Large Scale Engineering

This series of articles was extracted starting with the May 2002 issue of the CallBoy—Pat Young, Librarian.

Large Scale Model Railway Engineering

Introduction

Designing a good performing model locomotive is a relatively simple job. During the next several months I will describe the procedure that I use when I build a diesel or steam locomotive. This month we will begin by calculating the train weight and from this determine the weight and horsepower required. In future months design parameters for a diesel and steam locomotive along with construction suggestions will be covered.

So lets get started.

Section 1 The load

The first thing one needs to know is the load that one wants to pull. We will use 1 1/2 scale as an example, but this procedure also applies to the small and larger scales. One may wish to pull 6 cars with 2 people in each car. A 1 1/2 scale car weighs about 100 lbs and we will use a average weight of 125 lbs. for each person. We can then calculate the total train weight as follows:

1 car 100 lbs.
2 people 250 lbs.
(1) total for each car = 350 lbs.

350 lbs / car X 6 cars = 2100 lbs.

We must also add the weight of the locomotive which we will say is 400 lbs. The total train weight is therefore:

locomotive 400 lbs.
train 2100 lbs.
(2) total train weight = 2500 lbs.

The rolling resistance of a train on straight level track is approximately 10 lbs. per ton of train weight. Using our results from equation 2 above we can calculate the rolling resistance as follows:

(3) 2500 lbs / 2000 = 1.25 tons
(4) 1.25 tons x 10 = 12.5 lbs rolling resistance

To the rolling resistance we must add the resistance due to grade and curvature. At high speed (over 30 mph) we must also add air resistance, but since our speed are much slower than this we can ignore this factor. The grade resistance is approximately 20 lbs. per ton for each 1% of grade (1 ft in 100 ft.). In our example we will assume a 2% grade.

(5) 20 lbs per ton X 2% grade = 40 lbs. per ton

Since our train weighs 1.25 tons (equation 3).

(6) 1.25 tons x 40 lbs. per ton = 50 lbs. grade resistance

The curve resistance has been found to be the following:

(7)

35 ft. radius = 16 lbs. per ton
45 ft. radius = 12 lbs. per ton
60 ft. radius = 10 lbs. per ton

We will use a 45 ft radius in our example. To find the total train resistance we will add the values for the rolling resistance (equation 4), the grade resistance (equation 6) and the curve resistance (equation 7).

rolling resistance = 12.5 lbs.
grade resistance = 50 lbs.
curve resistance = 12 lbs.
(8) total train resistance = 74.5 lbs.

This means that the locomotive must have at least 74.5 lbs. of tractive effort to pull our train. In order to generate this tractive effort we need two things. First we need enough power on the wheels and second enough weight to prevent the wheels from spinning. This last factor is a function of the friction between the wheel and the rail. This is known as the coefficient of adhesion, which for steel or cast iron is approximately 0.25 under ideal conditions. This value drops off rapidly under wet conditions. The maximum tractive effort that can be generated is equal to the weight on the driving wheels times the coefficient of adhesion. In this discussion we will assume that all the weight are on the drivers.

(9) 400 lbs x .25 = 100 lbs. tractive effort

In equation 8 we calculated that we need 74.5 lbs of tractive effort to pull our train and equation 9 tells us that we can generate 100 lbs.

The next thing we must consider is the speed that the train is to run. This is typically 4 - 6 miles per hour with a maximum speed of 8 mph when dealing with 1 1/2 scale. The speed is a function of the wheel diameter and revolutions per minutes(rpm). In this example we will use a 40 inch diameter wheel which is 5" in diameter in 1 1/2 scale. To calculate the rpm required for a top speed of 8 miles per hour we proceed as follows:

(10) 1 mile per hour = 88 ft per minute

(11) 88 ft per minute = 1056 inches per minute

The circumference of a wheel is found by multiplying the diameter by the value of "pi" (3.1416).

(12) 5 in diameter x 3.1416 = 15.70 inches

(13) 8 miles per hour = 8,448 inches per minute

To find our rpm divide 8448 inches per minute by the circumference of the wheel (equation 12).

(14) 8,448 / 15.70 = 538 rpm

We now have the speed (rpm) and the required tractive effort. The last step is to calculate the axle torque required to generate this tractive effort. To do this we will use the maximum tractive effort calculated in equation 9 which was 100 lbs., and the radius of the wheel (1/2 the diameter). The total axle torque is tractive effort times the wheel radius.

