



metkon[®]
Technology behind Specimen

MOST COMMON METALLOGRAPHIC
APPLICATIONS IN
FASTENERS



BASIC INFORMATIONS ABOUT FASTENERS



Fastener or fastening is a hardware device that mechanically joins or affixes two or more objects together. In general, fasteners are used to create non-permanent joints; that is, joints that can be removed or dismantled without damaging the joining components. Welding is an example of creating permanent joints. Steel fasteners are usually made of stainless steel, carbon steel, or alloy steel.

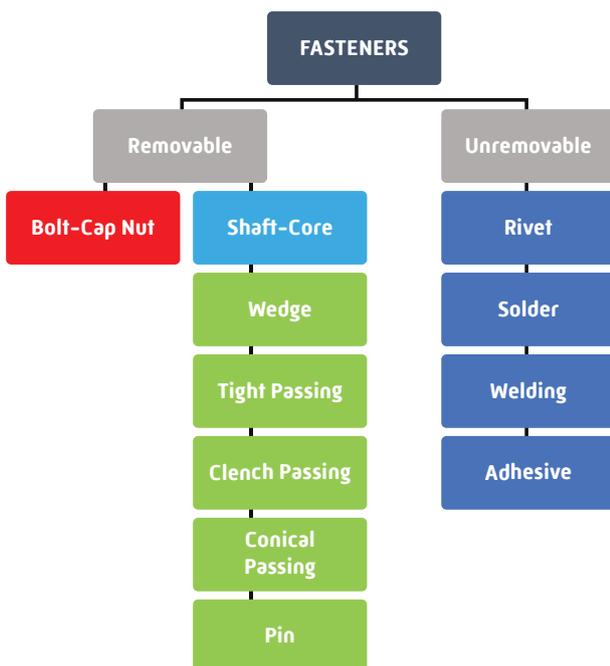
When selecting a fastener for industrial applications, it is important to consider a variety of factors. The threading, the applied load on the fastener, the stiffness of the fastener, and the number of fasteners needed should all be taken into account.

When choosing a fastener for a given application, it is important to know the specifics of that application to help select the proper material for the intended use. Factors that should be considered include:

- Accessibility
- Environment, including temperature, water exposure, & potentially corrosive elements
- Installation process
- Materials to be joined
- Reusability
- Weight restrictions

TYPE OF FASTENERS

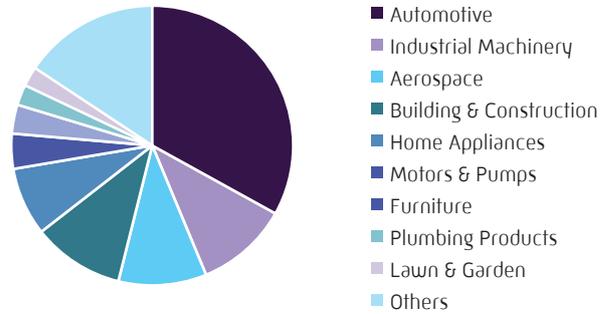
Fasteners usually categorized in two main topics. These are removable and unremovable fasteners.



MAIN APPLICATION AREAS OF FASTENERS

Fasteners use in many areas such as automotive, industrial machinery, aerospace, construction, furniture etc. At the same time, this situation leads to huge variation about fasteners' material type.

Global industrial fasteners market share, by application, 2018 (%)

