TECHNotes

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Metallographic Preparation of Fasteners; Small Sized Fasteners

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Sample preparation of small fasteners

Sectioning

For metallurgical assessment of small fasteners, Figure 1, these can be sectioned slightly off thread centre axis or mechanically ground in the as-received state after mounting to approximately their thread center axis. When sectioning small fasteners, abrasive cutters can be used to longitudinally section them using thin abrasive blades or alternatively use precision sectioning equipment as these ensure low kerf loss and the cut can be made closer to fastener threaded axis. Sectioning the fastener slightly off-centre, Figure 2 (a), leaves sufficient material for subsequent grinding and polishing stages.

Figure 1. *Illustrate typical fasteners sizes, and sectioning machine selection consideration*

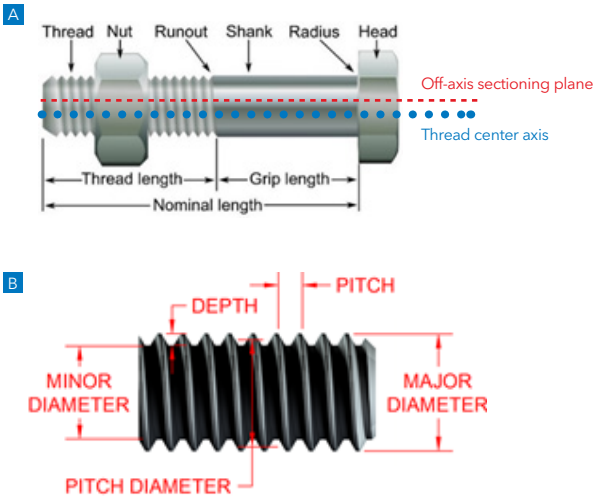


Figure 2. *(a) showing schematic illustration of threaded component with thread axis, and off-centre sectioning plane, and (b) showing the threaded region common terminologies*

An alternative approach is to pre-grind the head region of the fastener until close to the major diameter region around threaded region, Figure 2(b) before mounting. This ensures that during planar grinding stage, with a targeted thickness removal, the process would accurately remove material parallel to the fastener threaded center axis.

Clamping

A proper lengthwise sectioning needs to be done at one go, straight and near the center point of the fastener. Precision sectioning machines can be adopted for smaller fasteners to get accurate longitudinal sectioning. The challenges encountered with small fasteners relate to the ability to clamp the components without changing the cutting axis. When high clamping forces are employed, there is a high likelihood of tilting the fastener cutting axis as illustrated in Figure 3.

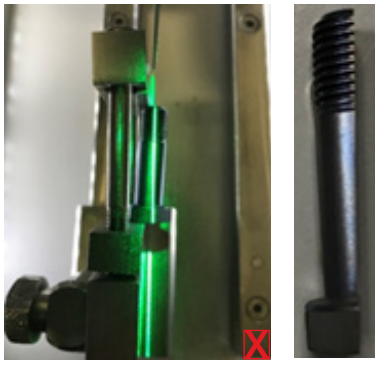


Figure 3. *Illustrates sectioning challenges attributed to clamping on a precision sectioning machine*

A good solution is to clamp the same type of fastener on the opposite position of the clamping system to counterbalance it, Figure 4. This will allow a straighter configuration for both fasteners and also allow higher clamping forces to be used resulting in a stable clamping action on both parts. In addition, one can section two fasteners with only one clamping operation.

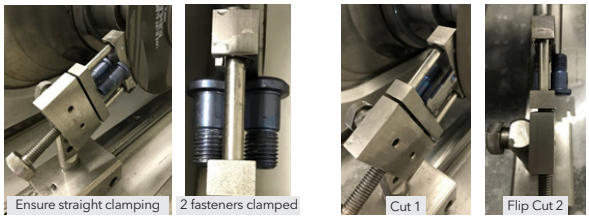
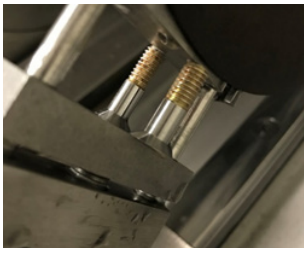


Figure 4. *Illustrates sectioning challenges attributed to clamping on a precision sectioning machine*



