_F}$ has not a constant variation; still the greatest values are registered at recovery for the variant M_c (fig.2).

It can observed that generally the temperature in the sternum area has the tendency to increase in the effort period, and then to decrease in the recovery period. The values for $\overline{t_s}$ are very close in the case of the 5 product variants, no matter of the organism state. After 10 min of recovery the smallest values appear for variants M_d and M_e, that means these easily allow perspiration evaporation, so a better cooling of the body (fig.3).

If for the variants M_a and M_b it can be observed a continual decrease of temperature in the back area on the entire period of determination, for the variants M_c, M_d and M_e it can be observed a increase of this after 10 min of effort, and then decreases after 5 min of recovery (the highest values being observed for the variant M_c, in comparison to variants M_d and M_e). By recovery it can be observed that the smallest values are registered for the variants M_d and M_e, probably due to the fact that these allow an easier evaporation of the body perspiration.

Generally, we can say that due to the warm microclimate, the temperatures for the three areas of the body (forehead, sternum, and spine) are very close as value being generally comprised in the interval of the average temperature of the skin because the chosen model of the worn garment allows better ventilation during body movement (fig. 4).

It can be observed that after 10 min of effort, the electric resistance of the skin decreases for the variants M_b, M_c, M_d and M_e in comparison with the value corresponding to the repose state. Among all variants here is detached the product M_d for the behavior of which the electric resistance of the skin permanently drops, even after 5 min of recovery; it registers an increase only after 10 min of recovery. These modifications of the electric resistance for the variant M_d are supported by the observations and signals of the tested subjects during the wearing tests, tests showing that the perspiration was flowing abundantly on the skin after effort starting.

Results and discussions

The qualitative analysis In the state of rest, the smallest value for $\overline{Rep}$ is registered when wearing the product M_a and is maintained at the same level and after 5 min of effort, differentiating thus from the products M_b, M_c, M_d and M_e. After 10 min of effort the tendency to maintain at high values is ascertained in the products M_d and M_e. It seems that the electric resistance of the skin differentiates better the M_a product (where we did not observe the abundant sweat) from the M_d and M_e products (when worn, after the beginning of effort, the perspiration was abundant).

The quantitative analysis The STUDENT "t" test, the formula for correlated samples, was used to differentiate the reactivity of the organism when wearing the 5 variants of product by using (taking into account the fact that the same subjects were investigated in five clothes variants, with five stages of measurements). The calculation relations used are (eq. 2 and 3) [11, 43-60]:

$$t = \frac{\overline{m_d}}{\frac{\sigma_d}{\sqrt{N}}} \qquad (2)$$

$$\overline{\sigma_d} = \sqrt{\frac{\sum d^2 - \frac{\left(\sum d\right)^2}{N}}{N-1}} \qquad (3)$$

where: $\overline{m_d}$ is the mean of differences between the data compared; $\overline{\sigma_d}$ is the standard deviation of the differences; N- the number of investigated subjects; Σd^2–is the sum of squares of differences between the data compared; Ód – is the algebraic sum of differences between data compared.

Among the comparisons achieved at the indicators presented above between the variants analyzed (the variant M_a consecutively with M_b, M_c, M_d and M_e) were considered as significant those differences that presented a significance threshold, $p \leq 5\%$, according to the situation taking into consideration (more seldom) the significance threshold of under 10%, taking into account the small number of investigated subjects. In the following tables 3 and 4 are presented the results obtained regarding the significance tests ("t"). In the tables, there are the values of Student "t" test, and where there are significant

Table 3
THE VALUES OF STUDENT "t" TEST FOR THE FOREHEAD, STERN AND COLUMN TEMPERATURE
(Ma compared with condition of organism STATE)

Conditions of organism state	M_b			M_c			M_d			M_e		
	1	2	3	1	2	3	1	2	3	1	2	3
At rest	-1.00	-1.21	-0.14	-1.89	0.03	-0.02	0.00	- 0.04	0.49	-0.71	- 0.40	0.46
Effort 5min	0.69	1.76	-0.31	-0.72	0.55	-0.16	0.43	1.36	0.16	-1.08	0.95	1.79
Effort 10min	-0.81	1.33	-0.16	-1.37	1.48	-1.07	-0.25	1.66	-0.27	0.18	0.09	-0.27
Recovery 5min	-0.64	0.34	-0.15	-1.63	- 1.69	.06	-1.45	0.85	1.05	-0.53	-0.02	0.05
Recovery10min	0.62	- 0.48	0.25	-0.61	- 0.23	-1.14	0.67	0.25	0.56	-0.58	0.84	0.57

