COMPARING STRENGTH PROPERTIES OF NATURAL AND SYNTHETIC RUBBER MIXTURES

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Abstract: During in our research work we examine the condition of developing elastomer – metal connection at manufacturing machine – and car industry hybrid parts. As a first step we have carried out comparison tests relating to the strength properties of synthetic – and natural rubber mixtures. During tests we have compared four mixtures used often in the practice (NR, NBR, EPDM, CR) in three characteric hardnesses (43 Sh^0, 57Sh^0, 72Sh^0). In addition to hardness we have measured the elongation at rupture and the density, too. As a continuation of our tests we researched what connection is between the surface roughness of metal plate and the elastomer – metal bonding formed.

Keywords: rubber mixtures, latex, hybrid parts, strength properties

1 INTRODUCTION: CHARACTERIZING THE MIXTURES EXAMINED

The natural rubber is the most often used type of mixture of the rubber industry nowadays which is produced from the milk-like fluid (from latex) of certain tropical trees. The latex is a colloid state dispersion, the rubber is precipipated (killed) by acetic – or formic acid from it then is washed, pressed, dried or smoked [2]. After these the quality classification takes place then it is packed in to bales and according to the so called „green book" it is put into commercial circulation. This handbook was accepted by the International Federation of Rubber Producting Nations in 1960 which is a standard publication in classifying rubbers up to present days. The introduction of SMR-system (Standard Malaysian Rubber) in 1965 meant further development which standardized the mass, packing, etc. of rubber bales. By this possibility arose to classify the SMR-type based on two important characteristics.

a./ according to starting basic material:
- latex basis,
- waste coagulum basis,
- latex + waste coagulum basis,

b./ according to viscosity:
- stabilized viscosity,
- non-stabilized viscosity

So the bulk processing of rubbers according to exact receipt was possible. [1]
The properties of natural rubber mixtures are the followings:

- high static tensile strength (15-22 MPa),
- high elongation (600-900%),
- excellent elasticity at low temperature (up to – 10^0C doesn't change substantially)
- poor ozone and degradation stability,
- good confectionability because of excellent crude adhesion.

The degradation causes cracks on the rubber products however by receipt solutions and up – to – date auxiliary products they can be repaired considerably, so mixtures can be produced to be best suitable for the application required.
Example to the composition of a natural rubber based mixture. (Table1) [3.].

Table 1.

Naming	Mass-rate [%]
Natural rubber	75,1
Wood-tar	1,5
Resin oil	0,8
Stearine acid	1,1
Zinc-oxide	18,8
Sulfur	2,3
Other accelerators	0,5

The **butadiene-acrylic-nitril** (NBR) rubbers are also often applied types, their greatest advantage is they have got good resistance against mineral oils and aliphatic solvents, because of this various sealings, pipes, oil-resisting technical products are made of them. Their technical properties depend on the acrylic-nitril content substantially thus by increasing this their heat resistance increases but their cold-resistance, elasticity decreases [1].

The **ethylene-propylene** (EPDM) rubber is a low density synthetic elastomer (850-900 kg/m^3), its hardness can be changed between wide limits (20-99Sh^0). Their production is complicated, their mixing needs great attention whether it is made on bowl or in closed mixer. Their confection is difficult in consequence of poor cold-adhesion, to form appropriate metal binding needs special materials [5]. Their vulcanizing is slower whether it is made with peroxides or with sulfur + accelarator vulcanizing system, than the natural rubber. Despite a lot of difficulties they are very widely used materials, rubber boots, pipes, profile straps are made of them.

Characteristic properties:

- very good heat-resistance (up to 150^{0}C),
- ozone – proof,
- excellent electric insulating capability (average volumetric resistance about 10^{10} Ohmcm).