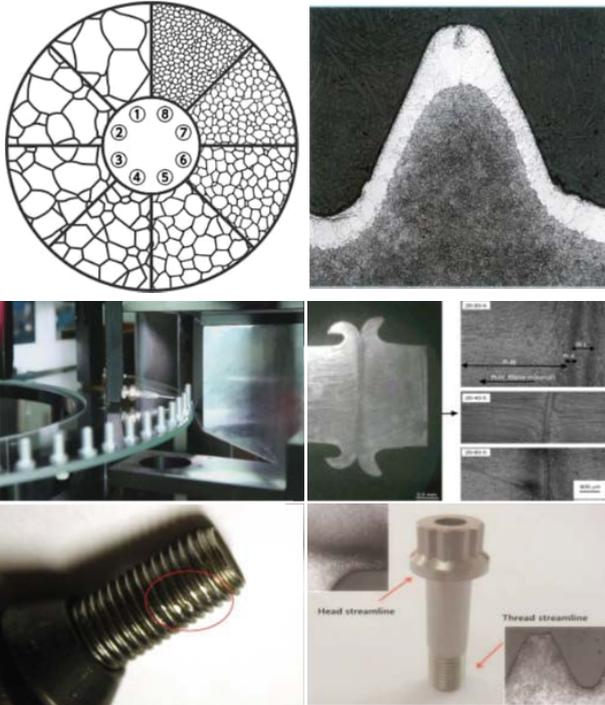


- **Steel:** The most used material in fasteners. Endurance for almost all applications. Most economical.
- **Aluminium:** In a lot of areas where lightness is important, used after special surface treatments.
- **Ti and Inconel:** Especially in aerospace industry.
- **Plastics:** Although not as strong as steel, aluminium and titanium; due to its high impact and vibration resistance or in applications where extra lightness is required.



MANUFACTURING & CONTROL PROCESSES OF FASTENERS

- Raw Materials Control: Grain size, inclusion, decarburization etc.
- Shaping (Hot/Cold Forging: Visual inspection, dimensional analysis etc.
- Heat Treatment: Microstructure, hardness testing, grain size etc.
- Machining/Drilling: Visual inspection
- Screw Threading: Forging lines, failure analysis, hardness testing etc.
- Surface Treatments: Coating thickness and depthness.



FUNDAMENTALS OF METALLOGRAPHIC PREPARATION OF FASTENERS

- The main inspection areas are samples' cross section edges especially surface hardened samples.
- Hardness value of samples are higher than routine samples. Hardness testing may be required during the sample preparation.
- High magnification values (500x, 1000x etc.) are necessary for a lot of details especially for fine grains, thin hardness surfaces, nitration, decarburization and carbonization layers, martensite, bainite and pearlite structure.
- As a result; prepared samples have to include good edge sharpness, planarity and parallelism.
- Methods and consumables for all metallographic steps are determine factor for this level.

1. Cutting Operation

- Cutting disc should be suitable for sample hardness and structure.
- Parameters should be optimized for burrless, unburned and planar surface for cutting operation. [avoid to possible hardness decrease.]
- Cooling process should be effective during the operations and cooling parameters should be suitable for sample quality.
- SiC cut off wheels must be chosen for especially ductile materials such as Al, Cu, Zn.
- When superalloys, Ti and Ni alloys choose for application; abrasive cut off wheels may have not enough performance. Diamond cut off wheels should be chosen for these materials.
- Fine grit cut off wheels and high RPM can be preferred for avoid to smearing.
- Abrasive or precision cutting method according to sample size and shape.
- Double-sided clamping if possible for avoid burrs.
- Universal or special clamping devices for samples.
- Before cutting operations of very small and sensitive samples; hot or cold mounting can be good for adhesiving.
- Stainless and plastic clips have a lot advantages for thin and small samples in mounting process.

Al ₂ O ₃			
Hard	Medium	Soft	Super Soft
< 23 HRC	>23-35 HRC<	>35-55 HRC<	>55-70 HRC<

SiC	
NF	Ti
20 – 130 HB	140 – 350 HB



2. Mounting Operation

- Edge sharpness is important almost all applications. Mounting is good for this topic.
- Sample planarity should be done before mounting operation. There should be no burrs and pollutions especially in screw thread.
- Mounting method should be chosen according to sample hardness and investigation type.
- Phenolic products are suitable for microstructure investigation, forging line analysis etc. However, if edge sharpness is important and if coating thickness, nitration or decarburization layers etc. will inspection; epoxy and diallyphalaf mounting powders must be chosen.
- Acrylic mounting powder can be preferred for dimensional analysis and numbering.
- Sample should be placed middle point in mould.
- Cold mounting is best way if there are a lot of small samples.



