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# A Simple Machining Jig for Chevron-Notched Specimens

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A simple machining jig has been designed to rapidly and consistently cut chevron-notches in fracture specimens. The geometry of the jig automatically aligns and positions the specimens while a mechanical clamping arrangement secures pairs of specimens. The design of the jig is adjustable to accommodate any number of specimens within the range of cutting machines which use a rotating blade and a reciprocating cutting action.

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## I. Introduction

Chevron-notched geometries are receiving increased interest for use as fracture specimens(1). Advantages of the chevron-notch include self initiation of the crack at the chevron tip and inherent stable crack growth due to the geometry of the chevron, thus allowing the calculation of the work-of-fracture(2)(3) or the crack growth resistance(4) in even brittle materials.

The general utility of the chevron-notched geometry is somewhat limited by the various machining operations necessary to produce the notch. The simplest machining method is to use a rotating saw blade with no reciprocating action to cut directly into the specimen resulting in the curved sides of the notch as shown in Fig. 1(a). Such a chevron notch will produce stable crack growth although the curved sides will complicate the determination of the fracture area and the specimen compliance in the subsequent fracture resistance analysis.

Straight sides of the notch have been produced successfully by Wu(5) using the specimen stage illustrated in Fig. 1(b). However, this design appears to suffer from inconsistency in re-aligning the initial machined slot with the saw blade after the single specimen is turned to make the second machined slot.

This paper presents the design considerations for developing a simple machining jig for the fabrication of straight notch-sides in chevron-notched geometries. The basic jig design is presented and the utilities of the design and the chevron-notched specimens are discussed.

## II. Chevron-Notch Geometry

The chevron notch has been applied to a

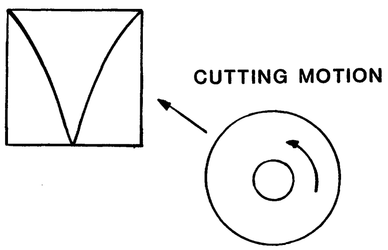


Fig. 1(a) Cross section of chevron notch with curved sides.

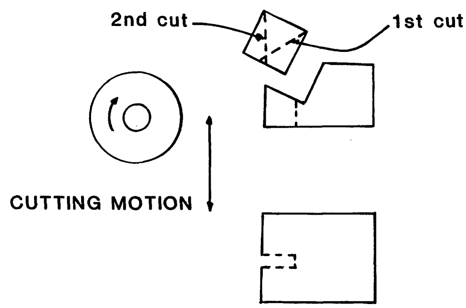


Fig. 1(b) Illustration of Wu's(5) jig for cutting chevron notches.

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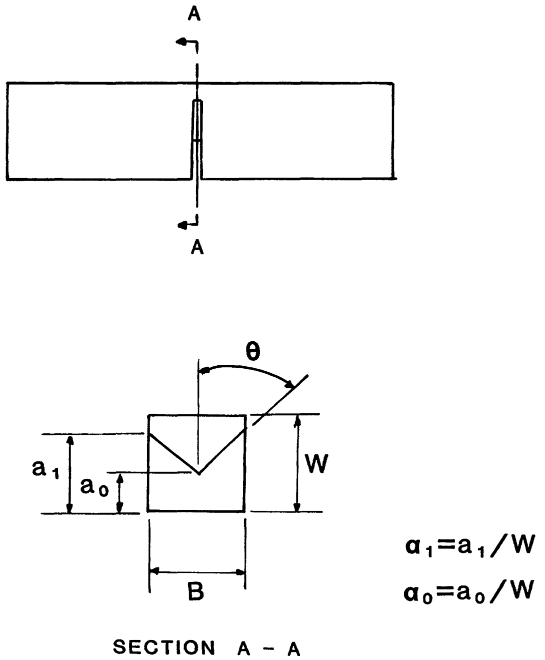


Fig. 2 Geometry and nomenclature for the chevron notch.

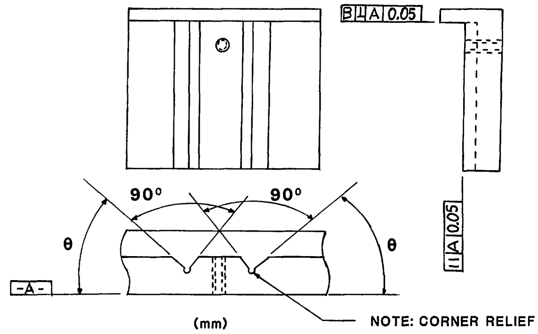


Fig. 3 General specifications for the machining jig.