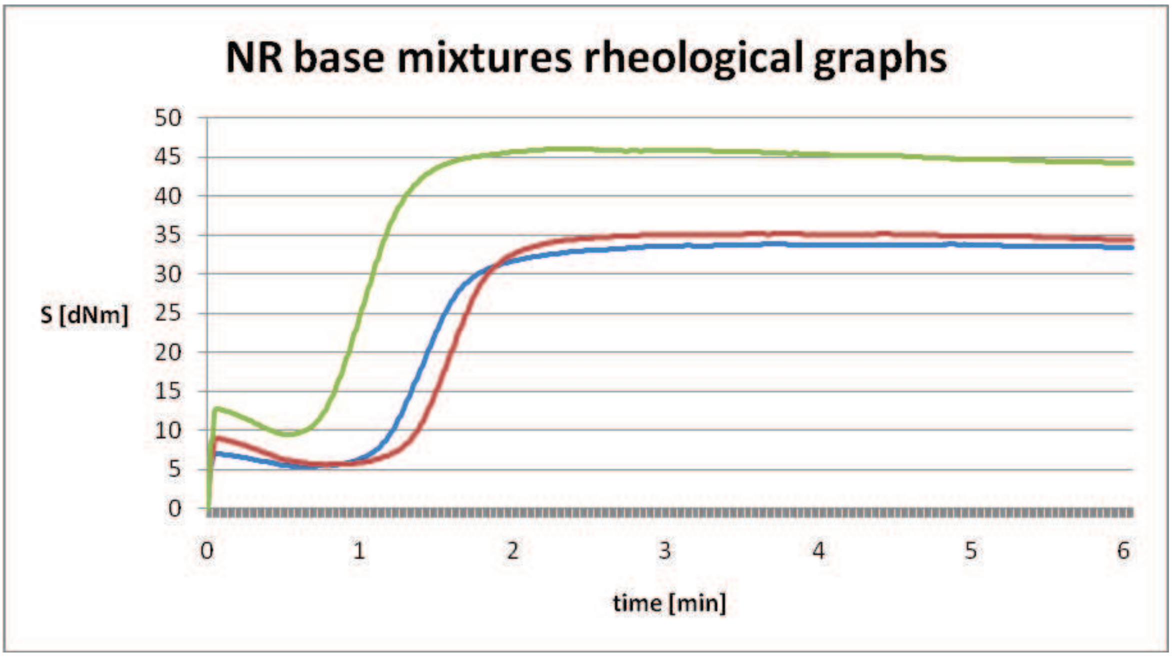
One of the most important characteristic is the insulating resistance of the electric insulators and of rubber mixtures. The ratio of the D.C. voltage connected to the material and the current value read after 1 min. of the connection means the insulating resistance. The 1 min. value is an agreement it serves the simplification of measurings and the comparability.
However it has to be kept in one's mind that the value got is not identical with the real insulating resistance of the material, which is the ratio of the voltage and of the leakage current.
The **chloroprene** (CR) rubber has got high density (1300-1350 kg/m^3), it is widely used synthetic rubber in the practice. Their cost price is high, in exchange for this it has got several favourable characteristics:

