IMPROVEMENT OF THE DIE CASTING MOLDS CAVITIES BY CERAMIC SURFACE TREATMENT

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ABSTRACT: The main components of the molds the cavities and inserts, which gave the final shape of the part, have a life time limited to a number of shots due to the wear caused by the temperature of the injected aluminium in the mould, due to the termal fatigue, due to the cracks which appears mainly in the ingate area and due to the undercuts or under washes caused by the aluminium injected with high pressure in the cavities.
KEY WORDS: Mold, Aluminium, High Pressure Die Casting, Surface Treatment, Hard Surface.

1. INTRODUCTION

In order to increase the lifetime of the molds and in order to increase the resistance of the ingate areas with the aim to diminuate the under washes caused by the flux of the aluminium a thin ceramic material can be applied on the surface of the active elements of the moulds usually TUNGSTEN CARBIDE or TITANIUM CARBIDE with the method named rocklinizer.

2. MATERIALS USED FOR HARD SURFACE TREATMENT IN CASE OF MOULDS

Tungsten carbide or wolfram carbide, WC, or Tungsten semicarbide, W2C, are chemical compositions which contains tungsten and carbide, similar to titan carbide.

Figure 1 shows the structure of the tungsten carbide. The carbon atoms are in gray and the blue atoms are the wolfram atoms.

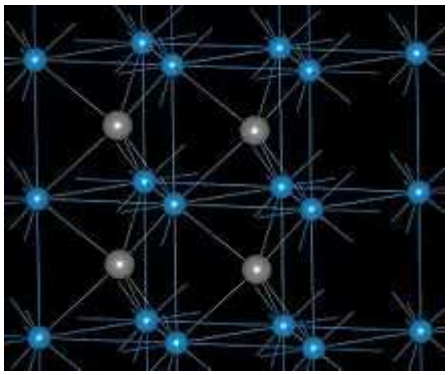


Figure 1 - Tungsten carbide structure

Tungsten carbide (WC) is an inorganic chemical compound containing equal parts of tungsten and carbon atoms. Colloquially, tungsten carbide is often simply called carbide. In its most basic form, it is a fine gray powder, but it can be pressed and formed into shapes for use in industrial machinery, tools, abrasives, as well as jewelery.

Table 1. Physical properties of the tungsten carbide

Molecular formula:	WC
Molar mass	195.86 g·mol^{-1}
Appearence	grey-black lustrous solid
Density	15.8 g·cm^{-3} in solid condition
Melting point	2870 °C, 5198 °F (3143K)
Boiling point	6000°C, 10832 °F (6273K)
Solubility in water	insoluble
Cristal structure	hexagonal
Hardness	8.5–9.0 Mohs scale 22 GPa Vickers hardness
Electrical resistivity	(1.7–2.2x10^{-7} ohm-m) comparable with metals like vanadium 1.99×10^{-7} Ohm·m

Tungsten carbide is approximately three times stiffer than steel, with a Young's modulus of approximately 550 GPa, and is much denser than steel or titanium. It is comparable with corundum (α-Al2O3 or sapphire) in hardness and can only be polished and finished with abrasives of superior hardness such as silicon carbide, cubic boron nitride and diamond amongst others , in the form of powder, wheels and compounds.

In the table 1 are presented the physical properties of the tungsten carbide.

The chemical properties of the tungsten carbide are described bellow. There are two well characterized compounds of tungsten and carbon, WC and tungsten semicarbide, W2C. Both compounds may be present in coatings and the proportions can depend on the coating method.

WC can be prepared by reaction of tungsten metal and carbon at 1400–2000 °C. Other methods include a patented fluid bed process that reacts either tungsten metal or blue WO3 with CO/CO2 mixture and H2 between 900 and 1200 °C. Chemical vapor deposition methods that have been investigated include:

- tungsten hexachloride with hydrogen, as reducing agent and methane as the source of carbon at 670 °C (1,238 °F)

$$WCl6 + H2 + CH4 \rightarrow WC + 6\ HCl$$

- reacting tungsten hexafluoride with hydrogen as reducing agent and methanol as source of carbon at 350 °C (662 °F)

$$WF6 + H2 + CH3OH \rightarrow WC + 6\ HF + H2O$$

At high temperatures WC decomposes to tungsten and carbon and this can occur during high temperature thermal spray, e.g. high velocity oxygen fuel (HVOF) and high energy plasma (HEP) methods.

