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ASSESSMENT OF THE CONDITION OF THE COATINGS AFTER THE TESTS IN A SALT SPRAY CHAMBER

Summary

Adhesive coatings in the form of layers are widely used in the protection of machines and equipment against corrosion. The article presents the research of four prepared areas which were subject to the influence of brine in the salt spray chamber. Powder paint was applied to one of the areas, another was covered with alkyd paint, another- with paint from spray can, and one of the areas was not protected against corrosion. The samples were exposed in a salt spray chamber. Changes occurring in the layers of individual coatings were registered at predetermined time intervals which were set in accordance with the standard. In addition, coating thickness measurements were made before and after samples exposure to brine. Based on the research, it was found that the first defects of powder coated coatings appeared only after 25 hours of brine influence, in contrast to the other areas where it occurred definitely early because after only 2 hours after starting the experiment.
***Key words**: coatings, corrosion, salt spray chamber*

OCENA STANU POWŁOK LAKIERNICZYCH PO BADANIACH W KOMORZE MGŁY SOLNEJ

Streszczenie

Powłoki adhezyjne w postaci lakierów znajdują szerokie zastosowanie w ochronie maszyn i urządzeń przed korozją. W artykule przedstawiono badania czterech przygotowanych obszarów, które poddano oddziaływaniu solanki w komorze mgły solnej. Na jeden z obszarów nałożono farbę proszkową, inny został pokryty farbą alkidową, kolejny - farbą w aerozolu, a jeden z obszarów nie zabezpieczono powłoką przed korozją. Tak przygotowane próbki poddano ekspozycji w komorze mgły solnej. Zmiany pojawiające się w warstwach poszczególnych powłok rejestrowano w z góry założonych odstępach czasowych, które zostały ustalone zgodnie z normą. Dodatkowo, przed i po działaniu solanki na próbki wykonano pomiary grubości powłoki lakierniczej. Na podstawie badań stwierdzono, że pierwsze wady powłok lakierowanych proszkowo pojawiły się dopiero po 25 godzinach oddziaływania solanki, w przeciwieństwie do pozostałych obszarów, gdzie nastąpiło to zdecydowanie wcześniej, bo już po 2 godzinach.
***Słowa kluczowe**: powłoki, korozja, komora mgły solnej*

1. Introduction

The varnish coating, in addition to protecting the surface against various external factors which are connected with the operating conditions cause that the vehicles are diverse and also have a decorative effect on car body. Another property of coatings consists in the vibration damping function that occurs during the operation of machines and vehicles. The varnish coating also has the task of sealing the surface on which it was applied. The most economical way to fill the gaps is to fill them with lacquer coatings. So there is no impurities and water accumulation in the gaps [1, 2, 9]. Currently powder coatings are used in the protection of machines and devices. It is a mixture in which all the components are in a solid form milled to a powder with a grain diameter in the range of 10-150 μm. This mixture is capable for forming on the substrate polymer coatings with the desired properties. The basic components of powder coating systems are: crosslinking agents, resins and auxiliary agents [4].

During the production of varnish coatings non-observance of the technological regime causes defects. The most important of them, which are not always revealed immediately after production, include [9]: loss of adhesion and peeling of the coating, cracking of the coating, pollination of the varnish, blistering of the coating, dulling and corrosion.

The quality of coatings can be assessed through the use of developed standards [6-8]. Thanks to this it is possible to determine the adhesion of the coating to the substrate, its thickness as well as its hardness. Some of the defects found in paint coatings can be detected thanks to the visual method of the using eye as well as using a magnifying glass or microscope.

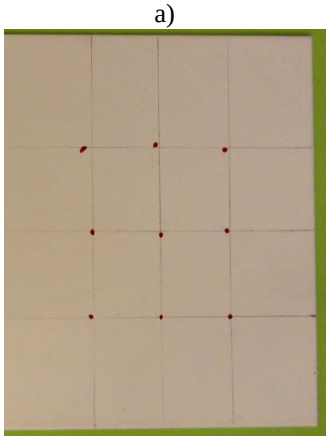
The purpose of the tests was to assess the quality of varnish coatings used in agricultural machines and devices made by various techniques which were subject to the influence of brine in the salt spray chamber. The aluminum samples were coated with a powder coating, an alkyd paint coating and the last coating was applied as aerosol paint. Information about the results of paint coating thickness measurements at selected points both before and after the salt spray chamber test was provided.