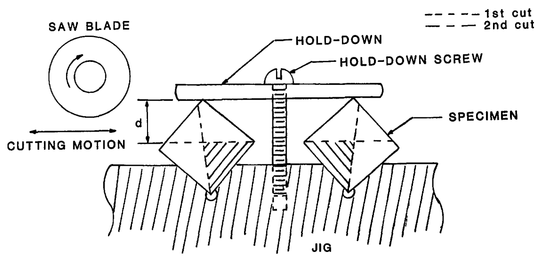


Fig. 4 Details of the specimen hold-downs and cutting operation.

variety of specimen geometries which include short rod, short bar, and three/four-point bend bars. The bend bar will be illustrated in this paper, although the general concepts are applicable to the other geometries.

The chevron-notch geometry and nomenclature are shown in Fig. 2. The chevron-notch half angle, $\theta$, determines the inclination angles of the machining jig. From simple geometric relations, the angle is written as:

$$\theta=\arctan[B/(2W(\alpha_1-\alpha_0))] \quad (1)$$

where the variables are as defined in Fig. 2. The choices of $\alpha_1$ and $\alpha_0$ are dependent on the test material properties and the stability requirements for the fracture test as discussed by Munz *et al.*[6] and Nakayama *et al.*[7], respectively.

## III. Machining Jig

The inclination angles of the machining jig are set by the selection of the specimen geometry parameters. The choices of the length, the width, and the height of the jig are flexible but will be affected by the dimensions of the specimens and the maximum number of specimens to be machined in a single set-up. The jig material should be a quality tool steel such as AISI 4340 so as to provide rigidity and durability in the jig although a good quality brass is an acceptable alternative where concerns exist about the machining of the jig itself.

The general lay-out of the jig is shown in Fig. 3. Note the tolerance for surface 'B' relative to surface 'A'. Surface 'A' is the contact surface of the jig with the cutting machine through either a magnetic chuck or a mechanical clamp. Surface 'B' is the reference surface for the specimen when it is turned to produce the second cut. Since the same end of the specimen is always in contact with 'B' as shown in Fig. 4, proper alignment of the specimen is assured.

The corner relief at the bottom of the inclinations is necessary to ensure the proper clearance for seating the specimen in the jig although the depth of the relief is dependent on the size of the specimen. The screw holes are used to attach the mechanical hold-down devices for clamping the specimens. These hold-downs must be compliant enough to prevent distortion of the specimen, yet rigid enough to maintain the specimen alignment in the jig. A semi-rigid polymer such as a section of PVC pipe works well.

Finally, the depth of the cut (vertical motion of the saw) from the corner of the specimen to the final side of the chevron-notch is written as

$$d=\alpha_1 W \sin\theta \tag{2}$$

where $d$ is the depth of the cut as shown in Fig. 4.

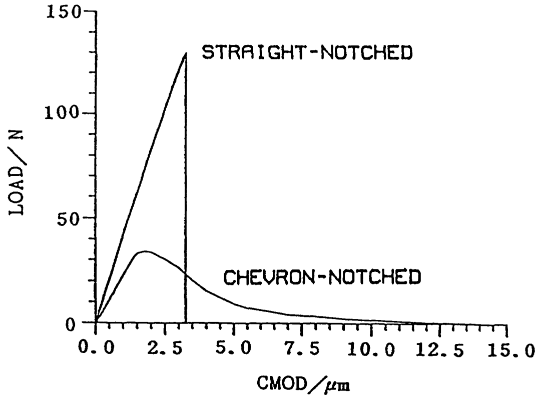


Fig. 5 Comparison of loading curves for silicon carbide three-point bend specimens.

## IV. Discussion

Experience with this machining jig has illustrated the excellent performance of this device for producing chevron notches. The advantage of the chevron-notch over the similar blunt, straight-notched type of specimen is shown in Fig. 5 where the stable crack growth loading curve for the chevron-notched specimen is compared to the catastrophic failure of the straight-notched specimen for a nominally brittle, monolithic silicon carbide at room temperature.

Overall, the consistency of the machining process in producing desired values of $\alpha_1$ and $\alpha_0$ is superior to that found in machining operations for single specimens. The maximum variability and offset which might occur from the rotation of the specimen during the cutting process is estimated on the order of less than 5%.

Loss and breakage due to the mechanical hold-downs has been found to be less than 5%. The increase in productivity has been estimated as a factor of 10 over machining operations which involve only single specimens. The flexibility of use for the jig has been noted for the range of specimen widths and thicknesses from 6–12 mm.

Thus, this simple machining jig has provided a cutting method which is effective, consistent, and flexible in use for producing chevron-notched fracture specimens.

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