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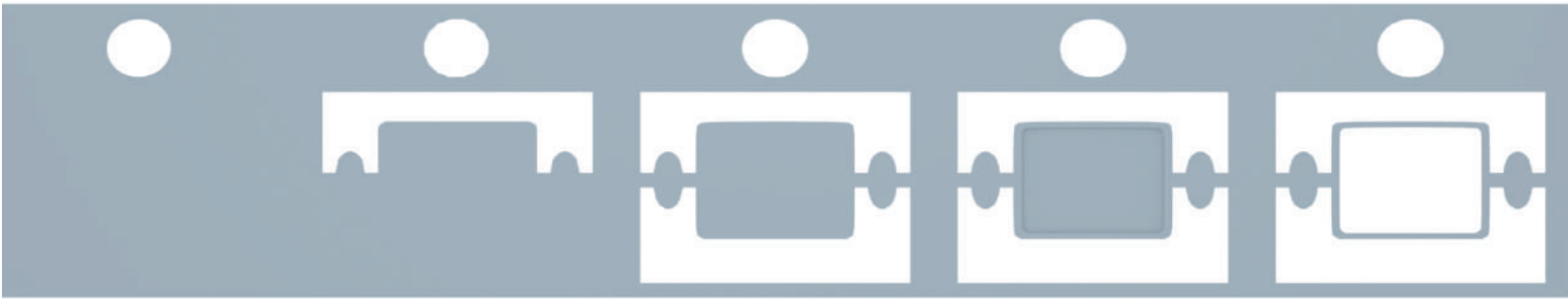

MULTI-STAGE COLD FORGING

June 2018

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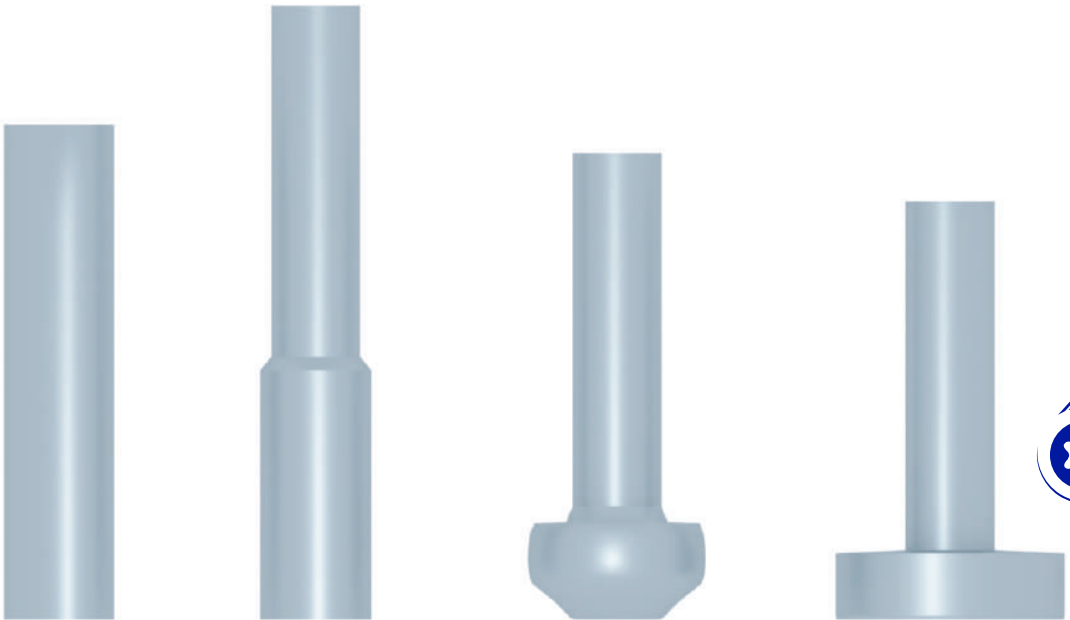


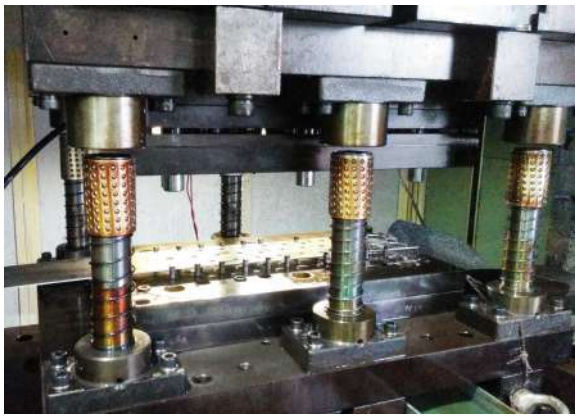
UNISTEEL®
The precision component specialist