2. Experimental study

The tests were carried out on prepared aluminum samples degreased, dried and cleaned of impurities on which three different coatings were applied. One coat layer was applied to each sample surface. The powder coating, an al-

kyd coating and a spray coating were applied. In addition, one of the areas was only degreased for which no corrosion protection was applied. The view of prepared samples with a template of measuring points which were used in the measurement of coating thickness is shown in Fig. 1.

a)



b)

c)

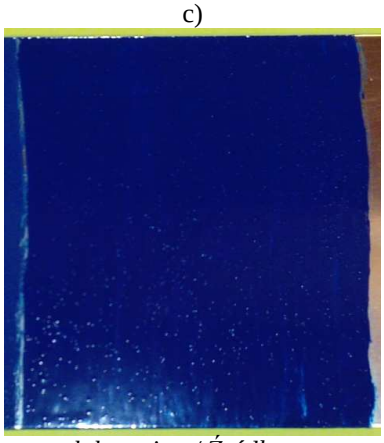


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Fig. 1. Aluminum samples used during the studies; a) spray coating, b) paint in spray can, c) alkyd paint
Rys. 1. Próbki aluminiowe wykorzystane podczas badań: a) powłoka proszkowa, b) powłoka nałożona z aerozolu, c) powłoka z farby alkidowej

The coating thickness was measured on aluminum samples painted with selected coatings protecting against corrosion. The measurement was made using the Karl-Deutsch PC-Leptoscope 2050, the STATWIN 2002 program of the measuring probe, allowing for measurements on a non-ferromagnetic substrate (NFe 2050.201 probe). In the further part of the tests the samples were exposed to the spray of brine. The test was carried out in accordance with PN-EN ISO 9227: 2006 [5]. A sodium chloride mixture was prepared. The pH indicator of the salt solution was set at 5-6. In addition the value of the spray overpressure was 70 kPa, and the temperature in the chamber was 45°C. The samples were placed in the Haida HD-E808-60 chamber (Fig. 2) and exposed to salt mist in subsequent time periods: 2 hours, 6 hours, 6 hours, 6 hours, 5 hours. The time segments were in line with the standard. After each period of time, samples were rinsed and dried and then they were observed whether changes occurred on their surface. The samples were exposed to the brine exposure for 25 hours. After this period the thickness of coatings was re-examined and compared with previous results.

a)

b)

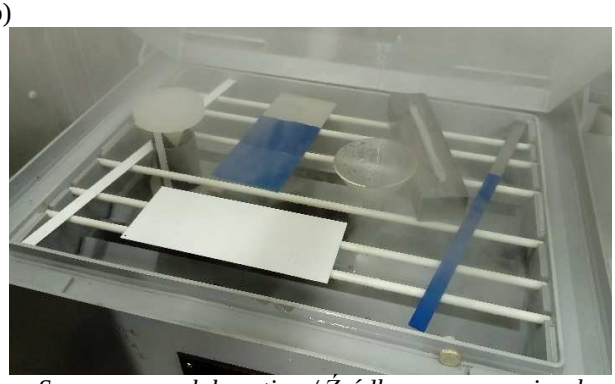

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Fig. 2. Salt spray chamber: a) view, b) samples in the chamber during test
Rys. 2. Komora mgły solnej: a) widok, b) próbki w komorze podczas badania

Based on preliminary measurements of the lacquer thickness a modified coefficient of variation was determined which allowed the number of 20 measurements to be taken at one measuring point.

3. Results of research

In the case of one layer of powder-coated coating at individual measuring points no significant differences were found in the measured thickness of the coating. The example of 10 results of thickness measurements for nine measuring points (7.1, 8.1 ... 9.3) are presented in Table 1.

Fig. 3 presents areas of the tested sample. Comparing the condition of the surface of the tested sample it can be seen that the first defect on the aluminum surface covered with one layer of powder varnish appeared after 25 hours of testing. Defects on the surface are tears caused by the reaction of the powder coating on the sodium chloride solution.