Oxidation of WC starts at 500–600 °C. It is resistant to acids and is only attacked by hydrofluoric acid/nitric acid (HF/HNO3) mixtures above room temperature. It reacts with fluorine gas at room temperature and chlorine above 400 °C (752 °F) and is unreactive to dry H2 up to its melting point.

WC has been investigated for its potential use as a catalyst and it has been found to resemble platinum in its catalysis of the production of water from hydrogen and oxygen at room temperature, the reduction of tungsten trioxide by hydrogen in the presence of water, and the isomerisation of 2,2-dimethylpropane to 2-methylbutane. It has been proposed as a replacement for the iridium catalyst in hydrazine powered satellite thrusters.

Carbide cutting surfaces are often used for machining through materials such as carbon or stainless steel, as well as in situations where other tools would wear away, such as high-quantity production runs. Carbide generally produces a better finish on the part, and allows faster machining. Carbide tools can also withstand higher temperatures than standard high speed steel tools. The material is usually called cemented carbide, hard metal or tungsten-carbide cobalt: it is a metal matrix composite where tungsten carbide particles are the aggregate and metallic cobalt serves as the matrix. Titanium carbide, TiC, is an extremely hard (Mohs 9-9.5) refractory metallic material, similar to tungsten carbide.

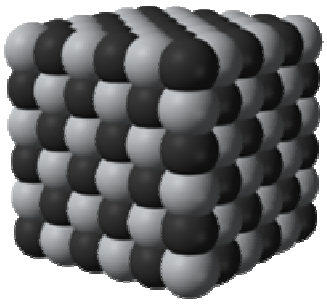


Figure 2 – The molecular structure of the titan carbide TiC

It is commercially used in tool bits. It has the appearance of black powder with NaCl-type face centered cubic crystal structure. It is mainly used in preparation of cermets, which are frequently used to machine steel materials at high cutting speed.

The resistance to wear, corrosion, and oxidation of a tungsten carbide-cobalt material can be increased by adding 6-30% of titanium carbide to tungsten carbide. This forms a solid solution that is more brittle and susceptible to breakage than the original material.

Tool bits without tungsten content can be made of titanium carbide in nickel-cobalt matrix cermets, enhancing the cutting speed, precision, and smoothness of the work piece.

Table 2 - Physical properties of the titan carbide

Molecular formula	TiC
Molar mass	59.89 g/mol
Appearance	black powder
Density	4.93 g/cm^3
Melting point	3160 °C
Boiling point	4820 °C, 5093 K, 8708 °F
Crystal structure	cubic
Hardness	Mohs 9-9.5

This material is sometimes called high-tech ceramics and is used as a heat shield for atmospheric reentry of spacecraft. The substance may be also polished and used in scratch-proof watches.

It can be etched with reactive-ion etching.

The mineralogical form is very rare and called khamrabaevite - (Ti,V,Fe)C.

In the table 2 are presented the physical properties of the titan carbide.

3. THE ROCKLINIZER COATING METHOD

The method consists in applying of a hard and wear resistant surface of tungsten carbide, titanium carbide and rockhard electrode material on the active surface of the tools and dies with the aim to prevent wear or to repair. The method is possible to be realized by using of the rocklinizer equipment, according the rocklinizing process.

The rocklinizer electronically impregnates and deposits wear-resistant material both underneath and on top of metal surfaces. Unlike welding or metal spraying, no appreciable heat is generated, and the electrode material will not separate or flake off the work piece. After rocklinizing, no heat treatment, grinding or other surface treatment is necessary.

The end result of this surface treatment is to increase productivity and reduce costs. When the tools and dies remain in operation without replacement due to wear, there will be less machine downtime, operator idle time, and expense of new or resharpened tools and dies. These savings justify the efficiency of the rocklinizer method.

The portable rocklinizer allows wear prevention and maintenance to be easily performed.

The rocklinizer Beamed Thunderbolt Gun is automatically triggered when the electrode is placed in contact with the workpiece, or manually triggered by the operator. Deposits are available from .0001" to .004" in a single application, controllable within .0001" by machine dial setting. Typical deposits are obtained from rocklinizing hardened tool steel.

Rocklinizing is applied to new or reground and resharpened surfaces.

