DSM Engineering Plastics Technical guide

Steel recommendations for molds, screws and barrels for injection molding EP materials.

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1- Engineering Plastics

The use of engineering plastics in the injection molding process is worldwide common business. The processing of these polymers is done at relative high processing (barrel- and mold) temperatures. To get special property performances for these polymers, fillers like glass, carbon, flame retardants are very often used.
The combination of these high processing settings, the use of fillers and moisture present in the melt on their turn may have a negative influence like abrasion and/or corrosion of the used steel in mold, screw and barrel.
In other words, special requirements to overcome this and increase the life time of the steel type are obligated.

High process temperatures

EP polymers like Akulon®, Arnitel®, Arnite T®, Arnite A®, EcoPaxx®, Stanyl®, Stanyl ForTii® are processed at melt temperatures range of respectively 250°C up to 340°C. Generally may be stated the higher the temperature, the faster chemical reactions leading to wear will take place, the more precautions have to be taken to prevent steel wear.

Fillers:

Using unreinforced, non flame retardant EP polymers, abnormal abrasive wear or corrosion is not to be expected. However many times fillers are used to get a specific performance on properties.
These fillers like glass, carbon, minerals, w&f additives are in fact “hard” components in the melt that potentially can cause abrasive wear.
On top of that the use of (halogen free) flame retardant’s can contribute to corrosion of the used steels.

Moisture:

EP polymers are hygroscopic, meaning the material have to be dried before processing. Although good drying some low amounts water may still be present in melt stage. Water will initiate a chemical reaction leading to lower material properties but also to corrosion of the used steels.

2- Tool steel selection

General advice

To be able to process high-end engineering plastics, high-end tool steels are of utmost importance.
Therefore we recommend using ESR/VIM (Electro slag Re-melting/Vacuum Induction Melting) or PM (Powder Metallurgic) steel types. These steel types ensure high purity and optimal morphology.
The choice for a specific tool steel type will always be a compromise between several properties, this leaflet will give you a good guidelines to do so.

Toolsteelnumber/identification code number:

In the second column in the tool steel table a W.nr (Werkstoffnummer) is plotted (US equivalent ASTM). These identification codes are still commonly used to indicate steel types.
One should be aware that this system is an aged system. The identification number only (for example 1.2083) is insufficient.
This identification system cannot fully cover the modern high tech steel types on the market. Therefore we need to specify a specific brand name and type to be sure to make the right steel choice. Additional to this, the heat treatment of the steel is of utmost importance to obtain the desired properties.
For detailed advice please contact us or the applicable steel supplier directly.

Topics to select best tool steel;

To be able to choose the correct tool steel and heat treatment for a specific mold, the most important questions are the following:
1) Identify the dominated failure mechanism (often more than one mechanism is applicable. In this case the most dominant needs to be considered).
2) Operating temperature.
3) What kind of polymer/filler.
4) Size and/or complexity of the mold.
5) What kind of surface finish required (High polish, textured etc.).
6) Production size.

These are the most important questions, tool steel supplier’s need answered, to make a good choice on the specific type of tool steel. In injection molds this choice is likely to be a compromise between several properties.

3- Failure mechanisms for tool steel

1) Wear: here we can distinguish;
   a) Abrasive wear (due to sliding contact)
   b) Adhesive wear (due to sliding contact)
2) Plastic deformation (local exceeding of yield stress due to contact pressure).
3) Chipping (parts flaking of due to fatigue).
4) Cracking (Total crack due to mechanical or local high thermal load)
5) Corrosion (can have a number of causes).

Ad 1a:

Abrasive wear is in principal the erosion of the steel matrix between the carbides.
This is highly influenced by abrasive fillers like; glass fiber, mineral fillers etc.
The solution direction;
- High purity steel.
- Steel with high carbide level.

Ad 1b:

Adhesive wear is in principal a local “cold welding” situation.
The solution direction;
- Steel with high carbide level.
- High tempering temperatures.
- Steel containing Aluminum as an alloy component.
- Use of CVD or PVD coatings.

Ad 2-3&4:

These failure mechanisms are a combination of fatigue and exceeding yield stress.
Be aware, that in Al alloyed steel, the AlO_3 can be a source of fatigue crack initiation.
The solution direction;
Correct heat treatment process of the steel type used (See steel supplier recommendations). Aim is to obtain an as large as possible martensitic structure. This can be achieved by using high hardening temperatures.

Ad 5:

Corrosion can be initiated by; moisture (hence drying of the resin is very important), hot gasses, aggressive fillers like flame retardants, aggressive cleaning agents etc. Corrosion resistance is driven by two major factors;

1) Chromium content of the steel should be >13%.
2) Heat treatment of the steel (tempering temperature level).

