New possibilities to plastic processing screws and tools with Lunac coatings

April 2005

Abstract:

Treating injection- and extrusion screws as well as other tools or molds with Lunac 1 and/or 2(HC)+ layers, offers a rising amount of interesting possibilities. The unique Lunac coatings deliver the very much-desired collection of the following features: a weld-like adhesion as well as a good shock resistance, a coating that is completely crack-free and very wear resistant (particularly in case of Lunac 2(HC)+), as well as highly corrosion resistant (particularly in case of Lunac 1). Much cheaper but generally stronger tooling steel can replace the expensive nickel alloy machine-parts with a Lunac coating. Moreover, a traditional weld-on hardfacing can completely be replaced by the low temperature deposited hardfacing process Lunac 2(HC)+, that is crack-free and relatively cheap. Although Lunac coatings were primarily developed for there anti-sticking effects up to 55% release force reduction, the above mentioned effects proved later to be just as important.
A chart of these properties is noted below.

- ***Lunac 1 offers one of the highest achievable reduction in adhesion of plastics on hard materials.***
- ***Lunac 1 strongly reduces the chance of degradation of especially PVC and up until the present time completely prevents the formation of 'black spots' with the PC or PET processing.***
- ***Lunac 1 shows a high resistance against acid producing plastics (containing chloride and fluoride).***
- ***Lunac 1 can be polished very quickly and delivers optically perfect surfaces.***
- ***Lunac 2+ is very hard and highly abrasive wear resistant in a solid filled plastic environment.***
- ***Nitriding and/or hardfacing with Colmonoy or Stellite can be completely replaced by Lunac 2(HC)+. The Lunac 2(HC)+ price/quality ratio is notably better.***
- ***Lunac 1 and 2+: Both coatings are hermetically sealed, porosity free and deliver a weld-like adhesion.***
- ***Lunac 1 and 2+ show a 6 fold better coating distribution (and consequently less edge buildup) than hardchromium***

Lunac 1 application:

With Lunac 1 coatings it is possible to create plastic processing machine parts like screws that achieve the second highest reduction in adhesion (behind PTFE), as well as improved conveying characteristics. These coated screws are very resistant to plastics that produce acids by generating hermetically sealed surfaces, making it resistant to the intrusion of plastics and corrosive substances.
Lunac 1 has solved the "black spots" problem with e.g. polycarbonate production completely, if this coating is applied to the injection screw and all downstream machine components (naturally when using a clean polymer and sharp edges (See figure 1). The reduction in foil striping and melt breakage is another important reason to apply Lunac 1 to plastic processing machineparts (See figure 2 and 3).
During the manufacturing of a machine part that is going to be coated with Lunac 1, one should take into account that the surface finish can be adjusted to only Ra 7.9^{E-6}" to 14^{E-6}" (= Ra 0,2-0.3 μm). In this way the Lunac 1 'flowpolish' effect is optimally used. This effect reduces the average polish time by at least a 20 fold. The Lunac 1 hardness reaches an acceptable HRc 65, making it fairly scratch resistant as well.

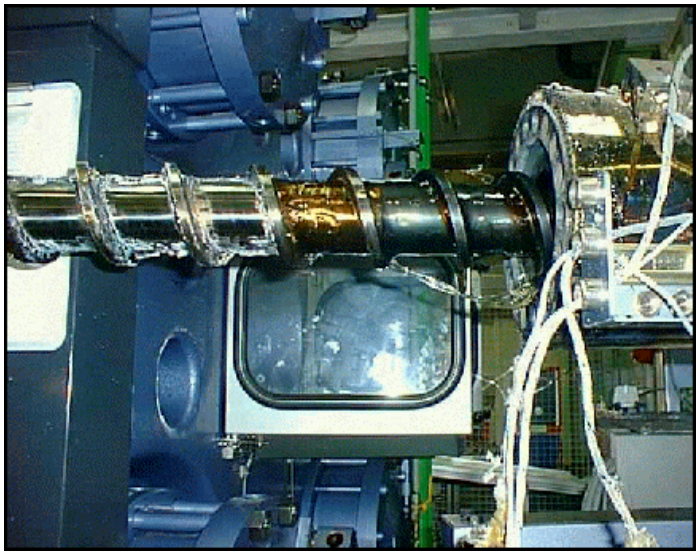


Figure 1. Photograph of injection after 1 year of clear polycarbonate production. The left part of the screw was coated with Lunac 1 and the right side of the screw was not coated. The polymer on the left part of the screw was not discolored, easy to remove and free of black specks, while there is clear discoloration of the polymer and steel on the right part of the screw. The new screw treated with Lunac 1 including the valve and nozzle has reduced the number of parts rejected because of black specks from 12% to 0%. The return on investment for the Lunac 1 coating is consequently very short.