Table 1. Results of coating thickness measurements before and after testing in a salt spray chamber for a powder coating [3]
Tab. 1. Wyniki pomiarów grubości powłok przed i po badaniu w komorze mgły solnej dla powłoki lakierowanej proszkowo [3]

No.	Coating thickness before testing in salt spray chamber [µm]									Coating thickness after testing in salt spray chamber [µm]								
	7.1	8.1	9.1	7.2	8.2	9.2	7.3	8.3	9.3	7.1	8.1	9.1	7.2	8.2	9.2	7.3	8.3	9.3
1.	53.9	55.5	64.1	63.7	63.1	63.2	55.8	55.6	54.6	53.7	53.9	62.6	62.2	61.8	63.6	55.1	57.5	54.2
2.	53.9	55.5	64.1	63.7	63.1	63.3	55.8	55.6	54.6	53.7	53.9	62.6	62.2	62.0	63.5	55.1	57.4	54.1
3.	53.9	55.5	64.1	63.7	63.1	66.2	55.7	55.6	54.6	53.7	53.9	62.6	62.2	62.0	63.5	55.1	57.5	54.1
4.	53.9	55.5	64.1	63.9	63.1	66.1	55.7	55.7	54.6	53.6	54.0	62.6	62.2	62.0	63.5	55.1	57.5	54.1
5.	54.0	55.5	64.1	64.0	63.1	66.1	54.4	55.7	54.5	53.6	54.0	62.6	62.2	62.0	63.5	55.1	56.0	54.1
6.	54.1	55.5	64.1	63.7	62.7	66.1	54.5	55.7	54.4	53.6	53.9	62.6	62.2	62.0	63.6	55.0	56.0	54.1
7.	54.2	55.5	64.1	63.7	63.5	66.1	54.4	55.7	54.4	53.6	53.9	62.6	62.2	62.0	63.6	54.9	56.0	54.0
8.	54.1	55.5	64.1	63.8	63.5	66.1	54.2	55.7	54.5	53.6	53.9	62.6	62.2	62.0	63.6	54.9	56.1	54.0
9.	54.1	55.5	64.5	63.9	63.5	66.1	54.2	55.7	54.5	53.6	54.0	62.6	62.2	62.0	63.6	54.8	56.2	54.1
10.	54.2	55.5	64.5	63.9	63.5	66.1	54.3	55.9	54.4	53.6	54.0	62.6	62.2	62.0	63.5	54.8	56.2	54.1

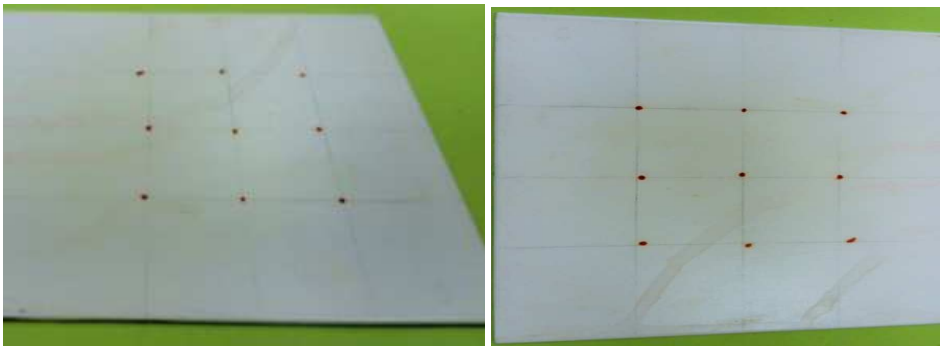

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Fig. 3. Sample with powder coating after 25 hours in a salt spray chamber
Rys. 3. Próbka lakierowana proszkowo po 25 godzinach w komorze mgły solnej

Fig. 4 and 5 present the results of measurements of the thickness of the varnish applied by means of a spray before and after the examination in the salt spray chamber. The thickness distribution of the coating on the test sample was irregular. However there were no significant differences in coating thickness before and after chamber testing. The measurement results differed by a maximum of about 1 µm.

The analysis of the sample surface has shown that after 2 hours of testing in the salt spray chamber visible defects appeared on the sample. On the back side of the sample loss of gloss of the lacquer was observed and the coating cracked which also occurred on the front side after 25 hours of testing in the salt spray chamber (Fig. 6).