HOT MOUNTING



29-001 BAK-B



29-002 BAK-R



29-010 NET



229-011 EPO



29-012 DAP



29-013 CON

COLD MOUNTING



EPOCOLD



DMT 20



DMT 35



DMT ACE



DMT CON



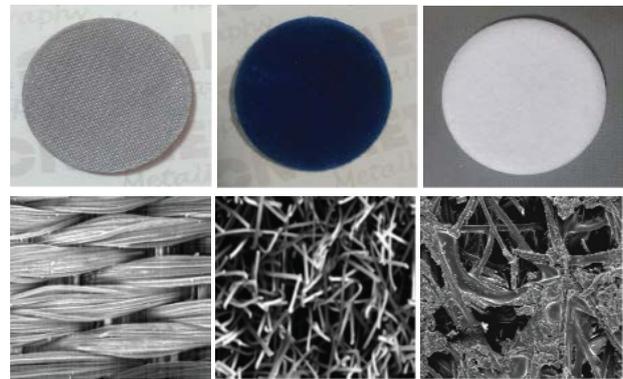
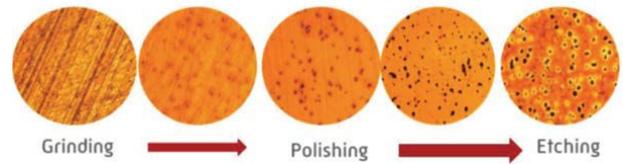
3. Grinding Operations

- Traditional SiC grinding papers often use in grinding operations because SiC grinding papers have very good grinding performance, low cost and suitable for manual operation and non-mounted samples
- Diamond grinding discs are best option for edge sharpness. However; diamond grinding discs are not suitable for un-mounted sharp samples like screw. They can be chosen after planar grinding operations.
- If automatic grinding/polishing machine is chosen; sample holder should be positioned to edge of the grinding disc. Double surface and half moon effect can be eliminated with this method.
- Sample holder and base should be turned same direction for minimum deformation in automatic operation.



4. Polishing Operation

- Woven clothes should be chosen in coarse polishing. Because they have good abrasion, good planarity and low relief feature.
- Diamond and alumina products are functional with flocked clothes for eliminate scratches with minimum deformation in fine polishing operations.
- Gradual polishing steps and polycrystalline diamond suspensions very good for special application like matrix control, coating, high magnification requirement etc.
- Colloidal silica is perfect solution almost for all non ferrous materials like Al, Ti, Inconel etc. in final grinding

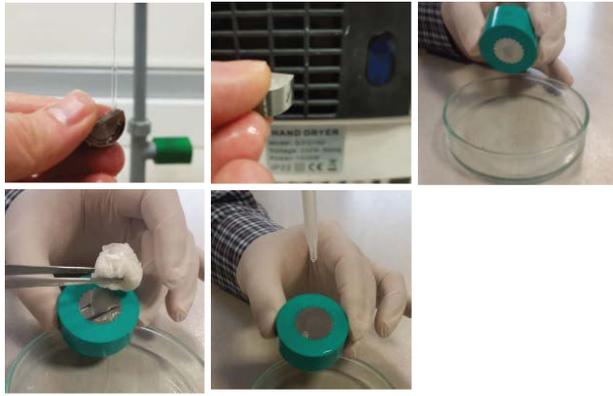


5. Cleaning and Etching

- Edge area investigation is important topic in fasteners application. Therefore, there should be no pollitions and gaps between sample edges especially non mounted samples.
- If colloidal silica uses in final polishing; samples can cleaned with water completely and ethanol can be chosen final cleaning. (water can be opened in polishing operation last 30 sec.) In addition; colloidal silica has pre-etching skill especially for non ferrous materials.

Most Common Etchants

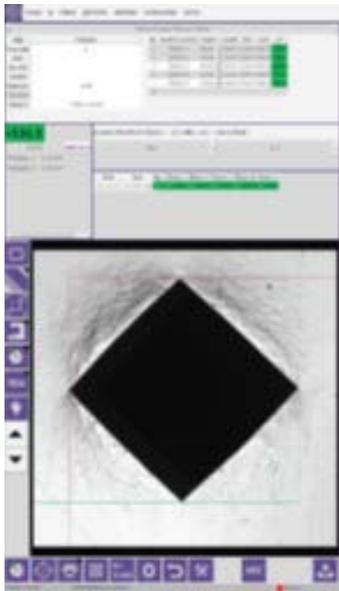
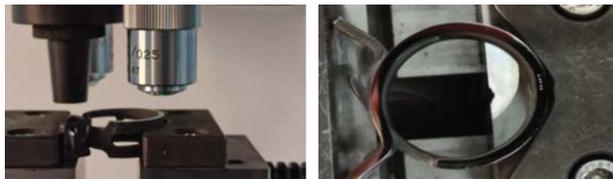
- For Steels: Nital
- For Al: Keller, Tucker NaOH Solution
- For Cu: Water+FeCl₃ +HCL Solution
- For Ti: Kroll Solution



