DC53 & Surface Treatments

Surface Treatments - DC53 is well suited for supporting a wide variety of surface treatments which include Case Harden Nitride (Nitriding) which is diffused into the substrate tool steel or use the Physical Vapor Deposition (PVD), Chemical Vapor Deposition (CVD) and Thermal Diffusion (TD) otherwise known as Thermal Reactive Diffusion (TRD) which are applied on the surface.

Surface treatments are either into the surface of the substrate tool steel which is otherwise known as case hardening or on the surface in the form of a surface coating. These treatments while very hard are also very thin making them nearly impossible to detect using a conventional hardness testing methods. When a combination of diffusion and surface coatings are used, a Vickers Micro Hardness Tester should detect a rise in surface hardness however, it will not reflect the hardness of the actual surface treatment alone.

Cold Process vs. Hot Process - For heat treat and application processing purposes, surface treatment processes can be broken down into two categories, Cold Process and Hot Process. Surface treatments applied below 480° C (900° F) which is lower that the substrate tempering temperature is considered a cold process treatment.

Nitriding and PVD coating treatments fall into the Cold Process category because the temperatures which they are applied at are more than 28° C (50° F) below the tempering temperature of most potential substrate tool steels and therefore, should not affect the integrity of their initial heat treat. Tool steels such as S7, A2, and D2 typically do not meet this requirement. DC53 however, when tempered at or above 540° C (1,000° F) is not affected by these processes and will maintain original size and heat treat characteristics. For intricate or large tools needing optimum size stability, third temper of at least 400° C (750° F) can be applied. DC53 with a Case Harden Nitride and or PVD coating are excellent for precision tooling components.

CVD and TD coatings are considered Hot Process surface treatments because they are applied at from 925° C (1,700° F) to 1,040° C (1,900° F). The higher temperatures typically mean better coating adhesion due to diffusion of carbon alloy elements. These temperatures exceed the tempering temperatures and fall within the austenitizing range (Hardening temperature range) of most potential substrate materials and greatly affect the integrity of the initial heat treat. Distortion and dimensional stability in the form of growth by of as much as .15%, or 0,0015mm per millimeter (.0015" per inch) is to be expected. Because this is a percentage change, larger tools will see more overall size change than small tools.

Nitriding - Nitriding is a process which case hardens the existing surface of the tool steel. The most common ways to apply nitriding are: salt bath, fluidized bed and ion nitride. Although this process can be applied at nearly 535° C (995° F) potential damaging the substrate tool steel heat treat can be avoided by choosing a process which is at least 10° C (50° F) below the tempering temperature of the substrate material and by keeping the case hardening depth to a minimum. The recommended case hardened depth

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for most stamping applications should not exceed 0,025mm (.001"). By keeping the case depth shallow, it minimizes the heat exposure and prevents the formation of a white layer on the surface making it brittle and prone to chipping and breakage. Shallow case Fluidized Bed or Ion nitriding applied below 500° C (930° F) work best for DC53.

PVD Coatings - Surface treatments such as Titanium Nitride (TiN), Titanium Carbonitride (TiCN), Chrome Nitride (CrN) & Titanium Aluminum Nitride (TiAlN) applied using the PVD process are coatings on the surface of the steel. These coatings are very thin typically measuring less than .025mm (.0001"). Because they have very little support of their own and require significant heat to be applied, these coatings should only be applied to tool steels with sufficient obtainable hardness of HRC 60 after being exposed to coating process temperatures as high as 480° C (900° F). For DC53, the standard two tempers at or above 520° C (970° F) perform well. A third temper at 400 C (750 F) is recommended for intricate and high precision applications.

CVD Coatings – There is a correlation with a coating process temperatures and coating adhesion. Higher coating process temperatures typically mean better coating adhesion due to diffusion of carbon and alloy elements. There are also minimum temperature limits as to how low of a temperature some coatings such as Titanium Carbide (TiC) can be applied. While adhesion improves and additional coating materials become available for this process, precision is diminished due to the high process temperatures involved.

CVD coatings are applied between 925° C (1,700° F) and 1,040° C (1,900° F) which is equivalent to the hardening temperature and well above the tempering temperature of nearly all potential substrate tool steels. This will require some form of post coating heat treat because the high coating process temperature has pushed the tooling up into the hardening temperature range, affecting the structure of the steel. The tool hardness will likely be unacceptably low and un-tempered which reduces its toughness and strength.

Ideally, tooling that has been CVD coated should be annealed and re-heat treated after these surface treatments are applied. The reason tools are heat treated prior to the coating process is because its size from the annealed state to the hardened state otherwise known as the martensitic (Hard) state differs and it is not always possible to predict how much size change will occur when hardening. A tip to minimize the growth of DC53 when CVD coating, is to temper at 500° C (930° F) to 510° C (950° F) in the heat treat before coating process.

TD Coatings – These coating are applied at between 1,010° C (1,850 F) and 1,030° C (1,886 F) and can be handled similar to CVD coating however, they can also utilize the coating process itself as a part of the reheat treating process. By using the proper salt bath temperature in the coating process, it can be used to also hardening harden the tool steel. For optimum hardness DC53 should be TD coated at 1,030° C (1,886° F). This process is followed be multiple tempers at the appropriate temperatures to achieve the desired hardness. In order to achieve optimum tool life, it is recommended to anneal and reheat treat the tool.

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Conclusion - Tools should be finished to size and polished prior to applying the surface treatment. A light polish after coating is also beneficial. This is particularly important when applying surface treatments on form, draw, and extrusion tools.

Higher temperature surface treatments utilizing the CVD and TD process coatings should be annealed, re-hardened, and tempered for optimum tool life.

In general, surface treatments can reduce the coefficient of friction and improve wear resistance. Higher hardness of the substrate material offers superior strength reducing plastic deformation resulting in optimum coating adhesion. Understanding the difference in precision capabilities based on the process temperatures and the specific properties of the coating themselves are important. Contact your surface treatment supplier for details on specific surface treatments.