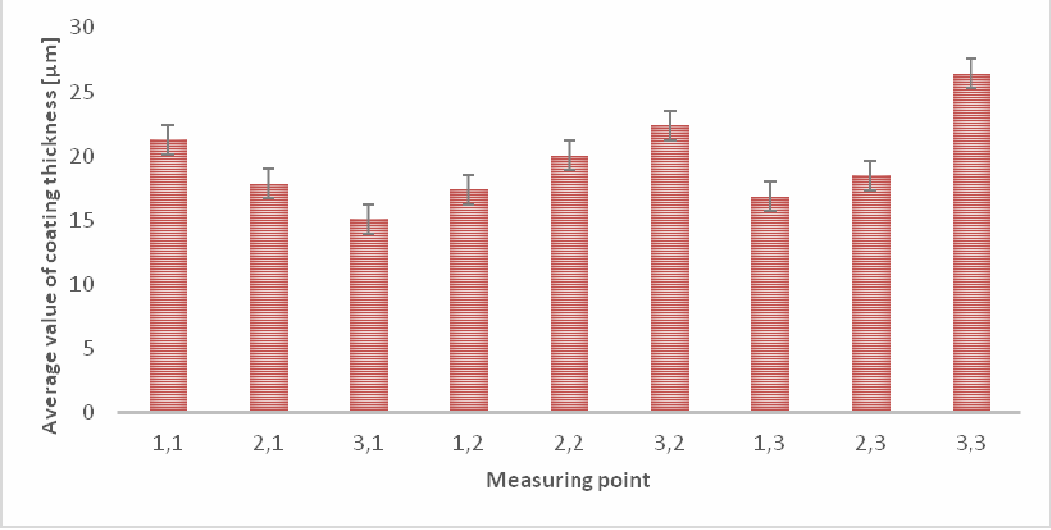

Fig. 4. Distribution of the average thickness of the coating applied by a spray before testing in a salt spray chamber [3]
Rys. 4. Rozkład średniej grubości powłoki nałożonej za pomocą aerozolu przed badaniami w komorze mgły solnej [3]

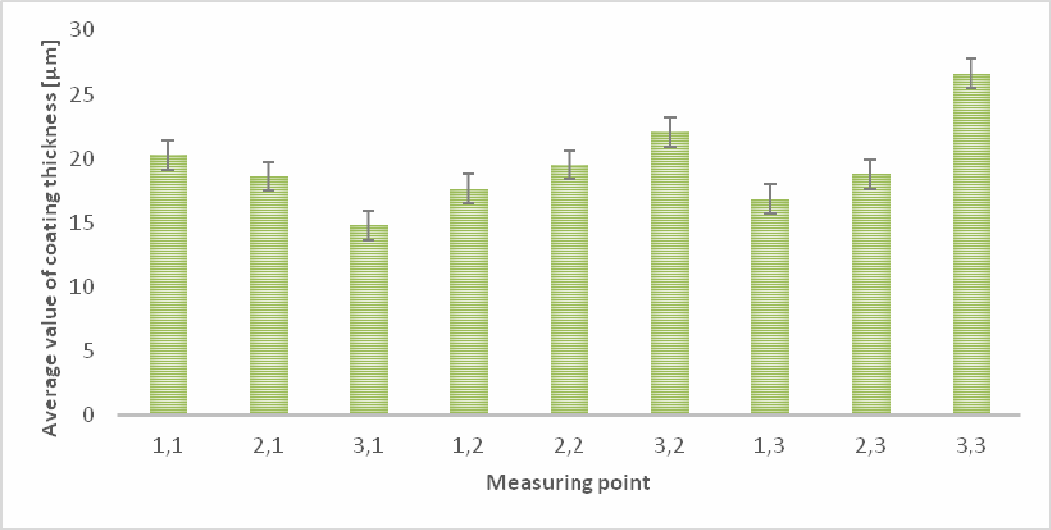

Fig. 5. Distribution of the average thickness of the coating applied by a spray after testing in a salt spray chamber [3]
Rys. 5. Rozkład średniej grubości powłoki nałożonej za pomocą aerozolu po badaniach w komorze mgły solnej [3]

