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An examination and comparison the zinc phosphate coatings microstructure on the shot blasted, sandblasted and raw steel surfaces

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OVERWIEW

In vehicle manufacturing, mechanical surface cleaning is often used as a surface preparation before painting. The blasting is used for cleaning and the blasted surface is a very clean surface and providing excellent mechanical adhesion for the paint layers. Media selection plays an important role in effective blasting. Shot (grit) or sand-blasting can be widely used to remove rust, oxides, scales. Its main scope is to provide surfaces free of adhesion preventing materials. The increased surface roughness provides good adhesion for the first layer of the coating. However, the clean raw surface which was created by the two media (shot and sand) does not behave equally during chemical pretreatments.

Research Goal

In this studies were compared the difference between the surface structure of the sample plates after shot blasting and sandblasting as mechanical surface pretreatment with the structure of a raw sample plate without mechanical surface pretreatment and with a Q-Panel sample plate, witch representing the ideal surface, based on digital light microscope images.

Materials and Methods

The surface roughness R_z (mean roughness depth) was measured by surface profile measurement is made with a MAHR profilometer according to DIN EN ISO 4287. The chemical composition of the surfaces was determined by energy dispersive X-ray spectroscopy (EDX) and spark excitation optical emission spectroscopy (OES) measurements.

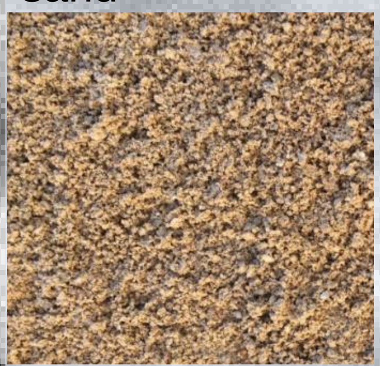
Metal substrates preparation

S420MC steel: High-strength normalized, low alloy steel for cold forming, thermomechanically-rolled.
Tensile strength: 480-620 MPa

Q-Panel: the world standard for a consistent and uniform test surface for paints, plating, adhesives, sealants, rust inhibitors and other coatings. Made from standard low-carbon, cold-rolled steel, they are clean, consistent.They are a dull matte mill finish produced by roughened rolls.
Tensile strength: 310-448 MPa

Surface mechanically pre-treatment

Sandblasting with 0,1-1,0 mm scattering sand



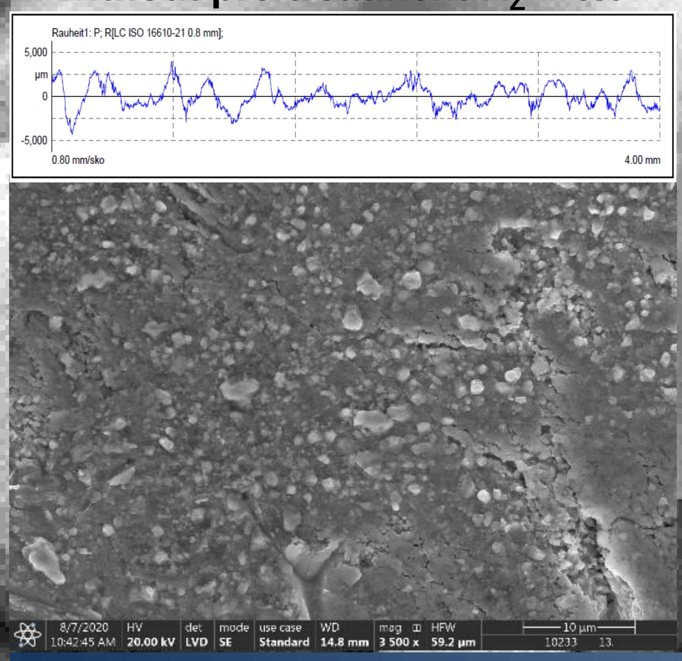
Shot blasting with S390 (44HRC) shot&grit

