

Wear Mechanisms in Tool Steels

A tool steel wears by abrasion, adhesion, corrosion or contact fatigue, and each one answers to a different property, so the remedy depends on which one is doing the damage. The page sets out the four mechanisms, the metallurgical factors that move each of them and the measured interfacial friction of the metalworking processes they appear in.

Reference only. This is a reference summary of published practice and it is not a specification of ours. The values are reproduced from the source tables, and the mechanism that ends a particular die depends on the workpiece, the press, the lubrication and the way the die was fitted. Final selection is confirmed on the job.

Four mechanisms, one of which is doing the damage

Mechanism	How it presents on the tool
Abrasion	A hard phase is rubbed against the tool steel. The hard phase can be embedded in the workpiece, as oxide inclusions are in steel, or it can arrive in a fluid, as grinding dust reaches a guide through the lubricant flow or as contaminant reaches a pump through the oil.
Adhesion	Metal is cold welded between tool and workpiece where direct contact happens, which is where the lubricant film has broken down, where the pressure is high or where the process leaves no room for a film. It becomes worse as the oxygen content of the environment falls, because no oxide layer can form.
Corrosion	Fresh tool steel is exposed by the sliding, the corrosion film grows on it and the workpiece then ruptures that film, uncovering new steel. It is rarely the leading cause of tool wear but it can become the dominant one at high temperature and in plastics processing.
Contact fatigue	Repeated sliding or rolling of one component over another spalls the surface and starts microcracks. On a tool this shows up as chipping along a cutting edge or a punch edge rather than as a wear scar.

The four wear mechanisms of tool steels and how each one appears in service, summarised from the article on friction and wear of tool steels in ASM Handbook, Volume 18. The source notes that these mechanisms rarely act alone and that the balance between them is set by the process.

What moves abrasive wear

What moves adhesive wear, and where the data disagree

The friction at the tool and workpiece interface

Matching the remedy to the mechanism

Mechanism	What actually changes the outcome
Abrasion	Hardness at the working temperature, carbon content, volume fraction of cementite, and the size, volume fraction and hardness of the primary carbides taken together. A powder metallurgy grade changes the size of the carbides, not their type.
Adhesion	Hot hardness, the built-in lubricity of the graphitic grades O6 and A10, small grain size, a large volume fraction of primary carbides and a small primary carbide size, all reported from empirical work. A coat or a change of lubricant is the practical lever.
Corrosion	Lubrication that keeps the fresh surface covered, a higher chromium tool steel, or a coating that does not react with the workpiece.
Contact fatigue	Higher toughness and higher hardness together, which pull against each other. Two ways to raise toughness without touching hardness are a powder metallurgy grade, which reduces carbide size, and a lower austenitizing temperature.

The metallurgical factors that control each wear mechanism in tool steel, from ASM Handbook, Volume 18. Where two of the factors pull against each other, as hardness and toughness do for contact fatigue, the source notes that raising one must not be allowed to create a larger problem than the one being solved.

Grades and stock

Aobo Steel, tool steel supplier

Aobo Steel supplies tool steel to distributors and mold, tool and die shops, including D2, D3, DC53, A2, O1, H13, H11, H10, H21, S7, M2, M42, L6, P20 and 420 and 440C stainless. Forged or hot rolled, annealed or pre-hardened, cut to your sizes, with test certificates.

Source, ASM Handbook, Volume 18, Friction, Lubrication, and Wear Technology, ASM International, 1992.

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