ANALYZING METHODS OF FASTENERS

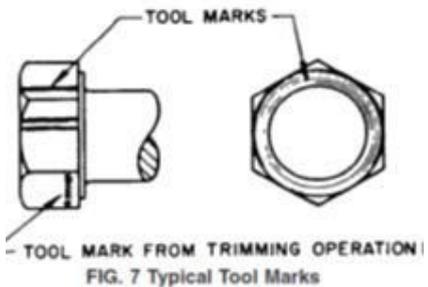
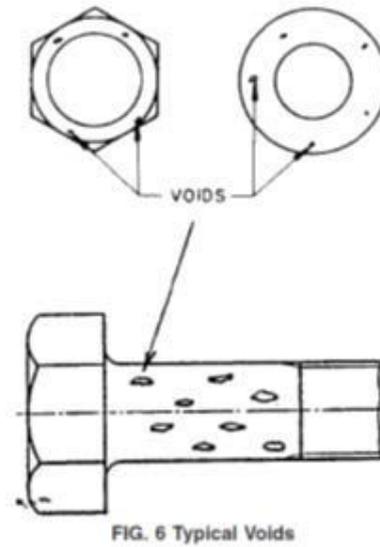
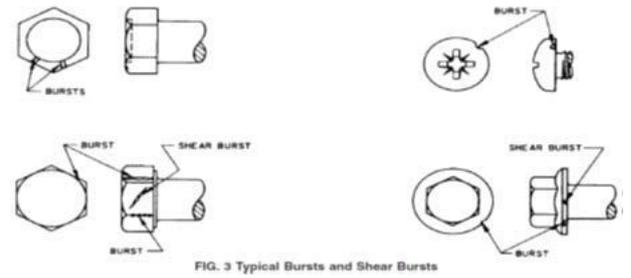
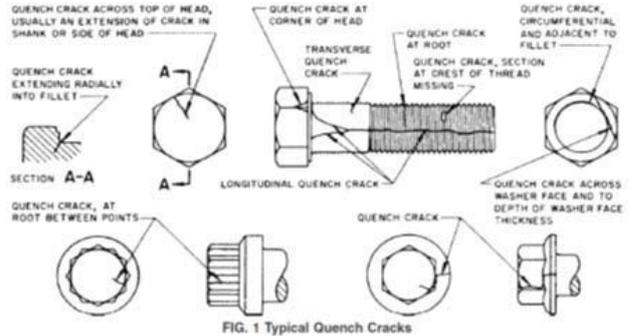
1. Hardness Analyzing

- Grinding and coarse polishing steps usually enough for analysis.
- Sample's planarity should be provided before investigation.
- Section area should be choosed middle point between screw head and threads.
- Latitudinal or longitudinally examination can be preferred according to screw size
- If want to decarbazation depth measue; light etching process can be useful for detemine to hardness area