Surface treatment

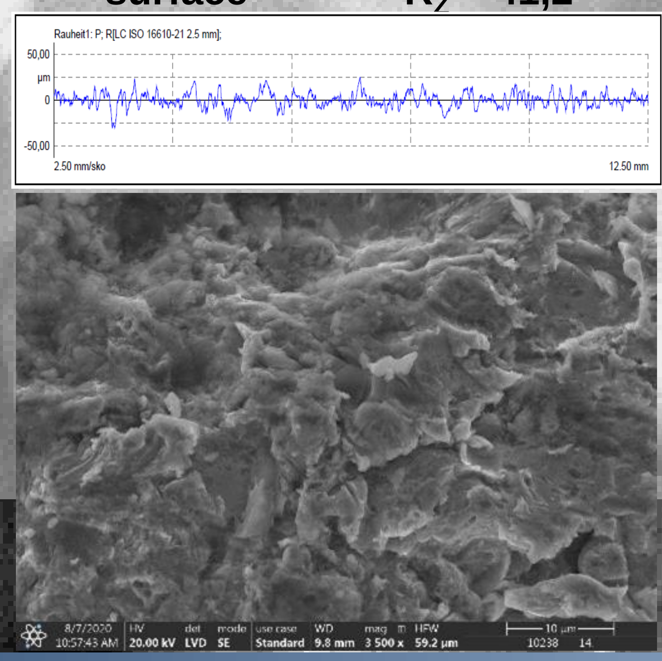
The sample plates were treated by zinc phosphating process with a dipping and spraying system, and microstructural characterization and surface properties of zinc phosphated steel were examined by scanning electron microscopy (SEM) and energy dispersive X-ray spectroscopy (EDX).

Optical light microscope images and surface roughness of the sample plate's surfaces

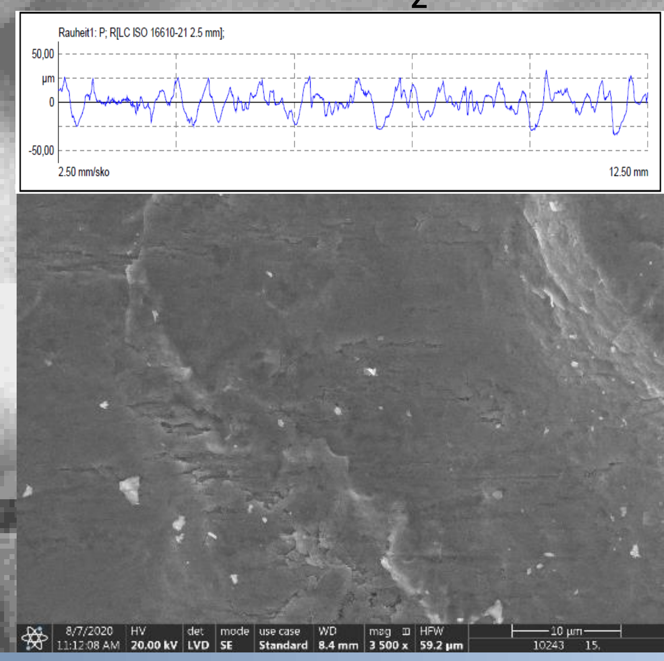
S420MC steel raw surface without pre-treatment R_z = 6.0