Figure 2. A multilayer extrusion machine part for a PP processing application has completely been plated with 0.0016" Lunac 1. The reduction of pressureloss is significant (Figure 5) as well as the ease to chip off possible remnants. The striping reduction is notable as well. The coating distribution in the deeper structures is remarkable better than in case of hardchromium plating. Although the total bond with the substrate is almost unrivalled, the coating itself is brittle and care should be taken with the edges.

Figure 3. Flat dye extrusion parts completely coated with 0,002" Lunac 1. The reduced friction together with the anti striping effect is striking. This manufacturer utilizes the high corrosion resistance together with the very closed Lunac 1 structure very efficiently. Instead of (partially) corrosion resistant steel, this manufacturer applies a low grade steel. This steel is much easier to machine as well. All necessary surface features are delivered by the Lunac 1 coating. This concept has irrefutable proven to be superior to a non coated chromiumsteel flat dye after 3 years application (See figure 4). The possible bending of the lip has to be limited because of the brittleness of Lunac 1 (0,11% elongation until breakage).

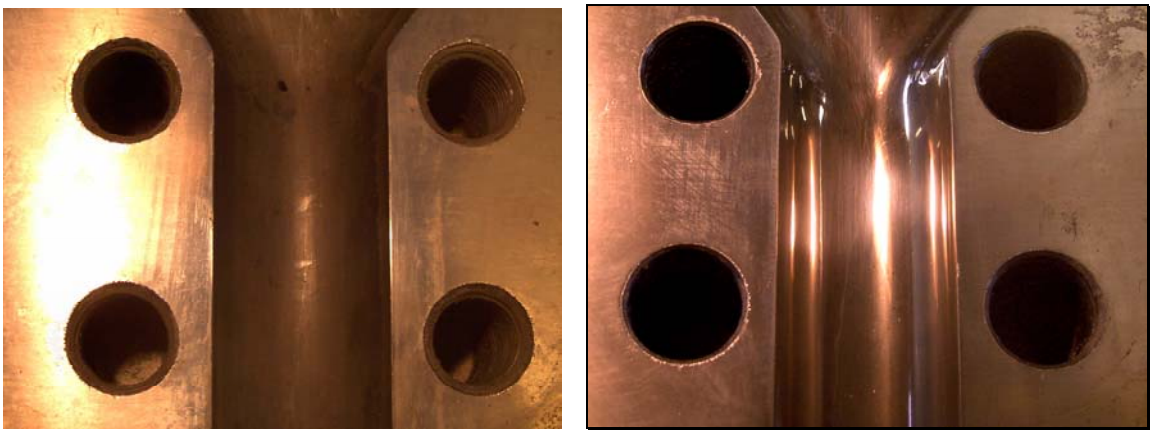


Figure 4. These pictures represent the mean canal of flat dye extrusion parts. The basic material from the left dye is based on a high chromium containing steel. These dyes were operational for 3 years in a HIPS environment. The left surface is dark and rough. This friction increasing effect noticeably influenced the plastic flow. The right picture displays a dye under equal conditions with a Lunac 1 coating on low-grade steel. The reduced friction coefficient as well as the surface appearance has not changed since the dye became operational.

Non stick properties:

The influence of an anti-sticking coating on the total pressure loss in a flow channel is limited but measurable. A manufacturer of extrusion machines has produced this diagram below.

