Stock Inletting With a Ball End Mill

By James A. Boatright

Introduction

Many small shops building custom target rifles occasionally need to inlet a new stock for a tubular action and barrel, or just the barrel channel alone, for a heavy target barrel. If a manually operated milling machine is available in the shop, an assortment of ball end mills can be obtained inexpensively in standard fractional inch sizes. We will explain in this article how to use a minimum number of milling passes with a slightly undersize ball end mill to mill-out a "circular" channel that is quite true and symmetrical in the stock. Of course, the best way would have been to anticipate exactly what diameters will be needed and to have procured a set of custom made ball end mills of the necessary diameters. It is an advantage for this job if the milling machine came equipped with an optional longer milling table for this set-up. A two-axis Digital Read-Out (DRO) system is also very useful in this approach, as are a quill-depth DRO and a motorized x-axis traverse capability.

Planning the Milling Operation

An important first step is to plan the milling operation clearly. When working with a raw, unfinished laminated wood target stock, we often plan on lightly milling the top surface of the stock blank for perfect trueness after it has been carefully set-up on the milling table. It might also be useful for the first time through this procedure to layout the centerline and desired arc of the barrel channel on the front end of the blank, and perhaps to layout the centerline and milling limits on the trued top surface of the stock blank, as well.

Determine the desired milling radius $\mathbf{R_D}$ for the longitudinal inletting cut in the stock. In our example here, we want to inlet a *Remington 700* action of diameter **1.357-inch** along with its fitted heavy target barrel of constant **1.250-inch** diameter. Of course, the barreled action is to be inletted to a depth so that its "equator" (mid-line) is exactly level with the top surface of the blank from end to end. In this case we are planning not to provide radial clearance around the action until after pillar bedding has been completed. We recommend this procedure to keep things straight. We can easily clearance the receiver later. So, the desired milling radius is:

$$\mathbf{R_D = 1.357/2 = 0.6785\ inch}.$$

In this example, we will assume that the largest ball end mill (not exceeding the desired cut diameter) that we could locate in the shop was a **1.125-inch** diameter mill. So, the radius of the cutting mill $\mathbf{R_C}$ is:

$$\mathbf{R_C = 1.125/2 = 0.5625\ inch}.$$

The diametral clearance in the barrel channel will be **0.107-inch**, and the radial clearance of **0.0535-inch** is suitable for the barrel of this target rifle.

Now, we are ready to enter these $\mathbf{R_D}$ and $\mathbf{R_C}$ values into our worksheet and adjust the allowable error size **E** or number **N** of milling pass-pairs desired. The calculated ***table of offsets*** should be printed for reference at the mill.

Set-Up

The next step is to secure the stock accurately in position atop the milling table. The stock must be *level* along its top surface and *aligned* with the cross-axis of the mill. It must be clamped *securely* with padding used to prevent damage to its surfaces. We usually try to use the main mill vise with padded jaws as part of this set-up. It has remained true and undisturbed on the mill table for several years. The stock must be clamped and supported in several places. We *zero* the y-axis of the DRO with the quill *centered* over the centerline of the stock as part of checking the stock set-up on the mill table.

The **1.125-inch** mill should be mounted into a suitable mill holder and placed securely into the quill. With the quill retracted (raised), move the y-axis back to exactly **0.0000** (if it is not still there), and lock it. Raise the mill table so that the work is about **1.0-inch** below the ball mill, and lock the table knee adjustment. Move one end of the stock under the mill and lower the mill into *minimal contact* with the top surface of the stock, and lock the quill. Run the mill at about 750 RPM, and observe carefully as you make a *trial pass* along the top centerline of the stock. Any misalignment should be apparent.