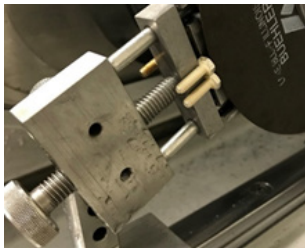
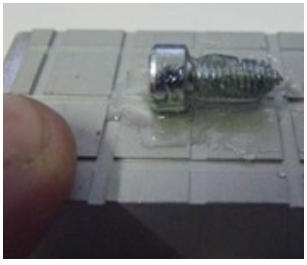
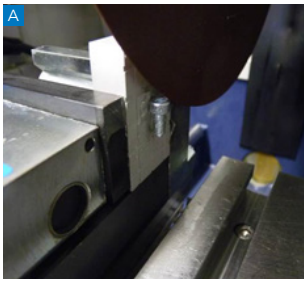


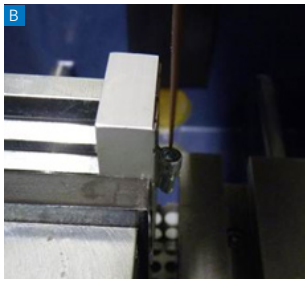
***Figure 5**. Illustrates clamping configuration with single and multiple fasteners on Single Saddle Chuck (Part No. 11-2661) prior to sectioning*

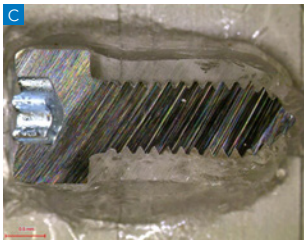
This option also allows multiple cuts on several fasteners as illustrated in Figure 5, for larger diameters and for small diameters to grip on the fastener head as shown. With the aid of laser alignment and the cutting axis more stable, precise off-set from fastener midpoint sectioning can be carried out. For samples that cannot be mechanically clamped due to size, these can be mounted onto a Wafer Chuck (Part No.11-1186) as illustrated in Figure 6 for lengthwise sectioning using crystal bond high temperature wax. The wax has sufficient strength and hardness to hold the fastener in place during sectioning. The wax will need to be heated up to its melting point before pouring onto the fastener to hold it in place. The wax takes 2 to 3 minutes to cure and get sufficiently hard before sectioning is carried out. To remove the sample from the wax mount, the chuck can be warmed up or use of a solvent to dissolve it to get the test pieces out. A good solvent for the de-mounting the wax is acetone as it dissolves the wax quicker.



Notes;
- As mounted threaded fastener using mounting wax before sectioning
- Mounted sample is sectioned on AbrasiMatic 300
- IsoMet high speed can also be used







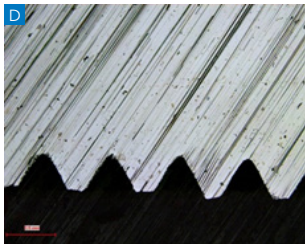


***Figure 6**. Illustrates mounting and sectioning of smaller sized fasteners that are tricky to clamp without mounting. Figure (a & b) show mounted fastener on wafer chuck before sectioning, (c) as sectioned and (d) showing cut finish.*

Mounting

Compression mounting is generally recommended as the best way to get test pieces ready for subsequent grinding and polishing steps. Compression mounting results in repeatable sample mounts and the resins used as highlighted earlier generally offer the best edge retention properties while having higher shore hardness facilitating flatter samples. One can also increase sample throughput by utilising dual mounting, such that two samples can be mounted using same cycle time as illustrated in Figure 7 (a) to (d). For example, using a SimpliMet 4000, one can mount 6 samples with one mounting press for less than 20 minutes, but this is also dependent on the mould diameter used. Larger diameter moulds also offer opportunities to fit more samples on a single mount, as illustrated in Figure 7 (e) further increasing throughput.