The Rocklinizer device applies electronically the material of the electrode into the work piece with a spark deposition method, where the work piece represents the anode and the ceramic electrode is the anode.

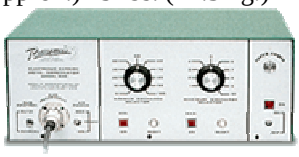
4. EQUIPMENTS FOR COATING

There are four different models of Rocklinizer equipment which can be chosen in function of specific needs. Each model is equiped with: power supply, applicator, electrode package and operating instructions.

In the table 3 are presented the equipments for coating.

Table 3 – Rocklinizer equipment models

MODEL / WEIGHT	DESCRIPTION
800/800E - Deposits up to .007" (approx.) 29 lbs. (13.2 kg.)	Faster Application Rotary Applicator Digital Readout Touch Panel Controls Portable Model 800 Rotary Applicator is automatically triggered when electrode is placed in contact with work piece, or

	manually triggered by the operator.
600/600E - Deposits up to .004" (approx.) 49 lbs. (22.3 kg.) 	Model 600 Applicator Gun is automatically triggered when electrode is placed in contact with work piece, or manually triggered by the operator.
500/500E - Deposits up to .002" (approx.) 33 lbs. (14.5 kg.) 	Model 500 Applicator Gun is automatically triggered when electrode is placed in contact with work piece, or manually triggered by the operator.
380/380E - Deposits up to .001" (approx.) 26 lbs. (11.8 kg.) 	Model 380 has variable discharge positions.

The Rocklinizer uses three types of electrodes to apply a hard and wear resistant surface:

- Tungsten carbide is applied to high speed steel and other metal surfaces to prolong useful life and reduce wear.
- Titanium carbide alleviates structural drawbacks of carbide tools and inserts. This seals the compressed carbide and binder particles for a homogeneous and longer lasting surface.
- Rockhard electrodes build up materials, reclaim undersized tools by restoring tolerances, provide gripping on collets and clamping blocks, and maintain dimensions on bearings, shafts, and other metal surfaces.

In the tables 4, 5 and 6 are presented the electrode and mini electrode models used for coating and the main accessories of the equipment.

Table 4 – Rocklinizer electrode models

ROCKLINIZER ELECTRODES	DIAMETER
8210 Tungsten Carbide	3/16" dia. x 2"
8211 Tungsten Carbide	1/8 " dia. x 2"
8212 Tungsten Carbide	3/32" dia. x 2"
8213 Tungsten Carbide	1/16" dia. x 2"
9251 Titanium Carbide	3/16" dia. x 2"
9252 Titanium Carbide	1/8 " dia. x 2"
9253 Titanium Carbide	3/32" dia. x 2"
9312 Rockhard	1/8 " dia. x 4"
9314 Rockhard	3/16" dia. x 4"

Table 5 – Rocklinizer mini electrode models

ROCKLINIZER MINI ELECTRODES	
8335-A Mini Electrode Holder	
8235 Tungsten Carbide	.020" dia. x 2"
8236 Tungsten Carbide	.030" dia. x 2"
8237 Tungsten Carbide	.040" dia. x 2"

The end result of this surface treatment is to increase productivity and reduce costs. When tools and dies remain in operation without replacement due to wear, there will be less machine downtime, operator idle time, set-up, inspection time, and the expense of new or resharpened tools and dies.