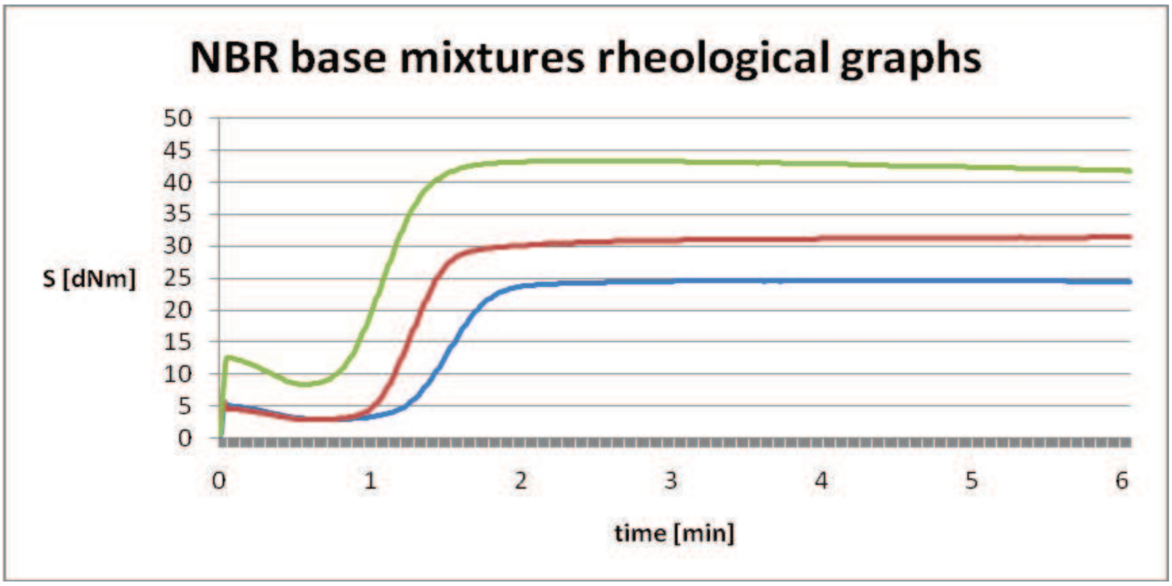
- weather – and ozone – proof,
- medium heat-resistance (90-100^{0}C),
- self-extinguish effect, its oxygen index is 40-50,
- resists mineral oils.

The so called oxygen index gives a very good picture from a mixture burning characteristic, which shows that what is the smallest amount oxygen in a nitrogen – oxygen mixture at room temperature at which the burning remains after setting on fire. [1].
Its application field is mainly pipes, belt conveyor slings.

2 PRESENTING THE RESULTS OF STRENGTH TESTS.

In order to compare the strength characteristics we have made mixture samples from all four materials, then we decided the vulcanizing optimum. The aim of deciding the optimum was that the values got during measurings should be the best results to be produced from the mixture given. It is not all the same that a mixture given in which vulcanizing state is examined and as the vulcanizing speed of the mixture compared is different for this examination was needed by all means. We have carried out examinations with S100 Monsanto Rheometer for this aim which results contains the No 1. diagram. The principle of the measuring is that a standardized rotor with 1,67 Hz frequency, oscillates with 3^0 amplitude in a heated chamber with determined geometry. The equipment measures the moment needed to drive the rotor in the function of time [1]. Figure 1. shows the graphs made with the equipment.
Key words: blue:43 Sh^0, red: 57Sh^0, green:72Sh^0, 170^{0}C, 6 min.


NR base mixtures rheological graphs
S [dNm]
50
45
40
35
30
25
20
15
10
5
0
0
1
2
3
4
5
6
time [min]


NBR base mixtures rheological graphs
S [dNm]
50
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30
25
20
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5
0
0
1
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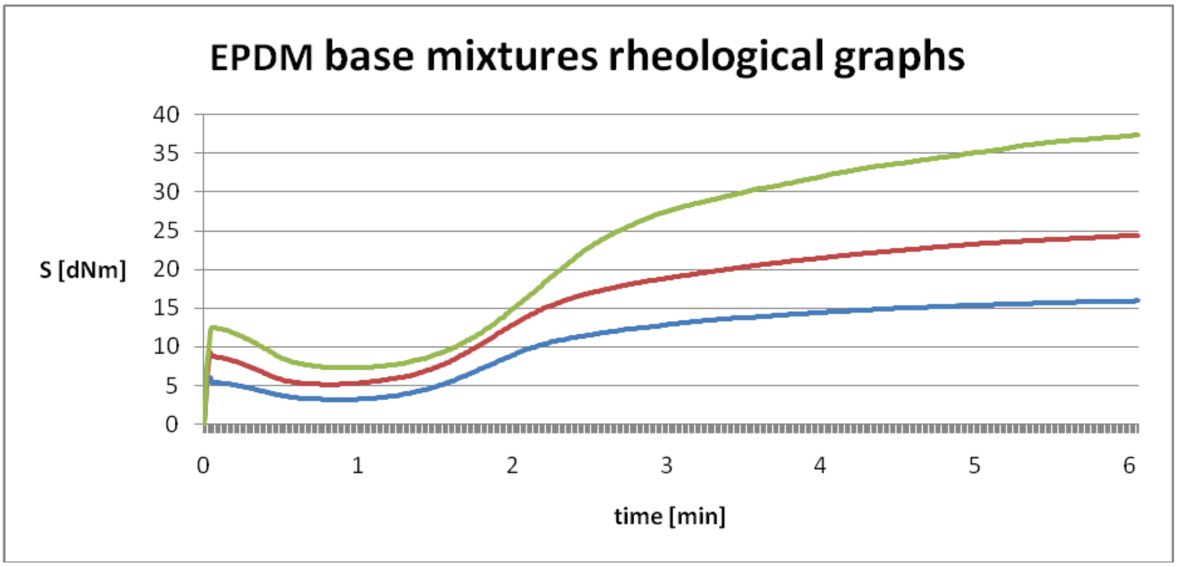
3
4
5
6
time [min]