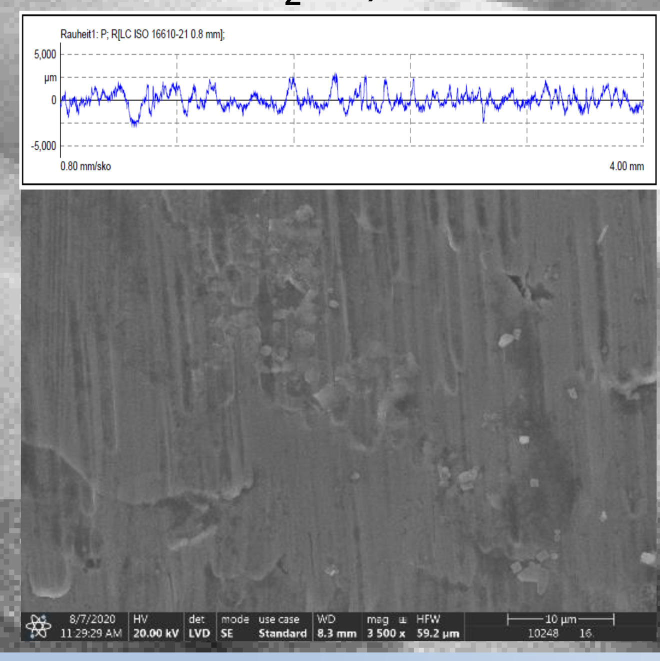
S420MC steel sandblasted surface R_z = 41,2



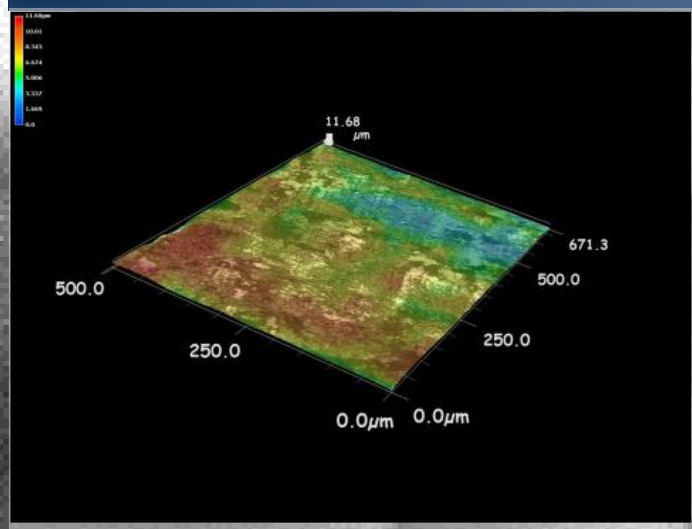
S420MC steel shot blasted surface R_z = 53.6