Table 6 – Rocklinizer accesories

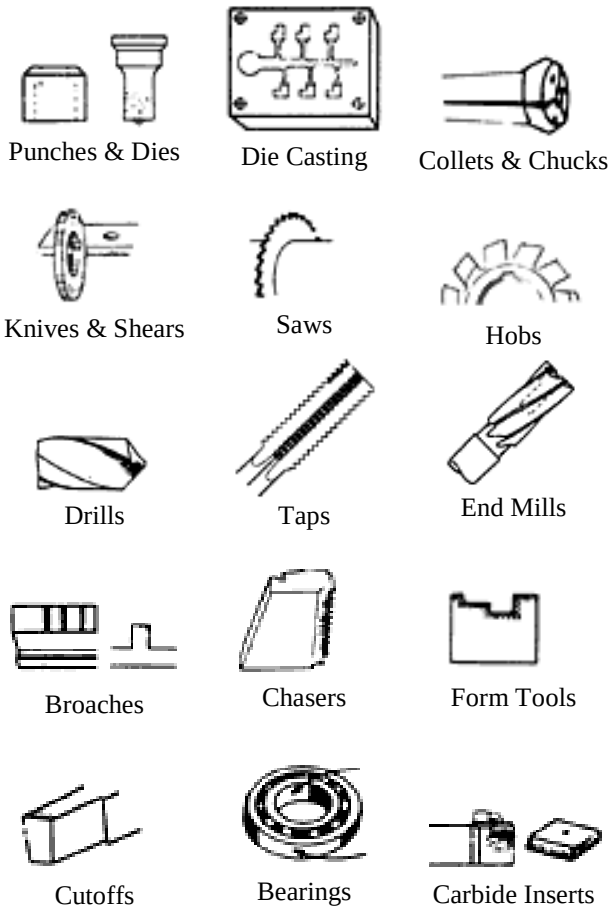
ROCKLINIZER ACCESSORIES
9250-A Applicator Gun (for use with Models 380 / 500 / 600)
9207-A Tool Post Gun w Mounting Assembly (for use with Models 380 / 500 / 600)
800-400 Rotary Applicator (for use with Model 800)
800-460 Magnetic Ground (for use with any Model)

5. COMMON APPLICATIONS OF THE ROCKLINIZER COATING METHOD

The Rocklinizer applies tungsten carbide, titanium carbide and Rockhard electrode material to metals, tools and dies. The Rocklinizer can be used with many tools and materials, from punches to drills to bearings, etc.

In the Table 7 are presented the main applications of the Rocklinizer method.

Table 7 – Applications of the Rocklinizer methods



Reamers

Milling & Thread Cutters

Tool Bits

6. APPLICATIONS OF THE ROCKLINIZER COATING METHOD IN CASE OF MOULDS

In the case of die casting dies and cores the hard coating apply has the following method: The electrode is applied to metal surfaces which come in contact with hot metals. The gate channel has to be coated with heavier Rocklinizer electrode deposit of 0.002". On cores has to be applied a coating of 0.0003" up to 0.0005" on areas where draw is made. Sometimes Rocklinized cores draw better than highly polished cores. Rocklinize heavier coatings have to be applied on areas which tend to solder to dies.

In the case of Die Casting the method helps to restore parting lines, to prevent heat checking, soldering, seizing of cores and protect gates and runners.

In the Figure 3 are presented the areas where rocklinizer coating is applied in the case of a mould for a gearbox suspension bracket.

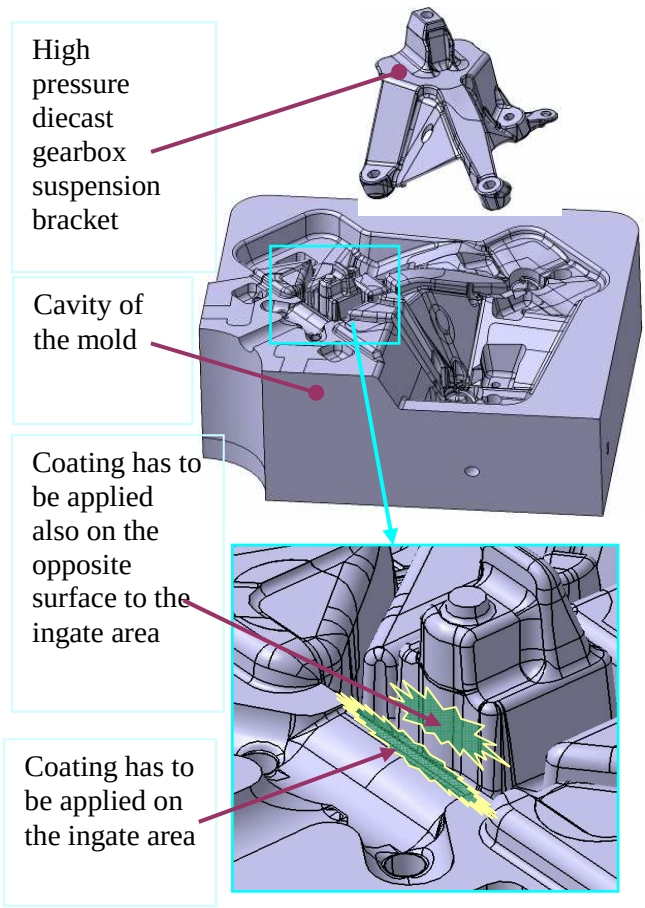


Figure 3 – Coated areas in the case of a HPDC mould for a gearbox suspension bracket

In the figure 4 can be observed that the way of the molten aluminium is orientated directly to the steel of the mould, which at high speed of second phase can cause soldering of the aluminium to the steel of the mould.