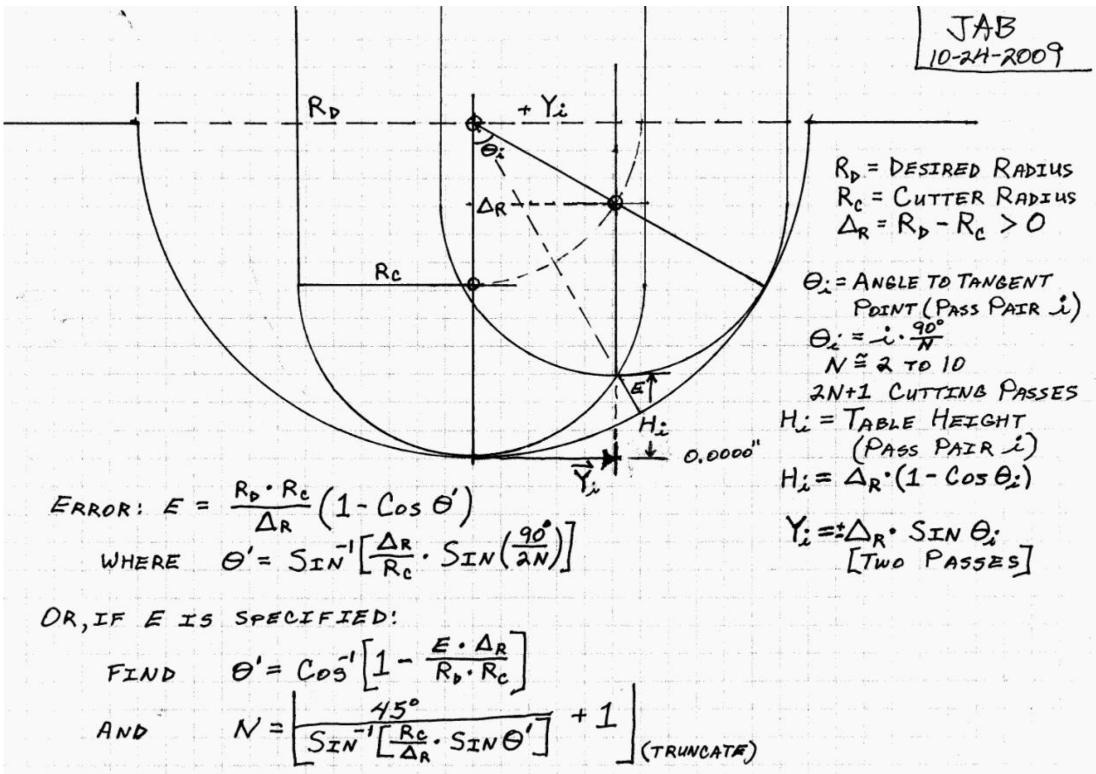
Making the Mill Passes

Now, position the work so that the quill can be lowered just off the fore-end of the stock. Carefully lower the quill by exactly $\mathbf{R_D = 0.6785}$ **inches**. Double check this setting and then *zero* out the quill-depth DRO. Sight past the mill against your limit arc (or depth mark) on the front of the stock. When you are certain that everything is correct, make a full-depth milling pass along the centerline of the stock. This “pass zero” performs most of the material removal, so a fairly slow rate of advance should be selected and set into the x-axis traverse mechanism. Run the table back to the starting end again so that we can adjust the table and quill with the mill hanging out in the air.

From here on, we will raise the quill to the *next shallower* milling depth shown in the worksheet, and re-lock it. Then we will use the DRO to set the *next wider* y-axis offset for a “forward cutting” pass through the stock, and re-lock the y-axis movement. Always ensure that the quill depth setting and the y-axis offsets being used are for the *same* mill pass. These pass-pairs will be removing little material and can be run at a much faster, but controllable x-axis rate. When the mill leaves the stock at the action end, the y-axis offset is *reversed*, and the return pass is made (again in the forward-cutting direction). You did not forget to re-lock the y-axis movement of the table, did you? Some types of wood stocks might actually mill better, with less splintering, if all cuts are made “backward” from the correct metal-removal milling direction. Note that with these “through passes,” all adjustments of cutting depth and offsets are made with the mill *out of contact* with the work. If we were milling-out only the barrel channel, then the reversal of the y-axis offset between the passes of a pair might have to be done as a *cutting operation* across the front of the receiver area. Your hands should know the direction in which to turn the control handle to make this movement correctly.

Finishing Up

After completing the last pass-pair, the milled channel will be quite smooth inside, but with a very slight "ripple" to its cross-sectional profile. If desired, these ripples can be easily scraped or sanded down. While the stock is still set-up aligned and level on the table, we should drill the pilot hole for the rear action screw, so that we can locate the ADL trigger guard for this single-shot action, and mill the trigger recess from the top to avoid interference from the pistol grip in later bottom milling. We would also drill the front action screw pilot hole if the action were to be bedded. In this example to be barrel-block bedded, we will layout the end locations of the block and use a conventional end mill to mill-out a flat-bottomed recess for bedding the barrel-block. We will then re-clamp the stock up-side-down to make three milling cuts along the centerline on the bottom of the stock: one that will exactly fit the polished ADL trigger guard (located on the rear screw pilot hole) and another two to inlet the aluminum ferrules that we will turn



to fit the two barrel-block mounting screws. There is no reason that all of these milling cuts could not be done without damage to a fully finished stock.

Summary of Mathematics Used in Worksheet.