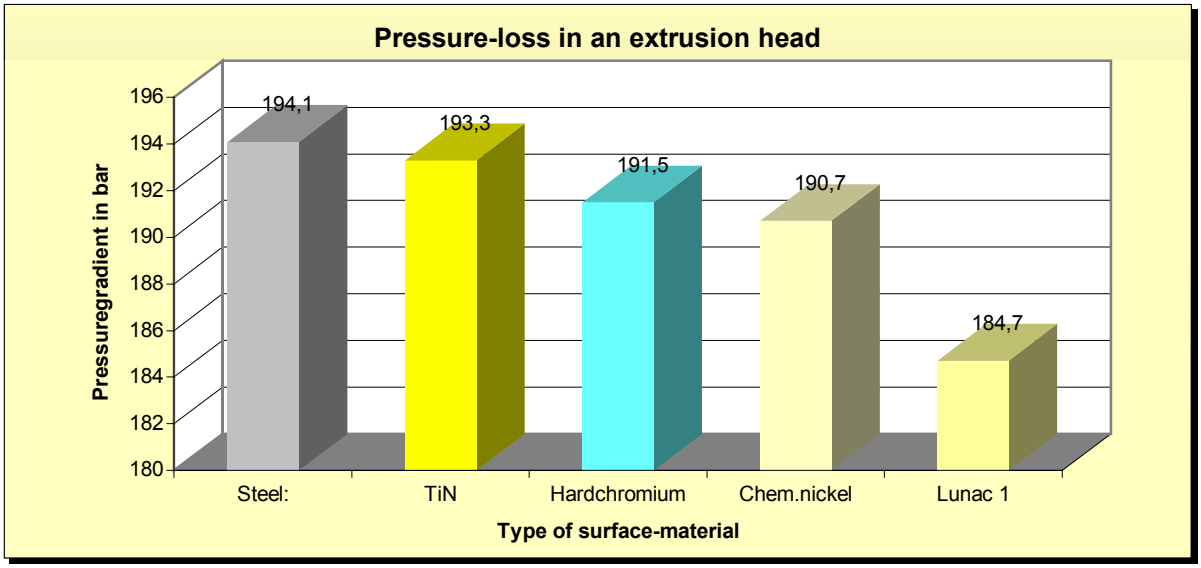


Figure 5. This diagram represents the influence of various coatings on the melt in an extrusion dye.

Clearance canal: 4.1 sq. inch **Temperature: 401 Fahrenheit** **Yield: 40 Pounds/hour**
Length canal: 7.7“ **Plastic: LDPE 5021**

To preserve the low Lunac 1 adhesion coefficient, it is strongly recommended not to sand or clean a Lunac 1 surface with an abrasive medium like scotch bright.

Corrosion resistance:

Because of the very dense Lunac structure and high corrosion resistance of Lunac 1 as well as the new Lunac 2HC+, a very interesting possibility has risen (See figure 6 and 7). Instead of expensive nickel alloys that are hard to machine and tend to show strong galling behavior, a mechanical much more optimized, but insufficient corrosion resistant, chromiumsteel can be applied. The corrosion resistance (especially Lunac 1) and anti galling (especially Lunac 2HC+) effects are covered by the Lunac coatings. The anti cracking property from mainly Lunac 2HC+ is much better than most other hard materials like conventional hardfacings.

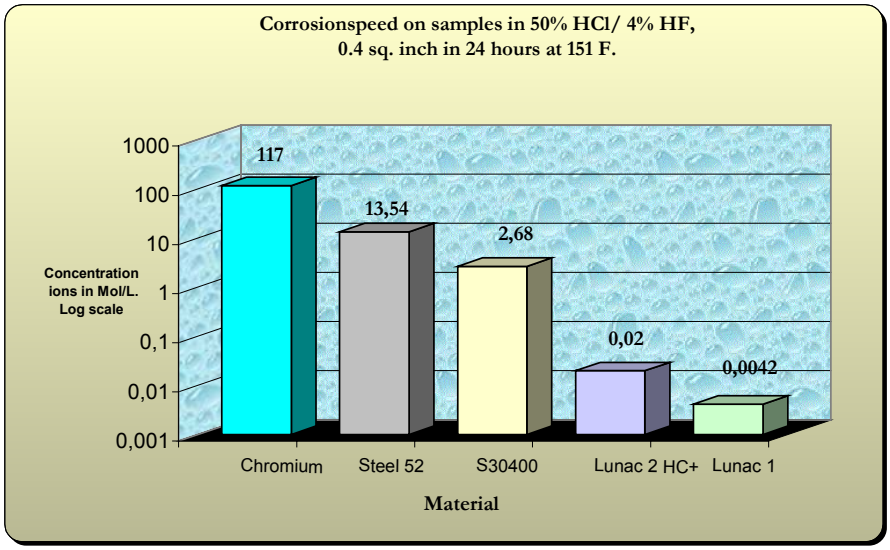


Figure 6. Corrosion resistance diagram; Lunac compared to other important Materials. (Lunac 2HC+ is 440 times more corrosion resistant than Lunac 2+.)

Picture 7. Lunac 1 replacement for Hastelloy C4. 1.4" screw after 5 weeks in a PFA fluorplastic environment. Not any corrosion effect has been detected. Basic material: PH 17-4.