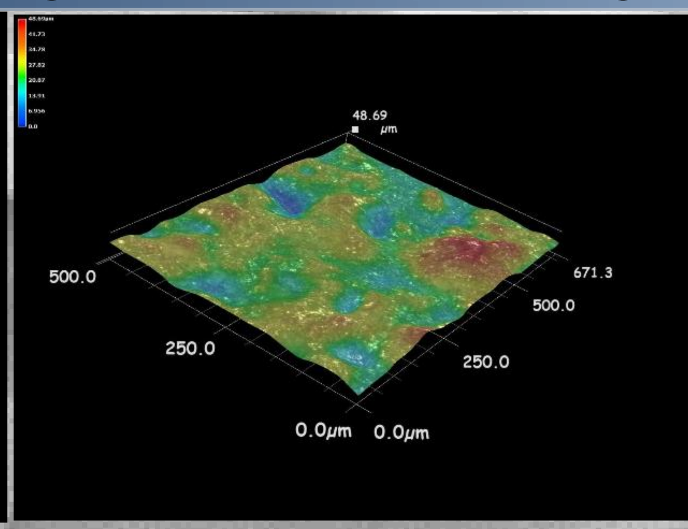


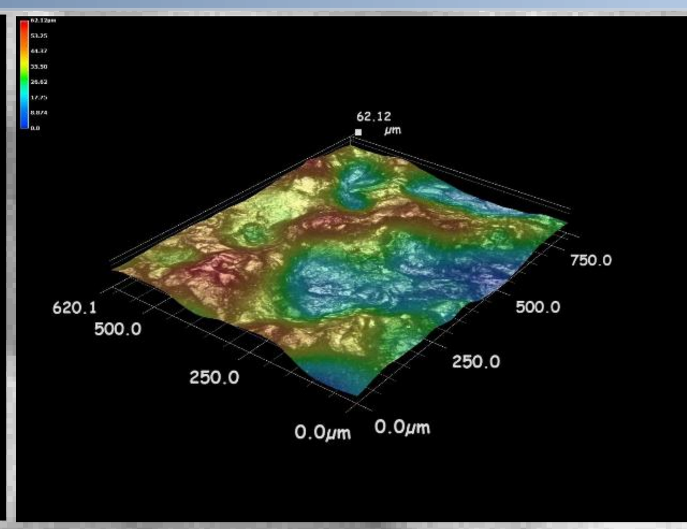
Q-panel surface R_z = 4,5

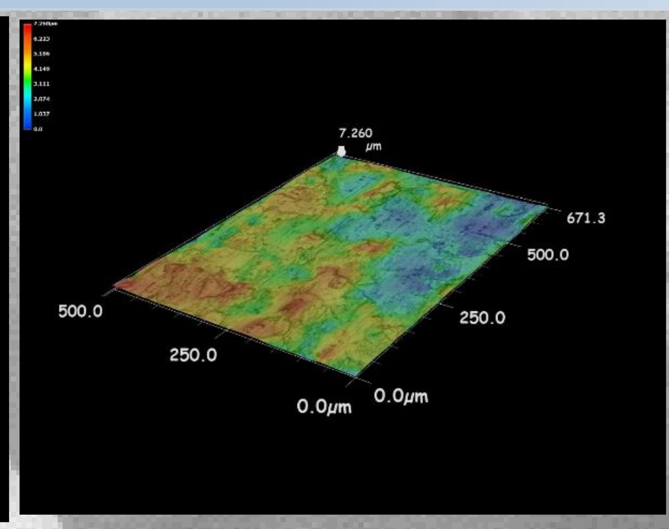


3D optical light microscope images of the surfaces of sample plates

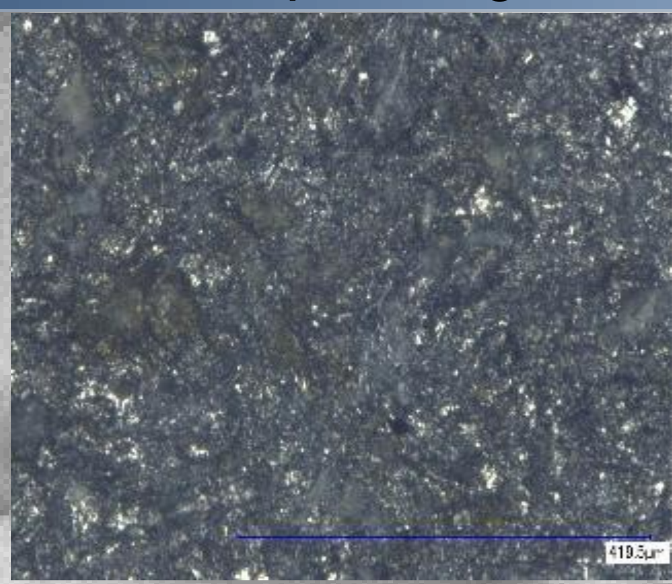


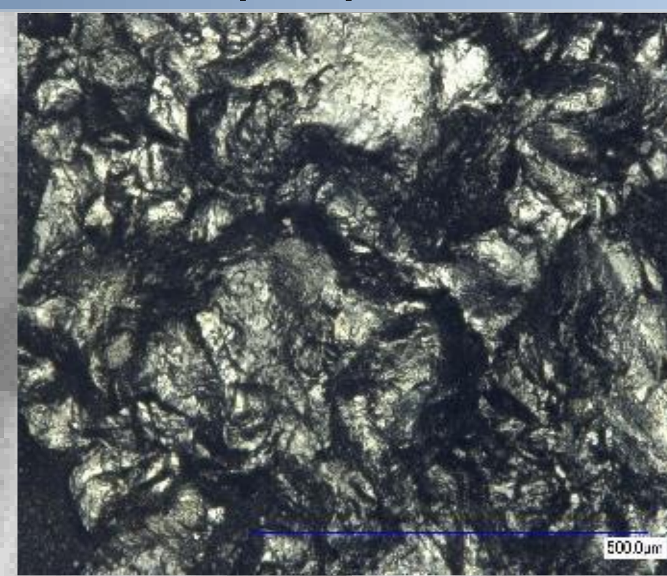


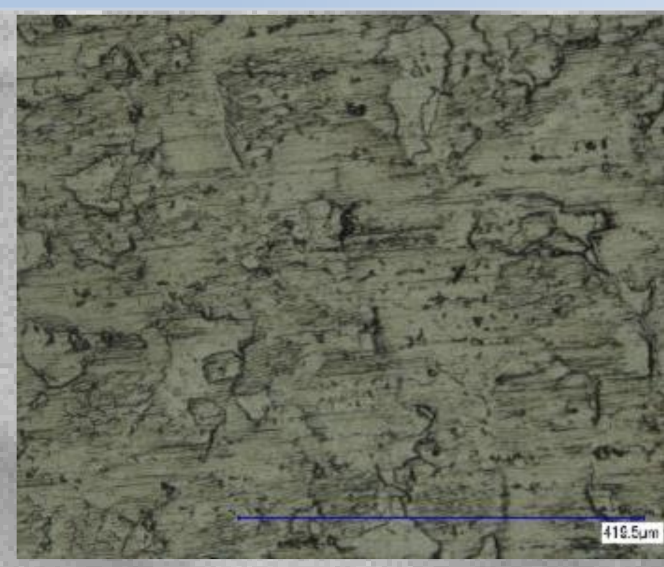




SEM microscope images of the sample plates surfaces







Chemical composition of the sample plates surfaces (EDS)