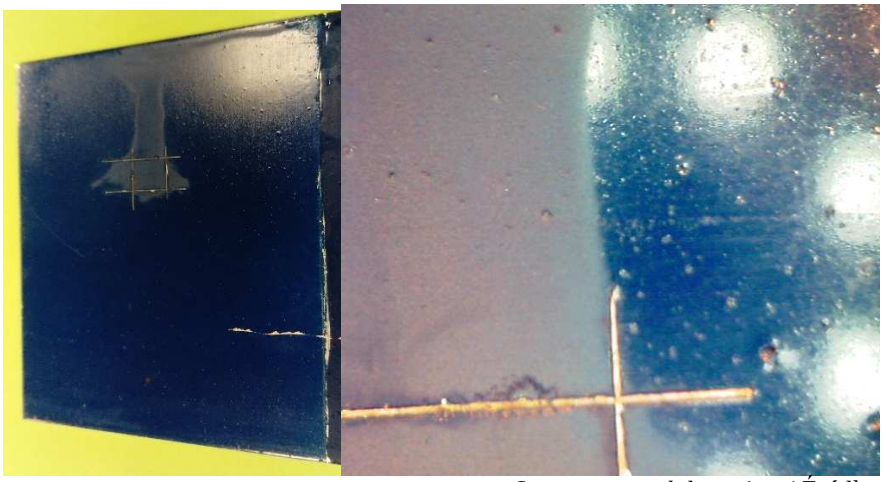

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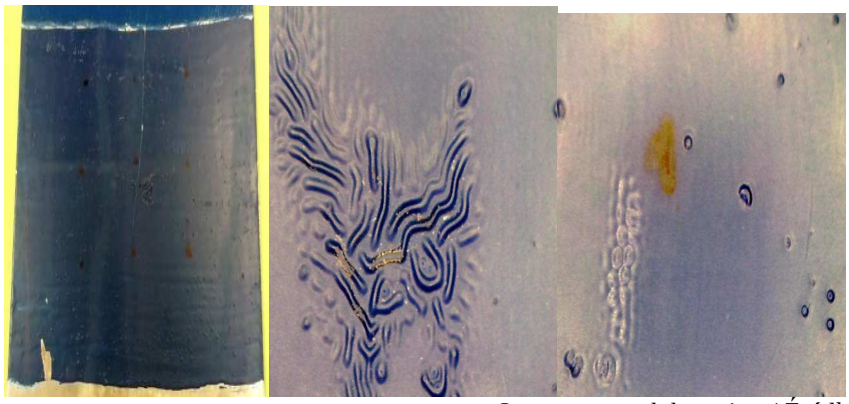
Fig. 6. Loss of gloss of the coating after 25 hours in a salt spray chamber
Rys. 6. Utrata połysku powłoki po 25 godzinach w komorze mgły solnej

Analysis of the thickness of the sample painted with alkyd paint has shown that the coating was applied evenly. The minimum coating thickness is 29.4 um while the maximum 31.2 um. The tests in the salt spray chamber caused defects on the surface of the sample. The coating has been wrinkled under the influence of sodium chloride mixture. This was evident already after the first test period in the salt spray chamber (Fig. 7) and deepened with the effect of sodium chloride (Fig. 8).

Source: own elaboration / Źródło: opracowanie własne

Fig. 7. Alkyd coating after 2 hours of exposure to sodium chloride
Rys. 7. Powłoka alkidowa po 2 godzinach oddziaływania chlorku sodu



Source: own elaboration / Źródło: opracowanie własne

Fig. 8. Alkyd coating after 25 hours of exposure to sodium chloride
Rys. 8. Powłoka alkidowa po 25 godzinach oddziaływania chlorku sodu

In order to observe the reaction of aluminum to the sodium chloride mixture in the sample painted with aerosol paint and alkyd paint the zone was left without coating with varnish. Surface corrosion occurred on the surface of the sample. The view of the area without corrosion protection after 25 hours in the salt mist chamber is shown in Fig. 9.

Source: own elaboration / Źródło: opracowanie własne

Fig. 9. The area without coating after 25 hours of exposure to sodium chloride
Rys. 9. Obszar bez nałożonej powłoki po 25 godzinach oddziaływania chlorku sodu

The study has shown that the salt spray affected negatively each coating applied on aluminum samples. The unfavorable effect was manifested first of all by the appearance of defects on the surface of the tested coating. In Table 2 there is listed the time when any defects have been observed on the surface.

Table 2. Time of defects occurrence for prepared areas
Tab. 2. Czas występowania wad dla przygotowanych obszarów

	2 hours	8 hours	14 hours	20 hours	25 hours
Sample with powder coating					X
Sample with coating made by paint in spray	X				
Sample with coating made by alkyd paint	X				
Sample without coating	X				

Source: own elaboration / Źródło: opracowanie własne

The purpose of this action was to check the effect of sodium chloride mixture on individual coatings and unprotected aluminum surfaces. Analysis of the obtained results indicates that samples coated with powder varnish have remained intact for the longest time. This may indicate that this varnishing technology will prolong the life of machines and equipment operating in difficult conditions.

4. Conclusions

The following statements can be made on the basis of the conducted research:

- The best corrosion protection of machine components and devices from tested adhesive coatings is ensured by a powder coating which was characterized by the occurrence of the first defects after 25 hours of exposure to salt spray chamber.
- For the alkyd coating and applied by aerosol paint the first defects were observed after only two hours of testing, and the most important of them are blisters and wrinkling of the coating.
- The effect of salt spray had no significant effect on the thickness of individual coatings which were measured before and after being in the salt spray chamber.

5. References

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