Code of product variant	Item code	Fibrous contents
Ma	G1.1	100% cotton
Mb	G2.2	33% cotton + 67 PES
Mc	H1.3	100% PES Micrell (microfibre)
Md	H5.4	100% PES, non-saponified
Me	H5.5	100% PES, saponified

Table 4
THE VALUES OF STUDENT "t" TEST FOR THE ELECTRIC RESISTANCE OF THE SKIN
(M_a compared with condition of organism state)

differences from the statistic point of view the value of the significant threshold is also written (p). In the tables are used the following notes: 1 are the values of STUDENT "t" test for the forehead temperature; 2 are the values of STUDENT "t" test for the stern temperature; 3. the values of STUDENT "t" test for column temperature [52-54].

In case of values of STUDENT "t" test for the stern temperature were not ascertaining statistically significant differences. At rest, $\overline{t_s}$ is significantly higher in the case of M_c variant compared to M_a one and after 10 min of effort $\overline{t_s}$ is significantly higher in the case of M_e variant compared to M_a. After 5 min of retrieval, $\overline{t_c}$ is higher in the case of variants M_c and M_e compared to M_a.

Both in the effort (after 5min and respectively 10min) and in recovery (after 5min), the values are higher for the product M_e comparing with M_a.

Conclusions

We can conclude that all the analysis applied, quantitative and qualitative, lead to the following conclusions:

-the organism reactivity is much better when wearing the M_a product compared to the other variants (M_b, M_c, M_d and M_e);

-we can make from this point of view a differentiation of the 5 variants on two groups, namely: the best reactivity of the organism is noticed at M_a and M_b products (a first group) compared with the products M_c, M_d and M_e (the one from the second group) moreover even, we can say that the M_c product manifests an intermediary behavior between the variants (M_a, M_b) and (M_d, M_e).

