

Why Dies Wear Out and Fail

A die is taken out of service by one of nine damage mechanisms, and which one arrives first is fixed by the process rather than by the grade. The tables below give the mechanisms and the process each belongs to, the service temperature band of each die material family and the normal life and life limiting factor of zinc, aluminium and brass dies.

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.

A die is discarded for one of nine reasons

Mechanism	Where it decides die life
Adhesive wear	Cold forming, cold extrusion, sheet metal forming under pressure. Metal is welded between tool and workpiece where the lubricant film breaks.
Abrasive wear	Hot forging. Oxide scale breaks down during deformation and the fragments cut the die as a third body.
Erosive wear	Die casting and other solidification processes. The incoming molten metal jet washes die material off the surface.
Corrosive wear	Runs alongside the others wherever the flowing material has a chemical affinity for the die.
Thermal fatigue	Die casting first, hot forging second. Cyclic heating and cooling opens a network of fine heat check cracks.
Mechanical fatigue	Cracks start at stress concentrations in the cavity and grow with every forging cycle.
Thermal shock	Sudden temperature change, usually a first-shot condition. It can crack the die outright.
Plastic deformation	Excess pressure against a die that is too soft at temperature. The cavity takes a permanent set.
Gross cracking	A few cycles from a high stress or a low toughness die, often from poor fitting or shrink fitting of inserts.

Die and mold wear and failure mechanisms and the processes each one is associated with, summarised from the article on friction and wear of dies and die materials in ASM Handbook, Volume 18. The source notes that the first three are common to most forming processes, and that erosion rather than abrasion is the leading loss mechanism in die casting.

What decides heat checking

Service temperature sets the material family

Tool material	Recommended service temperature, C	Recommended service, F
Low-alloy, air-hardening and shock-resisting tool steels	205-480	400-900
Chromium, tungsten and molybdenum hot-work steels, maraging grades, tungsten carbide	370-620	700-1150
Superalloys	620-925	1150-1700
TZM molybdenum	925-1205	1700-2200

Typical service temperature of die materials in forging, reproduced from ASM Handbook, Volume 18. The bands overlap because the useful ceiling of a grade depends on how long it spends at temperature and on the hardness it was tempered to.

Normal life of a die casting die, and what ends it

Casting alloy	Factors that limit die life	Normal life, number of shots x 1000	Die	Core
Zinc	Erosion, mechanical abrasion	500-1000	500-1000	
Aluminium	Heat checking, cracking, erosion, low compressive strength	100-250	50-150	
Copper (brass)	Heat checking, low compressive strength, erosion, cracking	10-100	3-20	

Life-limiting factors for die casting dies, reproduced from ASM Handbook, Volume 18. The life figures are thousands of shots. The core of an aluminium or brass die gives up before the cavity does because it runs hotter and is surrounded by melt on more faces.

Abrasive wear is what controls hot forging die life

Galling and pickup in sheet metal forming dies

Why Dies Wear Out and Fail

Measure	What it does
Check the fit first	Wrong clearance or poor alignment makes the sheet iron out wrinkles, and ironing out wrinkles is what tears metal from the die.
Nitride chromium grades	A2, D2, D3 and D4 nitrided and then polished or buffed. Nitriding a grade with no nitride former in it can spall on radii under about 3 mm.
Plate with hard chromium	Plating thickness 0.005 to 0.01 mm, base hardness above 50 HRC. Heat to 150 to 205 C for three hours straight after plating to release hydrogen.
Use a dissimilar counterface	Aluminium bronze draw rings keep their finish on stainless and high nickel work where a tool steel ring picks up.
Change the lubricant	Extreme pressure lubricants with sulphur or chlorine, zinc stearate soap, and phosphate coating on the workpiece where the draw is severe.
Watch the softening resistance	Among tool steels the ranking for resistance to softening runs T15 best and W1 worst, and resistance to softening is what decides pickup.

Measures against galling and pickup in sheet metal forming dies, from ASM Handbook, Volume 18. The source records that the amount of wear on a die radius can vary by a factor of twenty between the sharpest and the most generous radius, which makes radius design the first thing to check when a die that worked starts to pick up.

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.

CONTACT

EMAIL

sales@aobosteel.com

WHATSAPP

+86 180 6294 5370

WEB

aobosteel.com



Scan for the full reference page