EPDM base mixtures rheological graphs
S [dNm]
40
35
30
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20
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10
5
0
0
1
2
3
4
5
6
time [min]

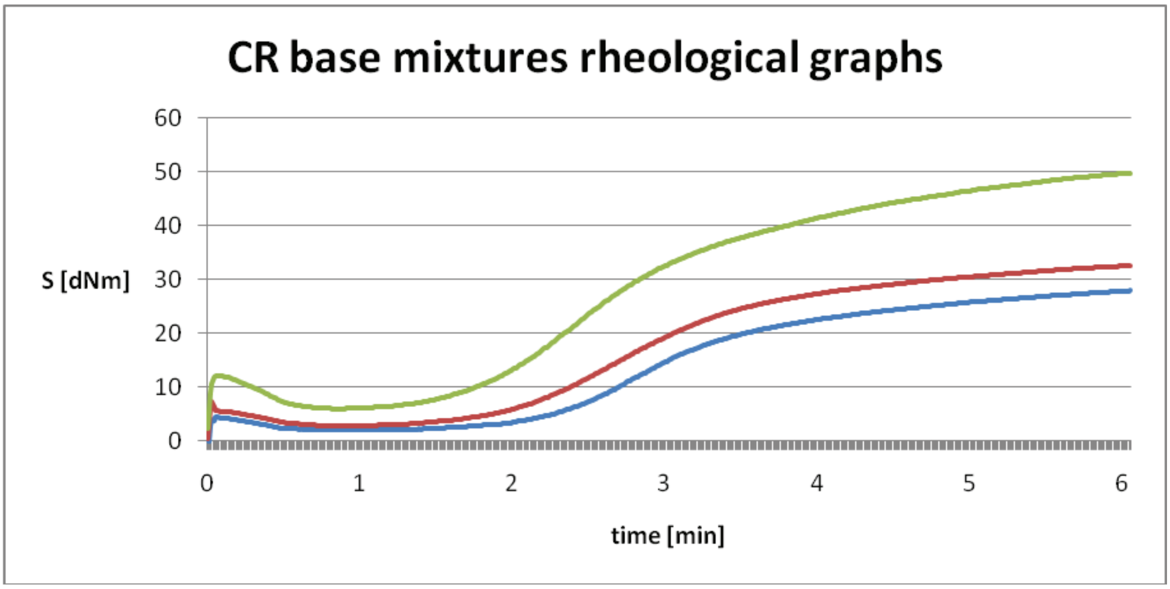


Figure 1. Rheological graphs

The O spatial-mesh point is ordered to moment curve minimum, the maximum to the moment curve maximum. As the maximum point can be defined with difficulty because of this according to the accepted practice the vulcanizing time of the material is considered that time (t_{90}) belonging to the 90% rising calculated from the moment curve minimum (according to measurings the tensile strength maximum is here, too). The time got t_{02} belonging to the 20% rising calculated from the minimum mark.
We summed up the corner – numbers in the No. 2 table from which the vulcanizing time can be determined to be read from the graphs.