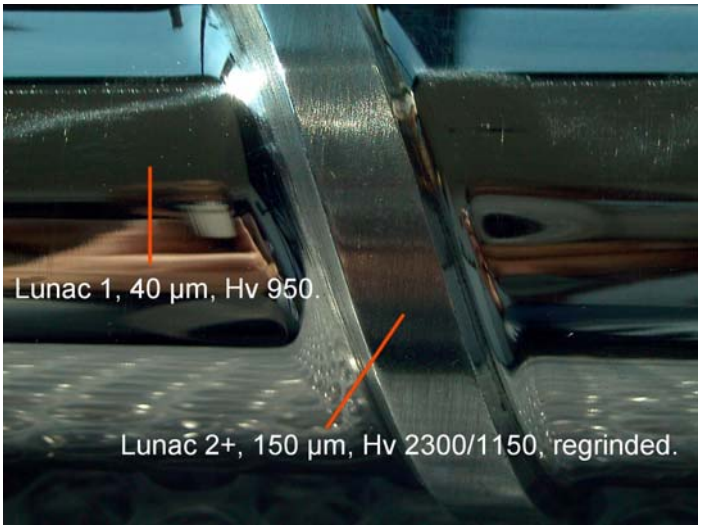
Lunac 2(HC)+ application:

For screws with both considerable adhesive wear on flights tips and adhesion problems.

By applying a Lunac 2+ layer to the flight tips, a screw can be created with strongly reduced galling behavior and high abrasive wear resistance on the whole screw. Lunac 2(HC)+ possesses a resistance against adhesive wear that is ten times greater than most conventional medium hard hardfacing materials. As a result, the Lunac 2(HC)+ can be applied with a thickness 10 times less with the same up-time. This requires a thickness of 0.15-0.20mm or 0.006-0.008". Consequently, the main benefit of Lunac 2(HC)+ is wear reduction. In case a very high flight tip load is expected we still advice to apply a stellite 12 hardfacing in this flight tip zone (Lunac 2(HC)+ is more brittle than Stellite 12). The Lunac 2(HC)+ will only be absent in this zone.

Procedure :

1. Preparation of a screw not harder than HRc 50 and reduced in the outer diameter by 0.012-0.0176" (0.3- 0.44 mm). The screw flight tip is first oversized strengthened with the Lunac 2(HC)+ layer as an armor against abrasive and/or adhesive (cold weld) wear.
2. Using a diamond based medium, the flight tips are ground (through the Lunac 2(HC)+ coating in case there is a stellite hardfacing) to the desired thickness 0.006-0.0088" (0.15-0.22 mm). Accuracy: 0.0006"(0.015 mm).
3. Polishing of Lunac 2(HC)+ and heat treatment at 626 F for 5 hours. Ultimate hardness: Hv 2300.



D70 injection screw for the processing of ABS, treated with Lunac layers using Lunac 1 and 2+. This screw diameter is on the forehand reduced to 0,012" (0.30 mm). First an oversized Lunac 2+ layer was deposited on the flight tips, followed by a complete 0,00016" (0.04 mm) Lunac 1 coating. Finally the flight tips were ground to the final diameter. Nowadays a cheaper only Lunac 2+ coating offers almost the same optimal result.

This concept offers the following advantages:

1. The production of a very wear- and corrosion resistant screw with improved anti sticking properties.
2. A repair of the Lunac 2(HC)+ flight tip armoring is feasible.
3. No danger of fractures as can occur with Stellite or Colmonoy welding.
4. A considerable reduction in cost.

Remarks on 'the Only Lunac 2HC+' coating on the whole screw.

This coating delivers one of the highest achievable combined 'all over wear- and corrosion-resistance' Lunac 2(HC)+ proved to be enough fluor acid resistant for general fluorplastic applications. This implies that Lunac 1 has still the best anti-corrosion properties. The anti-sticking effect is almost as good as with Lunac 1. The coating thickness is up to 0,0078" on the flight tips (conventional hardfacing replacement) and 0,0035" on the other structures. Despite the slightly reduced corrosion resistance (compared to Lunac 1), this high corrosion resistant Lunac 2+ variant is very promising because of its comprehensive nature and reduced price compared to other plating concepts.

Conditions and instructions for proper use of Lunac coatings:

- The screw may not be harder than HRc 50.
- The screw may not be nitrided or the hard casing has to be removed by grinding.
- Used screws should not have been in contact with polymers too long (intrusion). Removing the intrusion layer by grinding (may once again offer a solution.
- Surface roughness before the Lunac coating: 14 micro-inch

For extrusionscrews we developed special devices to obtain a perfect Lunac 2HC+ coating distribution in the deeper corners. These screws were normally chromium plated for an abrasive PVC application. Normally a serious micro-cracking corrosion structure arose within a few weeks. The latest Lunac 2HC+ coating proved to solve this problem for already 14 month now.