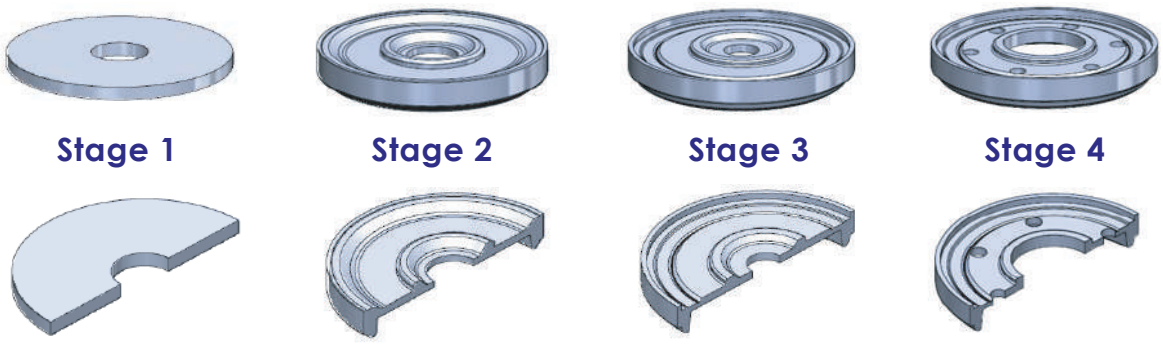
Cold forging, or cold forming is a metalworking process whereby raw material such as metal blank or slug is plastically deformed between dies to achieve a desired shape. As the name implies, cold forging is carried out at room temperature. It is one of the main manufacturing processes employed by Unisteel, being involved in production of two of our company's Core Products: fasteners and cold formed parts.

Deformation of a workpiece is divided into several stages depending on the workpiece dimensions, stress/strain of material, desired profile, and forging force applied at each individual stage. Multi-stage cold forming allows for various types of operations to be performed, so that complex shapes with high precision can be attained. At Unisteel, this process can be categorised based on vertical and horizontal orientations of the machines. Vertical cold forging, or stamping, is suitable for products with greater width/diameter than height/thickness. Horizontal cold forging is also known as cold heading. It is utilised to manufacture symmetrical parts with greater height/thickness than width/diameter.

Vertical Cold Forging (Stamping)

Stamping uses vertical mechanical presses to apply forces ranging from 25 tons up to 300 tons. Raw materials are fed into the machines either in the form of a continuous metal strip (progressive stamping), or in the form of a washer (transfer arm stamping).



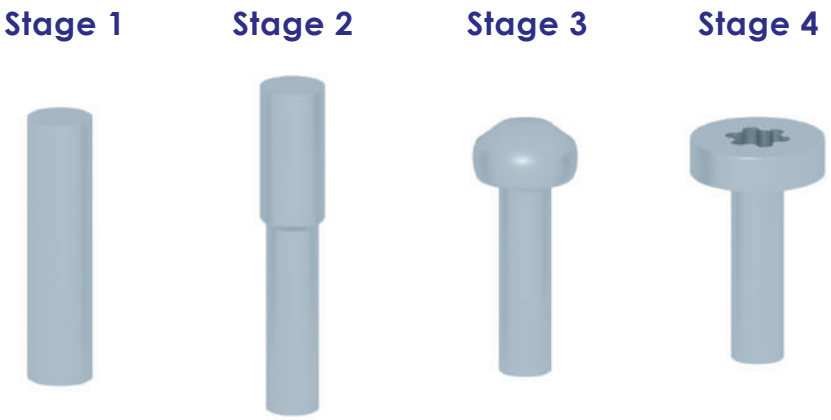


Above is a simplified illustration of operations performed in cold forging of a hard disk clamp:

1. Blanking: washer is punched out of a metal strip to be used for transfer arm stamping
2. Upsetting: part is compressed into shape. Outer diameter increases while thickness is reduced
3. Upsetting/flattening: surface profile is deformed, outer diameter and thickness are further increased and reduced respectively
4. Piercing: through holes are punched out of clamp

Horizontal Cold Forging (Cold Heading)

Cold heading machines at Unisteel are able to exert compressive forces from 8 tons to 85 tons depending on the product size. The number of dies and punches can be used to categorise machines. For example, 1D2B indicates that the machine is of single die and double blows (punches) variant. Components with complex shapes and bigger sizes require more stations and hence more dies and punches. Equipped with 1D2B, 2D3B and 4D4B heading machines, Unisteel has the capability to cold forge wire sizes between 0.5mm – 12mm.