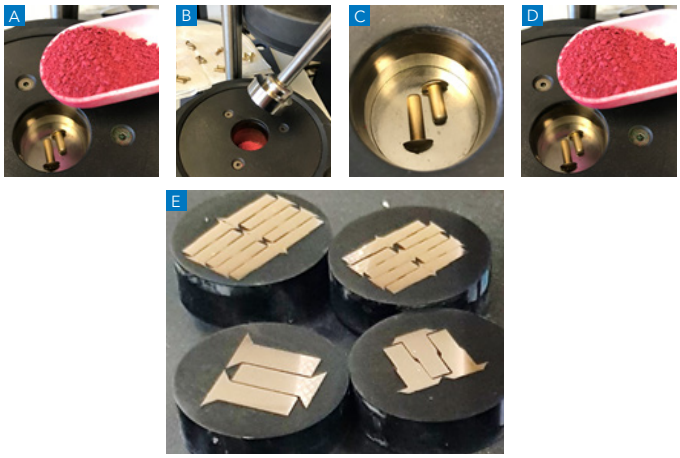


***Figure 7**. illustrates compression mounting (SimpliMet 4000) and the procedure for processing two mounts in one cycle*

For fasteners with diameters below 6mm, sectioning steps can be replaced by a planar grinding step to reach the fastener longitudinal center axis after mounting complete fastener part as shown in Figure 8. For better flatness and to reach the target fastener mid-point, we recommend to grind the fastener head down to the major diameter before mounting.

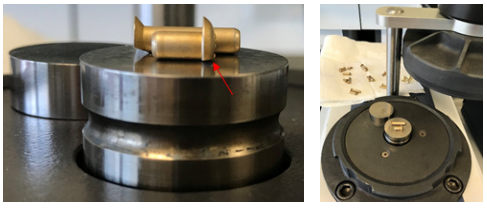


***Figure 8**. illustrates compression mounting (SimpliMet 4000) of un-sectioned fasteners, with head region preground (red arrow)*

An alternative method of mounting involves use of cold mounting media such as VariDur 3003, a three-part component acrylic system that offers excellent edge protection with sufficient shore hardness for good flatness during grinding and polishing stages.

Grinding & Polishing

After mounting, samples can be prepared using two methodologies. For fast preparation ideal for high throughput in the laboratory, a procedure involving planar stone grinding followed by polishing steps can be adopted or follow a more traditional method of grinding and polishing. The method highlighted in this section will illustrate planar grinding procedure carried out. The methodology will also be applicable for other smaller sized fasteners made from other metallic materials.

Table 1 Aluminum Preparation

	Surface	Abrasive	Lubricant/Extender	Force Per 6 samples (30mm)	Time (min:sec)	Platen Speed	Head Speed (rpm)	Relative Rotation	Burst
1	SiC Stone	120	Water	80	Until Plane	-	120	>>	-
2	UltraPad	9 µm Metadi Supreme	MetaDi	180	2:00	120	60	>>	1-2
3	PoliCloth	3µm Metadi Supreme	Metadi	120	2:00	150	60	>>	3-4
4	ChemoMet	MasterMet	Water**	80	2:00	120	60	>>	4-5

>> Comp, >< Contra ** last 15 seconds run water only

***Figure 9**. (a) before planar grinding (b) ground to centre of samples (c) after first polishing step (d) head and radius showing good edge retention (e) polished surface at (20x) magnification*

Planar Grinder Preparation

The procedure involve preparation of mounted samples without prior sectioning of the fastener. PlanarMet grinder can be set to remove up to 3 mm of material in once cycle. For routine analysis, the method tabulated above, Table 1 results in surface with no damage, ideal for dimensional checks and for mechanical defects evaluation along the shank (non-threaded) and head regions. The preparation time carried out as shown took about 10minutes for 30mm mounted sample

For aluminium alloys, Figure 9, after initial grinding, a 9um step with a hard-napped surface was used followed by a medium hard woven surface, Policloth, which is employed to sufficiently recover and remove damage observed after 9µm stage and present a surface ideal for final finish with 0.05micron grit. Final polishing is carried out using colloidal silica-MasterMet, that does a chemo-mechanical polishing aiding with damage removal and to reveal substrate microstructure

Useful References

SumMet, B. (2018). The Science Behind Materials preparation. Waukegan, Illinois, U.S.A. Retrieved from https://www.buehler.com/literature.php

Nelson J and Vander Voort G. TechNote Volume 1 Issue 1 Fastener metallography for today, Waukegan, Illinois, U.S.A. Retrieved from https://www.buehler.com/literature.php

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