Table 2

Mixture	S_{min}	S_{max}	t_{02}	t_{90}
NR 43 Sh	5,98	33,7	0,95	1,96
NR 57 Sh	7,41	37,14	0,9	1,77
NR 72 Sh	8,63	41,36	0,81	1,62
NBR 43 Sh	2,88	24,63	1,00	1,82
NBR 57 Sh	2,87	31,44	0,89	1,58
NBR 72 Sh	8,38	43,4	0,71	1,4
EPDM 43 Sh	3,15	16	1,12	4,17
EPDM 57 Sh	5,1	24,4	1,07	4,46
EPDM 72 Sh	7,26	37,36	1,27	4,67
CR 43 Sh	1,98	27,91	1,61	4,79
CR 57 Sh	2,78	32,52	1,4	4,59
CR 72 Sh	5,96	49,74	1,3	4,7

We have vulcanized specimens for hardness tests for various times from the materials made and we have carried out hardness tests (No.3 table). The table shows the Sh^0A hardnesses in the function of vulcanizing time.
It can be seen well from the results of No.3 table that the materials change their hardness differently in the function of vulcanizing time. The NBR mixtures vulcanize similarly as the NR mixtures, but the last two elastomer-groups are “slower” substantially. The specimen for tensile test had to be manufactured to longer time at latters.

We have vulcanized sheet-specimens before tensile test from all materials for the times marked in table No.3. After this we carried out the tensile test according to the DIN53504 standard, and we display the results in the Figure.2. and Figure 3. series [4].

The tensile test parameters:
Type of tensile test machine: LLOYD LR 300
Breaking rate [mm/min]: 500

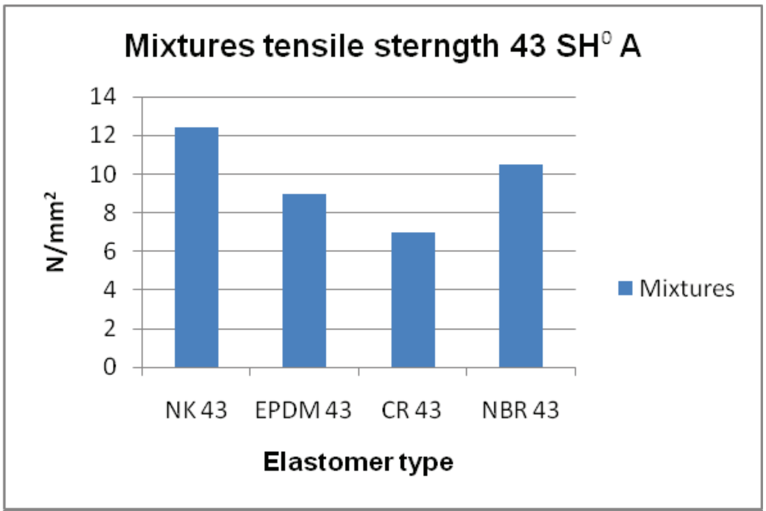
Cross section of sheet-specimen [mm^2]: 12 (2x6mm)
Ambient temperature [^0C]: 23
Relative humidity [%]: 40