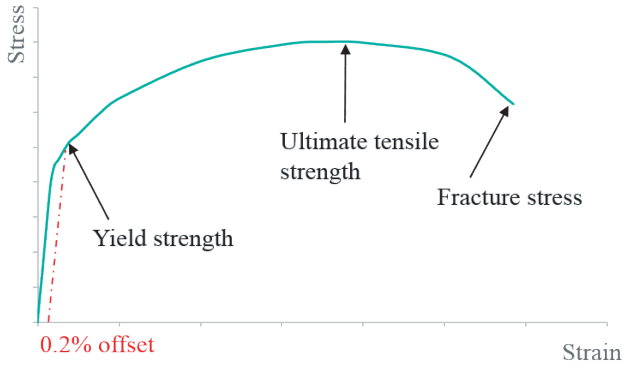
The above diagram depicts 2D3B cold heading of a screw:

1. Cut-off: a section (blank) is separated from rest of the wire and transferred to die
2. Extrusion: blank is backward extruded into die by first punch, reducing the diameter of the lower section. Blank length is increased
3. Upsetting/preforming: in the same die, blank is upset such that screw head is partially formed
4. Upsetting: preform is transferred to the second die where final head of shape is formed alongside the screw recess

Raw Materials

Table 1 Cold Forging Materials

Material	Grades	Properties
Stainless steel	300 series, 400 series	▪ Corrosion resistant ▪ High strength ▪ Non-magnetic (300 series)
Carbon steel	Low carbon steel (C1022), medium carbon steel	▪ High formability ▪ Wear resistant
Aluminium	6000 series	▪ Corrosion resistant ▪ Low density ▪ Non-magnetic
Brass	C2680	▪ High formability ▪ Corrosion resistant ▪ High thermal conductivity
Titanium	CP titanium, $\alpha\beta$ titanium, β titanium	▪ Corrosion resistant ▪ High strength ▪ Low density ▪ Non-magnetic



Choice of raw material for multi-stage cold forging depends on formability of a material. Formability is indicated by the material's ductility as well as the formability range. Ductility, which refers to the material's capacity to be stretched under uniaxial tension, is measured by reduction in cross-sectional area and elongation of specimen in a tensile test. Formability range can be defined as the difference between the yield stress (σ_Y) where plastic deformation starts, and the ultimate tensile stress (σ_U). Materials with larger difference between σ_Y and σ_U are more formable.

Products & Applications

Unisteel is able to fabricate a large variety of engineered products through multi-stage cold forging that meet customers' expectations. As mentioned previously, vertical cold forging is more suited for parts with larger diameter/width than thickness/height. Hence, products made using this method include:


Hard Disk Clamps


Separator Rings


Balance Weights


Washers

On the other hand, horizontal cold forging is utilised for manufacturing components that have smaller diameter/width compared to thickness/height, such as:


Fasteners


Electrodes


Pins & Spacers


Metal Prongs

Advantages of Cold Forging vs Machining Process: A Case Study

Compared to conventional machining, material wastage of multi-station cold forging is minimal, even though both techniques achieve comparable tolerances of IT8 on the International Tolerance Grade (≥10-14μm). Furthermore, surface roughness resulting from cold forging is 0.3-3.5μm versus 10-15μm asperity height caused by CNC machining, which leads to smoother part surface.

The table below compares the amount of scrap produced from cold forging (4D4B cold heading) and machining of a bolt:

	Cold Forging	Machining
Blank weight	4.8g	12.4g
Finished weight	4.1g	4.1g
Material loss	0.7g (14.6%)	8.3g (66.9%)

Compared to cold heading, machining produces 4.2g more scrap, which is enough material to cold form a second piece. Besides, the presence of dies ensures high repeatability, and allows for cold heading rate that is in excess of 100 parts-per-minute versus the long cycle time of machining.

Summary

Multi-stage cold forging is a metalworking process which has many benefits, including:

1. Zero or minimal material lost from the cold forging process
2. Extremely suitable for high volume mass production, due to high output quantity per minute
3. Dimensional tolerances and high consistency are easily achievable
4. Good surface finish, usually does not require further post processing
5. Parts have increased strength due to work-hardening effect

Cold forged products of Unisteel have found their uses in many applications especially in data storage, consumer electronics and automotive industries. Equipped with state-of-the-art machines and backed by its skilled workers, our company strives to become a multi-stage cold forming specialist that continues to provide consistent and reliable solutions to our customers.

Ref 1: *https://www.slideshare.net/Interplex2015/cold-forging-precision-cold-forged-progressive-stamping*
Ref 2: *http://www.fabricatingandmetalworking.com/2012/10/cold-forming-waste-not-want-not/*
Ref 3: *https://www.pivotpins.com/cold-forming-wp-download.html*
Ref 4: *Components For the Most Demanding Applications: Discover the World of Cold Forming, SFS*

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