4- Life time of a mold

The life time of a mold is depending on a number of factors;

- Choice of tool steel.
- Type of polymer/filler.
- Complexity.
- Operating temperature.
- Maintenance level (a high precision tool running a 24/7 production at elevated temperature should be disassembled and cleaned every 3 months to ensure maximum life).

5- Machining tool steel

In case of EDM(Electric Discharge Machining), it is very important to remove the so called "White layer" after this process. This is a thin layer which is very brittle, and can initiate cracking (this layer already contains micro cracks, which can propagate). In case of difficulties removing this layer, due to for example narrow spaces there should at least be a soft annealing step of the steel (50°C below tempering temperature).

6- Coatings tool steel

In case of a coating, one should make sure the coating process temperature is at least 50°C below the last tempering temperature. If the coating process temperature has been too high, the hardening of the steel will be destroyed. When applying a coating the base hardness of the steel should be high enough to prevent the egg-shell effect.

7- High end Tool Steel suppliers:

Table 1 on the next page shows the recommended steel types for a number of tool parts.
This table is developed in cooperation with, and based on the experience of the above mentioned tool steel suppliers (Bohler, Uddeholm, Assab).

8- Barrel, screw:

Taken into account the polymer portfolio you are using on a molding machine, the choice for best cylinder/screw/nozzle/etc. can to be done. Each machine supplier has their own trade names on applicable hardware to use. In table 2 on page 5 you can find suggestions applicable for the machine suppliers Arburg/Demag/Engel/Fanuc/Xaloy for screw and barrel, molding Engineering plastics.

Table 1. tool steel selection

Application	W.nr.	Recommended heat treatment and hardness	Suppliers Böhler/Uddeholm/Assab	Remarks
Chassis blocks / Runner blocks	1.2363	K340 1040/N_2 2x 540 60-62 HRc Rigor 950 /N_2 2x 540 54~56 HR c	K340 / Rigor / XW-10	Good machine-ability , wear resistance and hardness
Slider Guides	1.2379	1070/N_2 2x 550 60-62 HRc	K110 / Sv. 21 / XW-41	Excellence wear resistance and toughness
Sliders	1.2363	K340 1040/N_2 2x 540 60-62 HRc Rigor 950 /N_2 2x 540 54~56 HRc	K340 / Rigor / XW-10	Good machine-ability , wear resistance and hardness
Wear Plates	1.2379	1070/N_2 2x 550 60-62 HRc	K110 / Sv. 21 / XW-41	Excellence wear resistance and toughness
Gate Inserts	No equivalent nr	S790 1100/N_2 3x 560 61-63 HRc Vanadis 23 1100/N2 3x560 61-63 HRc	S790 / Vanadis 23 / ASP 23	High speed steel. Excellence wear resistance, high toughness and high hot hardness
Generic Inserts, Cavity, Core	No equivalent nr	M333 Isoplast 1020/N_2 2x 510 51-53 HRc Stavax ESR 1050/N_2 2x520 50-52 HRc	M333 / Stavax ESR / Stavax	High Chrome steel with superior polishability and corrosion resistance
	1.2344	1050/N_2 2x 550 51-53 HRc	W302 / Orvar / 8407 (H13)	Good machineability with high toughness, wear resistance and high hot hardness
	1.2358	56~58	Calmax / Calmax	High toughness and wear resistance
	No equivalent nr	1000/N_2 2x 510 54-56HRc	M340 Isoplast	High chrome steel with extremely good corrosion resistance and wear resistance
Critical Inserts w(long and thin)	No equivalent nr	M390 Isomatrix 1100/N_2 2x 510 59-61 HRc Elmax 1050/N_2 2x520 50-52 HRc	M390 / Elmax / Elmax	Powder tool steel with extremely good wear and corrosion resistance

Note: Listed information in the table may not be the latest developments. Always contact your tool steel supplier to get his advice.

Table 2. screw&barrel tool selection

	Screw		Cylinder	
	standard	EP polymer	standard	EP polymer
Arburg	Arbid	High-alloy tool steel	Arbid	Bi-metallic
Demag	High-alloy hardened steel	Corrosion resistant, wear resistant sintered metal	Nitrated	Bi-metallic WA611, WA618
Engel	S8	S24 Cabide metal coated; Onyx		Bi-metallic M9
Fanuc	Nitride	KAM31	KH	Ultra W/C
Xaloy		M390 or CPM 590V CrN or ceramic coating		X802 or X800 Tungsten Carbi-de coating Nickel based screw

Note: Listed information in the table may not be the latest developments. Always contact your machine supplier to get his advice.

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