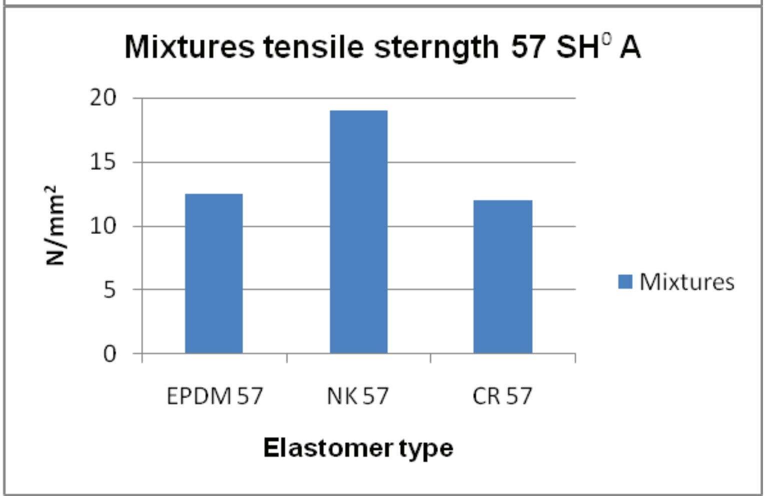
Table 3

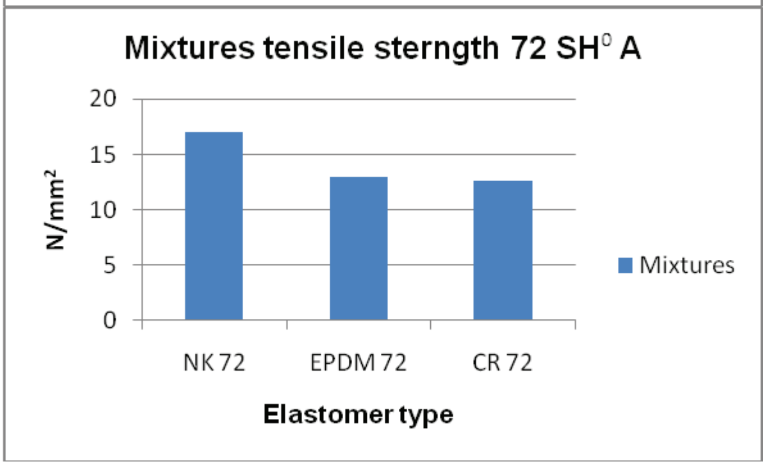
	6 min	8 min	10 min	12 min	14 min
NR 43	42	42	42	42	41
NR 57	56	56	56	55	55
NR 72	72	72	72	72	71
NBR 43	44	44	44	44	43
NBR 57	58	58	58	58	57
NBR 72	70	71	71	71	71
EPDM 43	40	42	44	45	45
EPDM 57	50	52	54	55	55
EPDM 72	70	72	72	72	72
CR 43	40	42	44	45	45
CR 57	50	53	54	57	57
CR 72	70	71	72	72	73

3 THE SURFACE ROUGHNESS EFFECT ONTO ULTIMATE TENSILE LOAD.

The forming of elastomer – metal bonding in industrial scale nowadays is realized by glue produced only in industrial circumstances. The general rules of bonding has to be kept at application of these materials that is after chemical cleaning mechanical metal preparation follows, then the glue spraying and finally the vulcanizing. As a continuation of our research work we have examined the effect of surface roughness onto the ultimate tensile load in the second phase. We carried out the measurings with metal plate fitted with 23 mm diameter M6x18 mm threaded shank, which we treated steel shot spraying material with different times. After this we carried out trial vulcanizing and we measured the ultimate tensile load. We show the results with the help of diagrams. The Figure 3 shows the formation the ultimate tensile load and the R_a average surface roughness in the function of spraying time in case of steel shot spraying material, while the No.4 diagram shows the same using corundum.


Mixtures tensile sterngth 43 SH° A
14
12
10
8
6
4
2
0
N/mm²
NK 43
EPDM 43
CR 43
NBR 43
Elastomer type
Mixtures


Mixtures tensile sterngth 57 SH° A
20
15
10
5
0
N/mm²
EPDM 57
NK 57
CR 57
Elastomer type
Mixtures


Mixtures tensile sterngth 72 SH° A
20
15
10
5
0
N/mm²
NK 72
EPDM 72
CR 72
Elastomer type
Mixtures