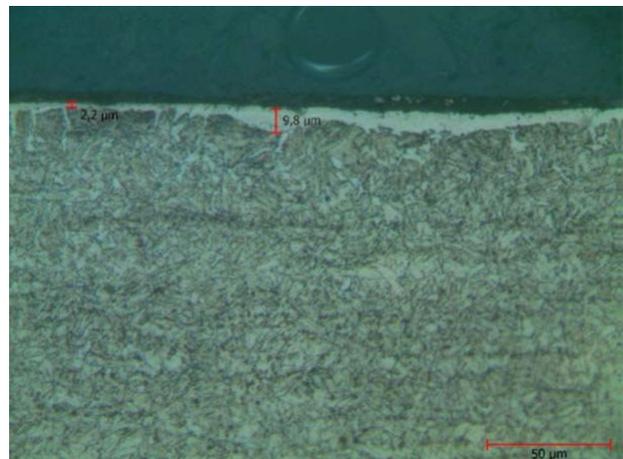
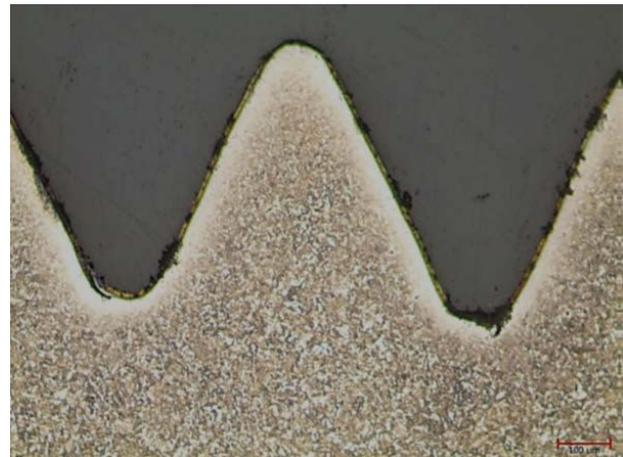
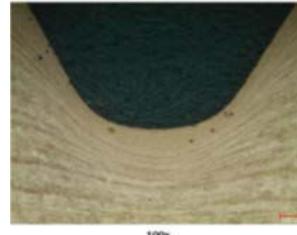
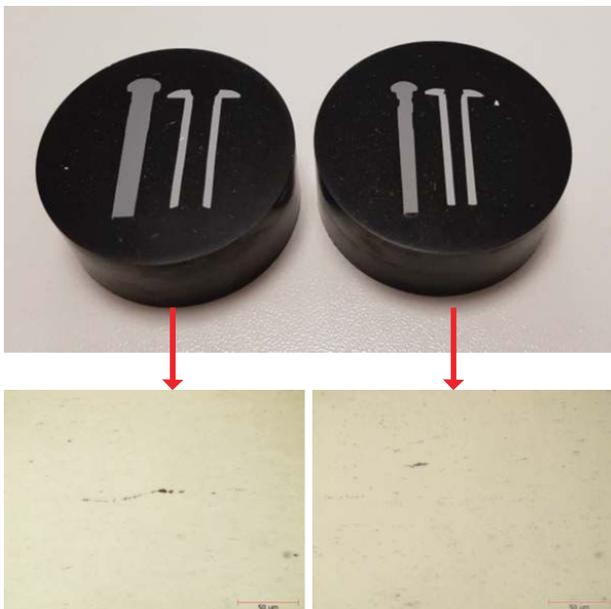
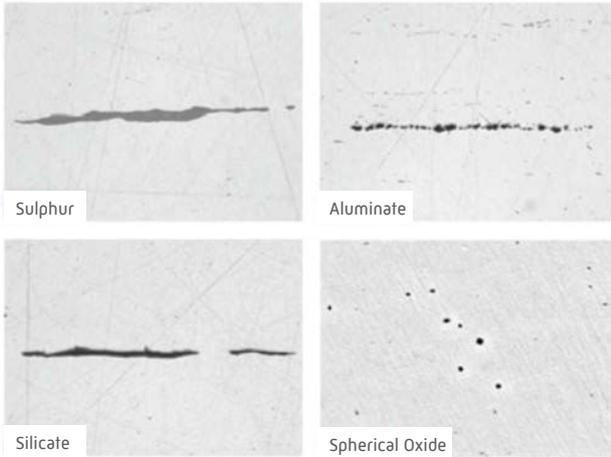
2. Failure Analysis and Visual Inspection.

- In order to fully see the possible defects, it is important that the sample is polished to the final stage.
- ISO 6157 and ASTM F788 standarts use for surface failure. Main failures are fractures, voids, lacerations, impacts, tool marks etc.



3. Inclusion Analysis

- In order to fully see the possible inclusions, it is important that the sample is polished to the final stage.
- ASTM E 45 & E 1245 are standards of inclusion types.



4. Decarburization, Forged Lines & Grain Size

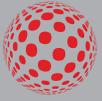
Samples must be grinded, polished step by step and etched with suitable etcher and final structure must be gained for all these examinations.

The decarburization layers can be determined easily due to contrast difference between ferrite layer and matrix microstructure

Forging lines direction can be observed throughout the sample cross-section after etching.

According to ASTM E 112 standard, etched microstructure picture with 100x magnification should be taken for grain size and microstructure analyses.





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