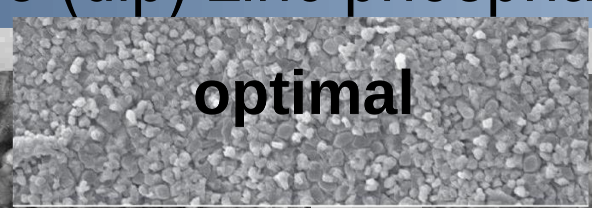
Element	Weight %	Atomic %	Error %
C K	4,27	10,78	12,8
O K	27,47	52,09	6,59
Si K	0,05	0,05	73,83
Mn K	0,41	0,22	29,8
Fe K	67,81	36,85	1,91

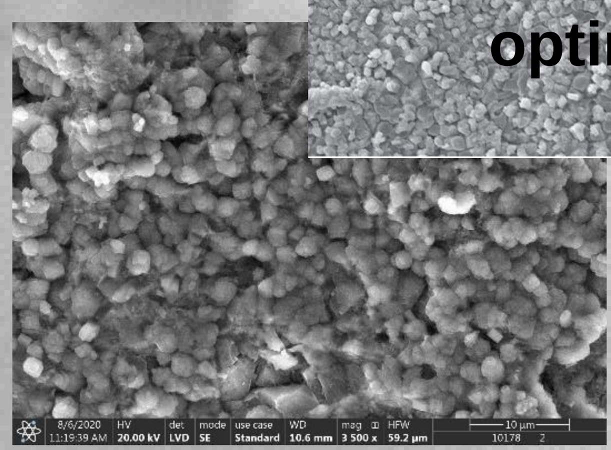
Element	Weight %	Atomic %	Error %
C K	3,02	8,68	18,17
O K	16,15	34,8	7,68
Mg K	0,36	0,51	33,43
Al K	1,46	1,86	11,83
Si K	**8,49**	**10,42**	**7,02**
Mn K	0,89	0,56	16,29
Fe K	68,94	42,57	1,83