References

1.GRIBINCEA, V., CHIRITA, M., MANEA, L., SUFITCHI, P., Izvestiya Vysshih Uchebnykh Zavedenii, Seriya Teknologiya Tekstil'noi Promyshlennosti, Issue 1, 2002, p. 18.
2. CHIRITA, M., GRIBINCEA, V., MANEA, L., Industria Textila, **48**, no. 2, 1997, p. 82.
3. HRISTIAN, L., SANDU, A.V., MANEA, L.R., TULBURE, E.A., EARAR, K., Rev. Chim. (Bucharest), **66,** no.3, 2015, p. 342.
4. GRIBINCEA, V., CHIRITA, M., MANEA, L., Industria Textila, **48**, no. 2, 1997, p. 79.
5. MANEA, L., GRIBINCEA, V., SUFITCHI, P., Rivista della Tecnologie Tessili, no.7, 2000, p. 112.
6. GHERASIMESCU, C., LEVA, M., BUTNARU, R., MURESAN, A., MANEA, L.R., Industria Textila (Bucharest), **62,** no. 1, 2011, p. 19.
7. SECULA, M.S., CRETESCU, I., CAGNON, B., MANEA, L.R., Materials, **6**, no.7, 2013, p. 2723.
8. MOISESCU, E., MANEA, L., Revista Romana de Textile - Pielarie, no. 3-4, 1999, p. 75.
9. MOISESCU, E., MANEA, L., SUFITCHI, P., Industria Textila, **50**, no.1, 1999, p. 21.
10. MANEA, L., MOISESCU, E., SUFITCHI, P., Industria Textila (Bucharest), **40**, no.4, 1998, p. 234.
11. MOISESCU, E., MANEA, L., SUFITCHI, P., Industria Textila (Bucharest), **49,** no. 3, 1998, p. 179.
12. POPESCU, V., MANEA, L.R., CURTEZA, A., VASLUIANU, E., Tekstil, **60**, no. 7, 2011, p. 306.
13. MANEA, L., MOISESCU, E., COMANDAR, C., Texsci 2000, 2001, p. 278.
14. VERZEA, I., LUCA, G.P., MANEA, L.R., LAZARESCU, R.P., Edited by: RUSU, C., PHILLIS, Y., Management of Technological Changes, Book 2, 2005, p. 137.
15. VERZEA, I., LUCA, G.P., MANEA, L. R., CHAIB, R., Edited by: RUSU, C., Management of Technological Changes, vol. 1, 2009, p. 757
16. POPESCU, V., MANEA, L.R., SANDU, I.G., CHIRCULESCU, A.I., SANDU, I., Rev. Chim. (Bucharest), **64**, no. 3, 2013, p. 281.
17. MANEA, L., LAZARESCU, R.P., LUCA, G.P., VERZEA, I., Edited by: RUSU, C., PHILLIS, Y., Management of Technological Changes, Book 1, 2005, p. 403.
18. MANEA, L., LAZARESCU, R.P., LUCA, G.P., VERZEA, I., Edited by: RUSU, C., PHILLIS, Y., Management of Technological Changes, Book 2, 2005, p. 71.
19. COMANDAR, C., ANDRIUTA, M., MANEA, L.R., TexsCi 2000, **12**, 2001, p. 91.
20. Xu, D.H., Applicable Analysis, **93**, no. 11, Special issue: SI, 2014, p. 2426.
21. MANEA, L.R. SCARLET, R., LEON, A. L., SANDU, I., Rev. Chim. (Bucharest), **66**, no. 5, 2015, p. 640.
22. BAKKEVIG, M.K., NIELSEN, R., Ergonomics, **38**, no. 5, 1995, p. 926.
23. DIACONU, M., CRETESCU, I., LUCA, F., LILIANA, M., POHONTU, C., Environmental Engineering and Management Journal, **9**, no.1, 2010, p. 67.
24. FAYALA, F., ALIBI, H., JEMNI, A., ZENG, X.Y., Fibers and Polymers**,** 16**, no.** 6, 2015, p. 1417, DOI: 10.1007/s12221-015-1417-7
25. SCARLET, R., MANEA, L.R., SANDU, I., CRAMARIUC, B., SANDU, A.V., Rev. Chim. (Bucharest), **63**, no. 8, 2012, p. 777.
26. MANEA, L.R., SCARLET, R., AMARIEI, N., NECHITA, E., SANDU, I.G., Rev. Chim. (Bucharest), **66**, no. 4, 2015, p. 542.
27. LI, Y., PLANTE, A.M., HOLCOMBE, B.V., Textile Research Journal, **65**, no. 6, 1995, p. 316.
28. MANEA, L.R., DANU, M.C., SANDU, I., Rev. Chim. (Bucharest), **66**, no. 6, 2015, p. 868.
29. KAPLAN, S., OKUR, A., Indian Journal of Fibre & textile Research, **37**, no.1, 2012, p. 46.
30. RADU, I., Psychological Methodology and Data Analysis, Ed. Sincron, Bucuresti, 1993, p. 59.
31. ZHANG, P., GONG, R.H., YANAI, Y., TOKURA, H., Textile Research Journal, **72**, no. 1, 2002, p. 83.