In case of a part is hardened (>HRc 50), we can not guarantee a perfect adhesion. However a workable concept exists by reducing the local Lunac coating thickness in a high loaded area (like the flight tips) to 0,0006" or remove the coating completely in this zone. This uncovered area can be replaced by a nitride treatment or a stellite 12 armor. Lunac coatings withstand a nitride treatment well. Ask us for the approved steels types.

On these screw parts there are also 2 different Lunac layers applied. Lunac 1 is applied where adhesion and black spot formation is observed. Lunac 2+ is applied to the pressure zones.(However with non-PVC and fluoride containing plastics, the complete valve assembly is treated with Lunac 2+).

Material preferences for Lunac treatment:
(A complete bond is obtained on these materials)

According to the DIN norm:

1.2379	1.4122
1.2316	1.851x
1.2767	

Or U.S indicated steel:

PH 17-4	H 13

An approximate price for a Lunac 1 coating is for example; 1,5" injection screw, 2003: 450 Euro.
The typical Lunac 1 discoloration effect is in theory guaranteed up to 644 Fahrenheit. Starting at 842 Fahrenheit, Lunac layers begin to lose the indicated hardness.

Points of attention on screws treated with Lunac 1 and/or 2(HC)+;

- Screws with Stellite layers give the operator a signal of being worn well ahead of time by a decrease in performance. The operator then knows that the Stellite layer will no longer give the desired protection in the near future. Screws with Lunac layers give a less obvious wear signal. The screw is considerably closer to its original tolerance when the armoring is no longer of sufficient thickness. A too thin Lunac 2+ layer will no longer give the underlying steel protection against strong wear and

cold-welding. The operator should be required to remove the screw at least once, far in advance to note the wear rate. The maximum term of life where a minimal 0,0016" Lunac 2+ resides can then be determined through extrapolation.

- Especially Lunac 1 shows a glass-like character and is thus susceptible to brittle fracture. Even though Lunac has a good adhesion up to the edges, this material is sensitive to shock and sliding loads on the edges.

- Lunac layers can be damaged by letting hard plastics (e.g. polycarbonate, nylon, polyester, etc.) cool down slowly and solidify on this coating. Lunac layers can hereby obtain internal (laminar) fractures through. Always rinse with PE or PP after use or keep the machine on 392 Fahrenheit.

Observable shortcomings with current (treated) screw systems which can be solved by Lunac coating:

1. Excessive adhesion and formation of (black) degradation products.
2. Corrosion of the nitrated steel as well as the transition zone to the welded on armoring due to plastics with polar groups.
3. (Under)corrosion of the eventually applied hard chromium, as this is less resistant to non-oxidizing acids (HCl or HF).
4. Cold weld and scratch forming on screws that frequently touch the barrel in the welded-on armoring and valve system.
5. Needing to re-align especially after welding. Chance of fractures in the Stellite or Colmonoy weld.
6. High cost of weld-on top armoring.
7. Discoloration of the screw (especially with high production temperatures) and therefore +/- 40% adhesion-increase. This is already observable on the dyes with PE applications and generates dull/rough sticking surfaces.
8. Insufficient mixing.
9. Flaking coating.

Injection nozzles for DVD production treated with Lunac 1 on the inner surface. If only these end parts of an injection system are treated, a reject percentage due to black spots is generally reduced by 45%. Up until the present time only the complete Lunac 1 treated injection system solves the black spots problem completely. The end opening is only 0.07"wide (measured over a length of 0.16") and completely plated.

Granulator coated with 0.004" Lunac 2+ after regrinding with diamond. The holes are blended during the process by the represented plastic insert (behind). The granulator in the granulator/knife set lasts 45 times longer than the original nitrited steel concept. This concept is very competitive with hard metal inserts.

At this moment the maximum treatable length is 116". Due to positive developments we will install 160" process bathes around early 2004 in our new plant.
Naturally circumstances can arise that are unknown to us and which could influence the noted results. The intention of the WMV method of working is to achieve a high quality of service and goods. We achieve this by operating with an extensive technical database and delivering the measurements cards. All procedures per customer are registered for reproducibility.

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More pictures and information on:
www.wmv.nl at Lunac 1 en 2+.