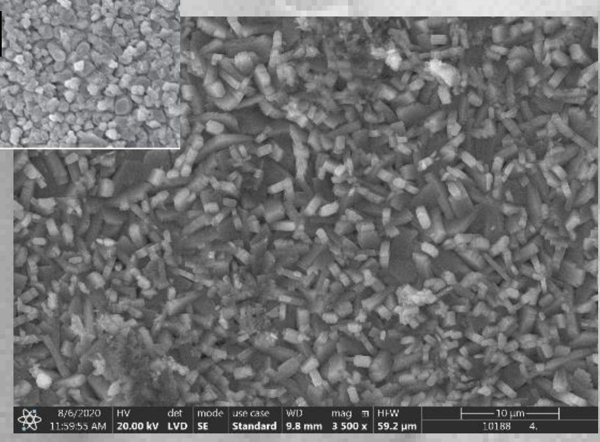
Element	Weight %	Atomic %	Error %
C K	2,21	8,39	18,34
O K	5,69	16,23	8,17
Al K	0,08	0,13	79,32
Si K	0,12	0,2	65,28
Cr K	0,49	0,43	23,2
Mn K	0,91	0,75	18,4
Fe K	90,5	73,87	1,75

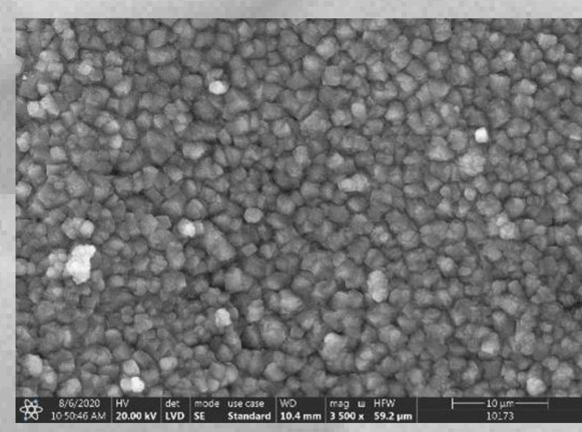
Element	Weight %	Atomic %	Error %
C K	3,72	14,28	15
O K	3,04	8,75	9,31
Mn K	0,51	0,43	25,18
Fe K	92,73	76,54	1,76