By applying the ceramic treatment the effect of soldering is minimized or eliminated.

In the figure 5 and figure 6 are presented the areas where rocklinizer coating is applied in the case of a mould for a pinion housing.

In the Figure 7 are presented the areas where rocklinizer coating is applied in the case of a mould for an engine oil pan.

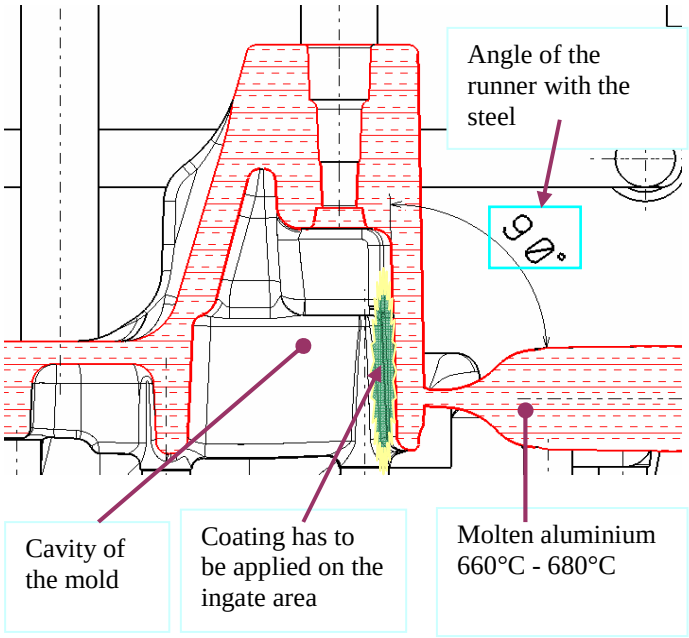


Figure 4 – Orientation of the molten aluminium to the steel of the mould

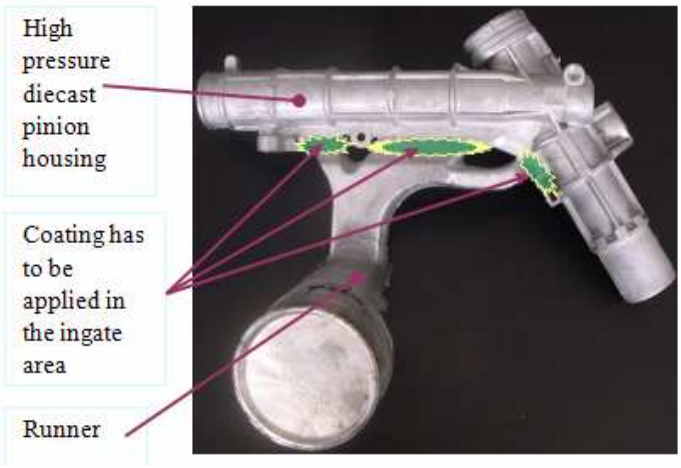


Figure 5 – Coated areas in the case of a HPDC mould for a pinion housing

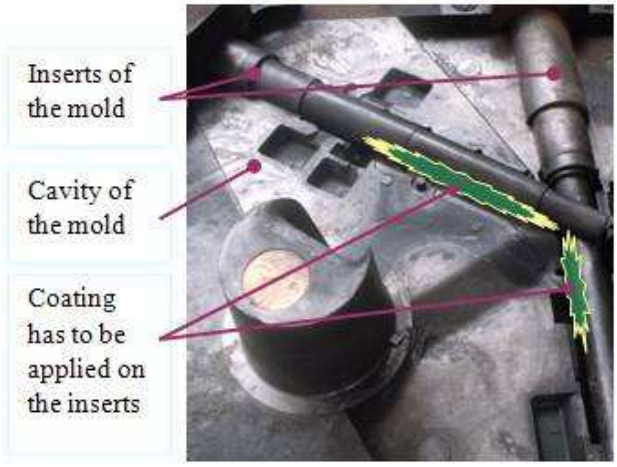


Figure 6 – Coated areas in the case of a HPDC mould for a pinion housing

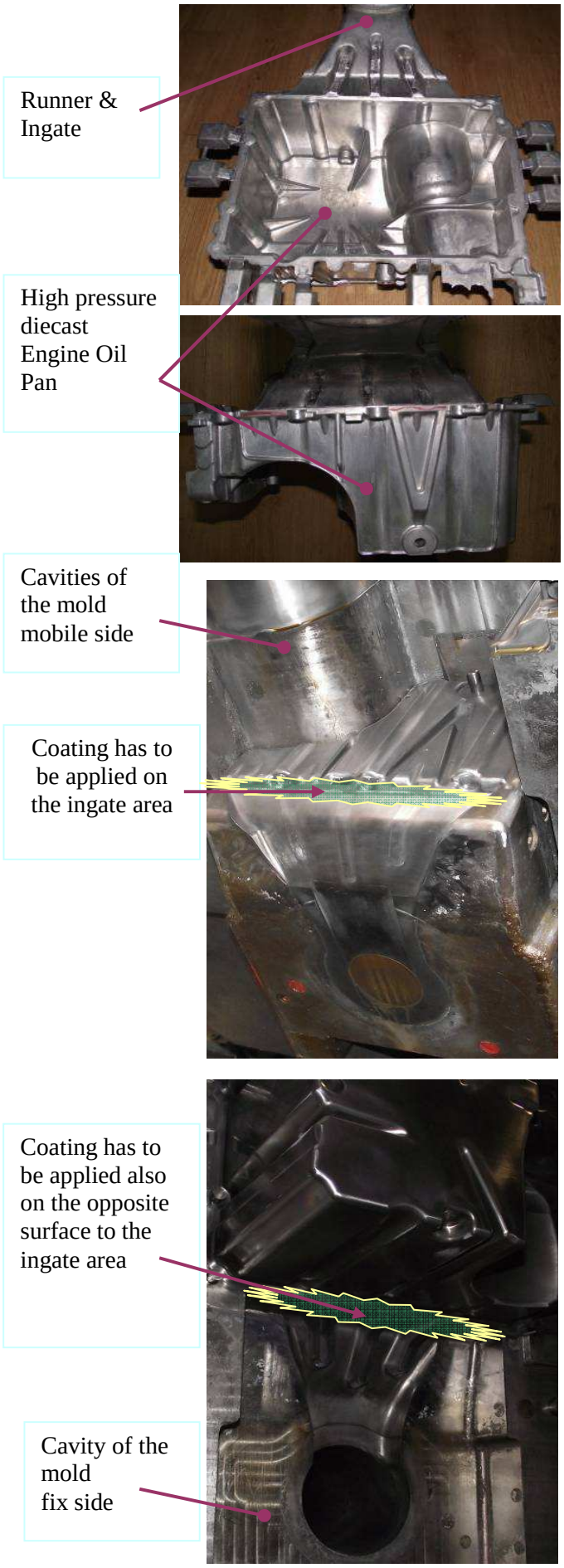


Figure 7 – Coated areas in the case of a HPDC mould for an engine oilpan

7. REFERENCES

[1]. AUREL NANU – *Tratat de tehnologii neconvenționale*, Vol. 1, Tehnologii neconvenționale la început de mileniu, Ed. Angusta, Timișoara, (2003).

[2]. ERNST B.: *Praxis der Druckgussfertigung*, Ed. Schiele & Schön, Berlin, (1991).

[3]. HERBERT R.: *Mold Engineering*, Ed. Carl Hanser Verlag, Munich, (2002).

[4]. IOAN V. MIHĂILĂ: *Tehnologii neconvenționale*, Ediția II, Ed. Universității din Oradea, ISBN 973-613-400-8, (2003).

[5]. MONTES J.: *Revision Tecnica del Producto*, CIE C. Vilanova, (2008).

[6]. STREET, A.: *The diecasting handbook*, Portcullis Press LTD, (1977).

[7]. www.sme.org

[8]. www.rocklinmanufacturingco.com

[9]. http://en.wikipedia.org/wiki/Die_casting

[10]. http://ciepedia.cie.lan/ciepedia/index.php

[11]. http://www.diecasting.org