32. VERZEA, I., LUCA, G.P., MANEA, L.R., LAZARESCU, R.P., Edited by: RUSU, C., PHILLIS, Y., Management of Technological Changes, Book 2, 2005, p. 143.
33. SCARLET, R., MANEA, L.R., PANTILIMONESCU, F., BERTEA, A., Buletinul Institutului Politehnic din Iasi, Sectia Stiinta si Ingineria Materialelor, Tomul LV (LIX), **4**, 2009, p. 223.
34. PANTILIMONESCU, F., SCARLET, R., DELIU, R., MANEA, L.R., Buletinul Institutului Politehnic din Iasi, Sectia Stiinta si Ingineria Materialelor, Tomul LV (LIX), **4**, 2009, p. 339.
35. LAU, L., FAN, J.T., SIU, T., SIU, L.Y.C., Textile Research Journal, **72**, no. 11, 2002, p. 949, DOI: 10.1177/004051750207201103
36.DELIU, R., MANEA, L.R., CRAMARIUC, B., SCARLET, R., 5th International Textile, Clothing & Design Conference, Dubrovnik, Croatia, 2010, p. 234.
37. SCARLET, R., DELIU, R., MANEA, L.R, 7th International Conference TEXSCI, 2010, p. 6,
38. LU, Y.H., SONG, G.W., LI, J., Applied Ergonomics, 45, no. 6, 2014, **p.** 1439, DOI: 10.1016/j.apergo.2014.04.007
39. SCARLET, R., DELIU, R., MANEA, L.R., Buletinul Institutului Politehnic din Iasi, Sectia Stiinta si Ingineria Materialelor, Tomul LV (LIX), **4**, 2009, p. 139.
40. POPESCU, V., MANEA, L.R., AMARIEI, N., Mate. Plast., **46**, no. 1, 2009, p. 95.
41. VASILICA, P., LILIANA-ROZEMARIE, M., GABRIEL, P., Edited by: DAS, D.B., NASSEHI, V., DEKA, L., 7th International Industrial Simulation Conference 2009, 2009, p. 352.
42.POPESCU, V., MANEA, L.R., POPESCU, G., Edited by: RUSU, C., Management of Technological Changes, vol. 2, 2009, p. 769.
43.LUCA, G.P., VERZEA, I., MANEA, L.R., Edited by: RUSU C., Management of Technological Changes, vol. 1, 2009, p. 245.
44.LAZARESCU, R.P., DUDA-DAIANU, D.C., MANEA, L., Edited by: RUSU, C., Management of Technological Changes, vol. 1, 2009, p. 373.
45. SUN, C., AU, J.S.C., FAN, J.T., ZHENG, R., Applied Ergonomics, 48, 2015, p. 38, DOI: 10.1016/j.apergo.2014.11.012
46.LAZARESCU, R.P., DUDA-DAIANU, D.C., MANEA, L., Edited by: RUSU, C., Management of Technological Changes, vol. 1, 2009, p. 377.
47.VERZEA, I., LUCA, G.P., MANEA, L.R., BENIDIR, M., Edited by: RUSU, C., Management of Technological Changes, vol. 1, 2009, p. 753.
48. VASILICA, P., LILIANA-ROZEMARIE, M., GABRIEL, P., Edited by: DAS, D.B., NASSEHI, V., DEKA, L., 7th International Industrial Simulation Conference 2009, 2009, p. 347.
49. LEON, A.L., MANEA, L.R., Edited by: DRAGCEVIC, Z., ITC&DC: 4th International Textile Clothing & Design Conference, Book Of Proceedings, 2008, p. 803.
50. MANEA, L.R. NECHITA, E., SANDU, I., Rev. Chim.(Bucharest), **66**, no.11, 2015, p. 1841.
51. GRIBINCEA, V., CHIRITA, M., MANEA, L., Industria Textila, **48**, no. 1, 1997, p. 20.
52.SCARLET, R., MANEA, L.R., SANDU, I., MARTINOVA, L., CRAMARIUC, O., SANDU, I.G., Rev. Chim. (Bucharest), **63**, no. 7, 2012, p. 688.
53. EARAR, K., MATEI, M.N., SANDU, A.V., HRISTIAN, L., BEJINARIU, C., SANDU, I.G., Mat. Plast., **52**, no. 1, 2015, p. 98.
54. HRISTIAN, L., BORDEIANU, D.L., IUREA, P., SANDU, I., EARAR, K., Mat. Plast., **51**, no.4, 2014, p. 405
55. POPESCU, V., RADU, C.D., MANEA, L.R., Industria Textila (Bucharest), **61**, no. 1, 2010, p. 23
56. MANEA, L.R., CURTEZA, A., SANDU, I., Mat. Plast., **52**, no. 3, 2015, p. 312
57. MANEA, L.R., CRAMARIUC, B., SCARLET, R., CRAMARIUC, R., SANDU, I., POPESCU, V., Mat. Plast. **52**, no. 2, 2015, p. 180
58. MANEA, L.R., SCARLET, R., SANDU, I., Rev. Chim. (Bucharest), 66, no. 10, 2015, p. 1622
59. MANEA, L.R., CRAMARIUC, B., CAUNII, V., SANDU, I., Mat. Plast. **52**, no. 1, 2015 p. 82
60. PPESCU, V., SANDU, I.G., VASLUIANU, E., SANDU, I., CAMPAGNE, C., MANEA, L.R., Rev. Chim. (Bucharest), **65**, no. 12, 2014, p. 1439

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