SEM micrographs of the (dip) zinc phosphated sample plates surfaces

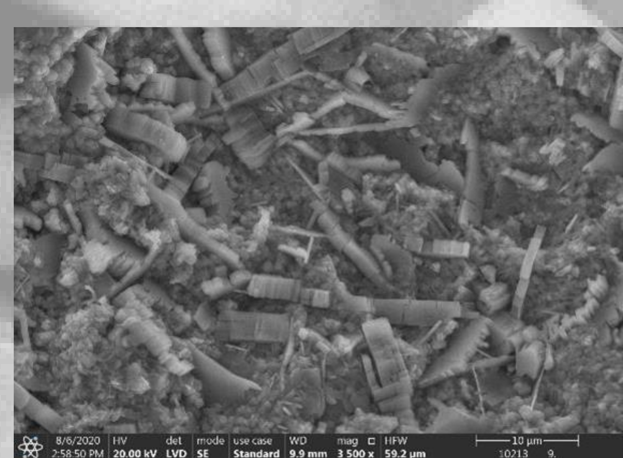


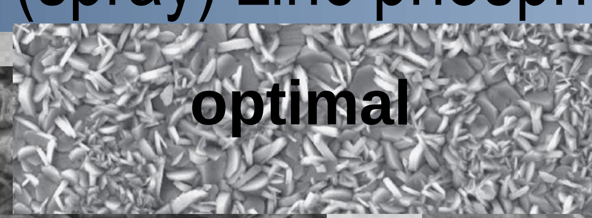


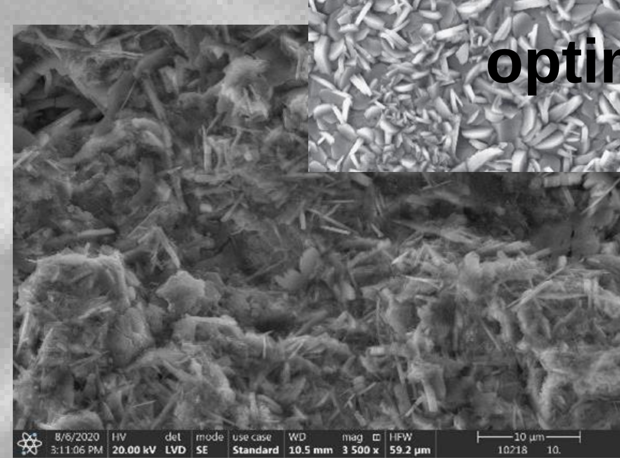


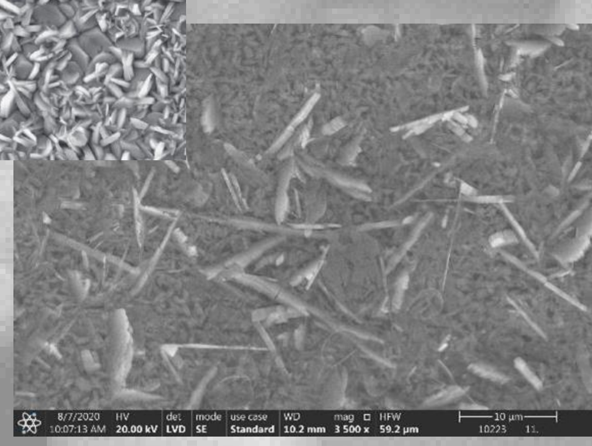


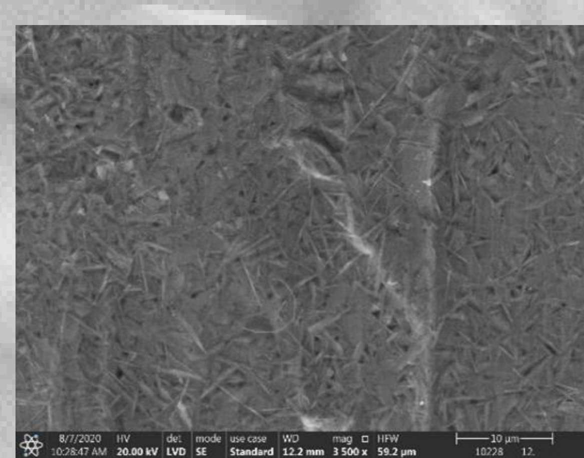
SEM micrographs of the (spray) zinc phosphated sample plates surfaces











Conclusions

Based on SEM images, it was found that the crystal structure of the zinc phosphate layer formed on the raw, untreated surface plates (roughness R_Z = 6.0) is irregular, from which it can be concluded that smooth surfaces react worse to phosphating. Images taken with a digital light microscope have revealed, that sandblasted (R_Z = 41,2) plates have zinc phosphate crystal structure similar to the one seen on sandblasted, untreated plates. Plates with surfaces properly roughened by shotblasting (R_Z = 53.6) have uniform crystal structure. Increasing the surface roughness is related to increasing the fineness of the coating structure. Increased surface roughness is related to improved fineness of the coating structure. Greater surface roughness means greater coating weight to surface ratio, and due to reactions in the boundary the acid pickling effect is stronger. However, the regular crystal structure shown in the literature has developed only on the surface of Q-Panels simulating an ideal surface. On these plates, changes in technological parameters did not affect the crystal structure in the conversion layer to the same extent as in the case of S420MC steel sample plates.