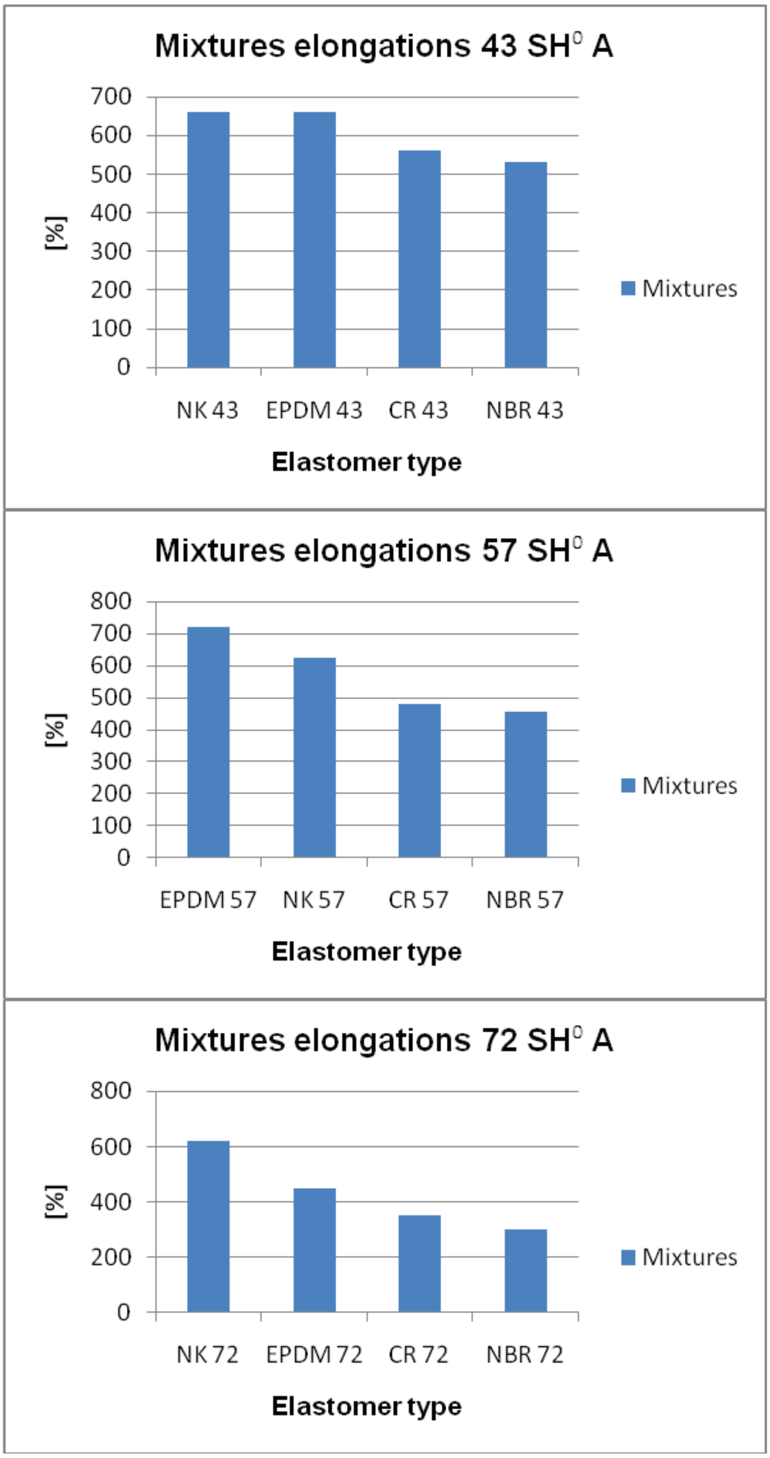


Figure. 2. Mechanical properties

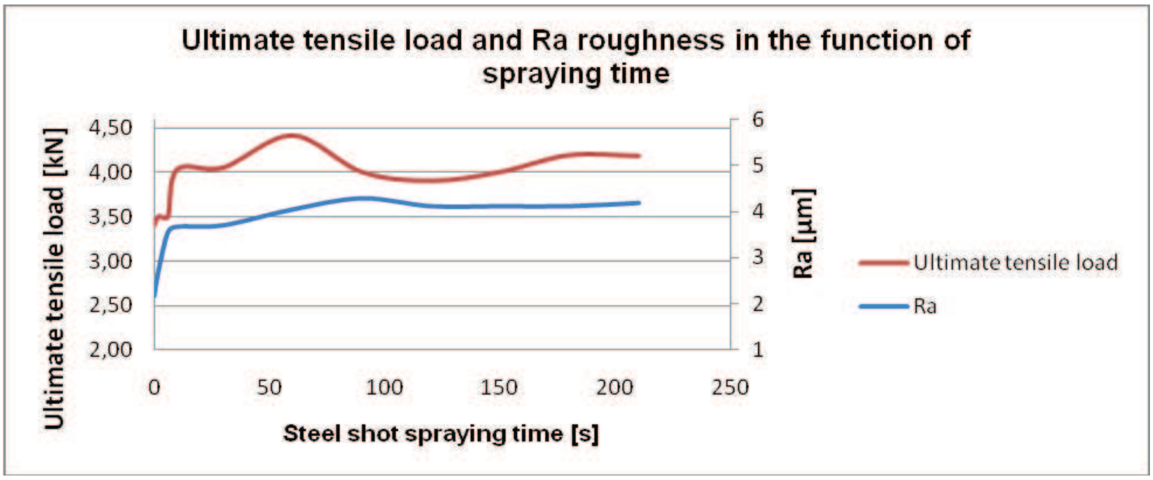


Figure 3. Effect of the steel shot spraying time

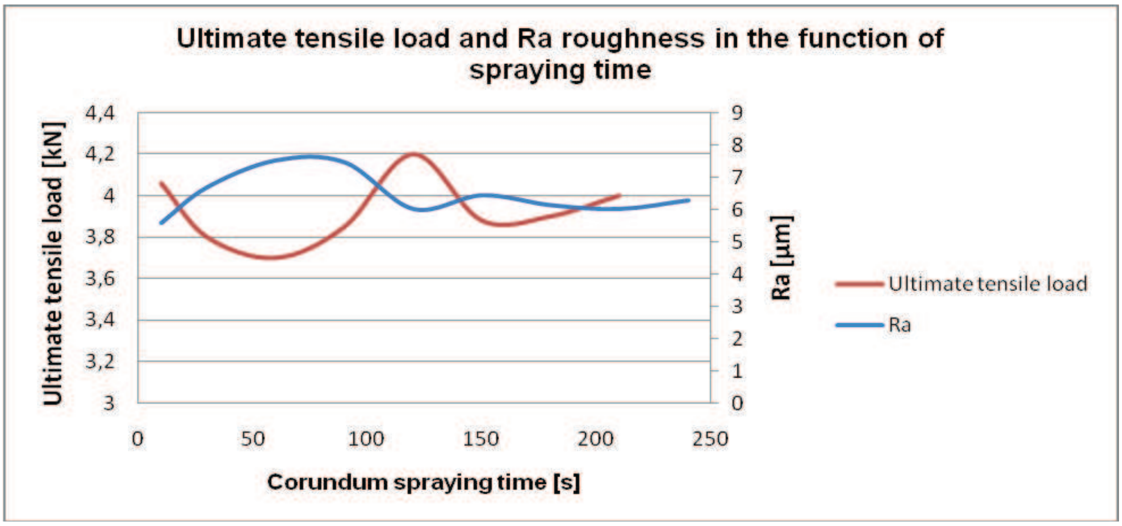


Figure 4. Effect of the corundum spraying time

4 CONCLUSIONS

- It can be seen at the representation in diagram form of the strength results that the strength values increase with the growth of hardness however the elongation decreases.
- It can be established characteristically that the up-to-date synthetic elastomers strength values are similar to the natural rubber mixtures, thus the most important deciding standpoint is the manufacturing capability, taking into account the resistance of products.
- The EPDM rubber mixtures have got visibly very high elongation, at softer mixtures surpass the natural mixture from time to time, too.
- It is evident from the results of surface roughness examinations that the R_a average surface roughness is not suitable to characterize unambiguously the preparation of metal plates because of this as a further development we are going to carry out 3D –al examinations on the metal surfaces prepared and chemical examinations on the specimens cut into half and on the bonding boundary surfaces respectively.

5 REFERENCES

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