(15) 100 lbs x 2.5 inches = 250 in lbs of torque

Our last step is to calculate the approximate horsepower required to generate this torque at this speed. This will be a rough approximation which we will refine latter. The horsepower is found by multiplying the torque (in in-lbs) by the speed (rpm) and dividing the result by 63025.

(16) hp = 250 in-lbs x 538 rpm / 63025 = 2.13 hp.

To sum up we have determine that we will need 250 in lbs of torque at 538 rpm to meet our performance expectations.

That's it for this month. Next month we will examine the power train for a miniature diesel locomotive.

Large Scale Model Railway Engineering

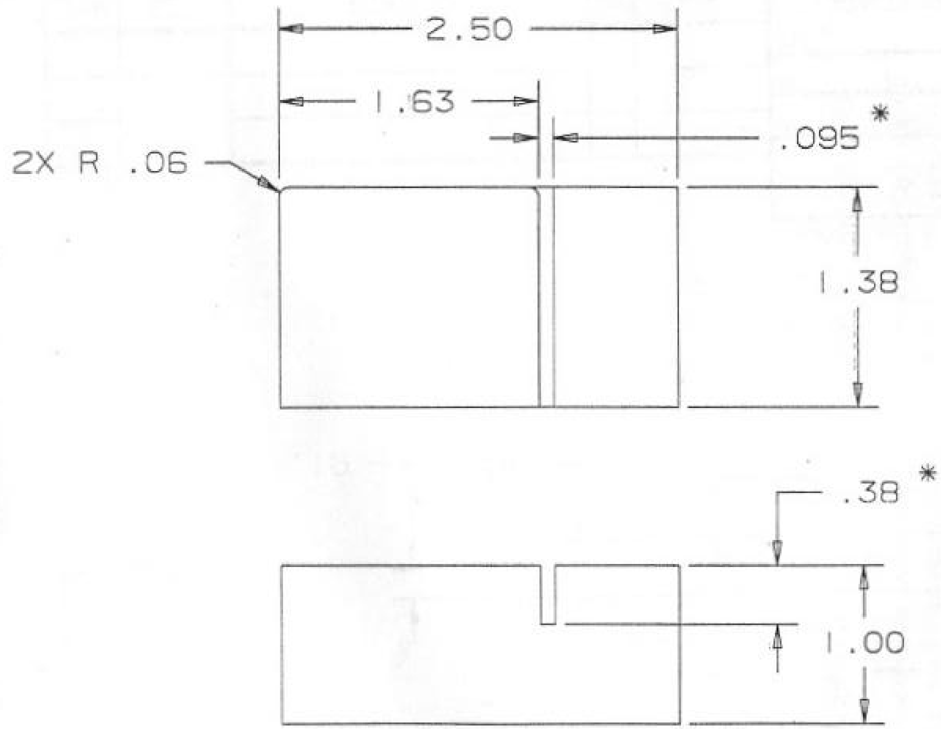
This month I will show you how I make stirrups for my cars. I use 3/32 x 3/8 brass strip cut into pieces 7 1/16 long. Steel can also be used if one desires. Either material is hard to find since it is not a common size but its worth the effort if you can find some. I have tried 1/8 material but it looks to large and 1/16 is too flimsy.

Start by taking the strip and sliding it into the slot of the forming block with 1 7/32 sticking out the side opposite the .06 radiuses. Bend the stock around the first .06 radius on the forming block then the second. You should now have a "u" shaped piece with the legs the same length. You might have to adjust the 1 7/32 dimension slightly to get the legs equal depending on the bending characteristics of the material.

Once the forming is complete take the place the stirrup back into the forming block and slide the forming tool (cd-134) over the exposed end. Twist the tool 90 degrees with a wrench and you will have a perfect twist in the stirrup leg. Drill the two 1/8 mounting holes using the forming tool as a drill fixture and then repeat the process for the other leg.

There you have it, perfect stirrups every time. Next month back to car construction.

Another article from the collection given to us by Tom.Artzberger



* SLOT WIDTH AND DEPTH TO SUIT STIRRUP DIMENSIONS

DO NOT SCALE DRAWING

TOLERANCES

UNLESS OTHERWISE SPECIFIED:

ANGLES ±1°

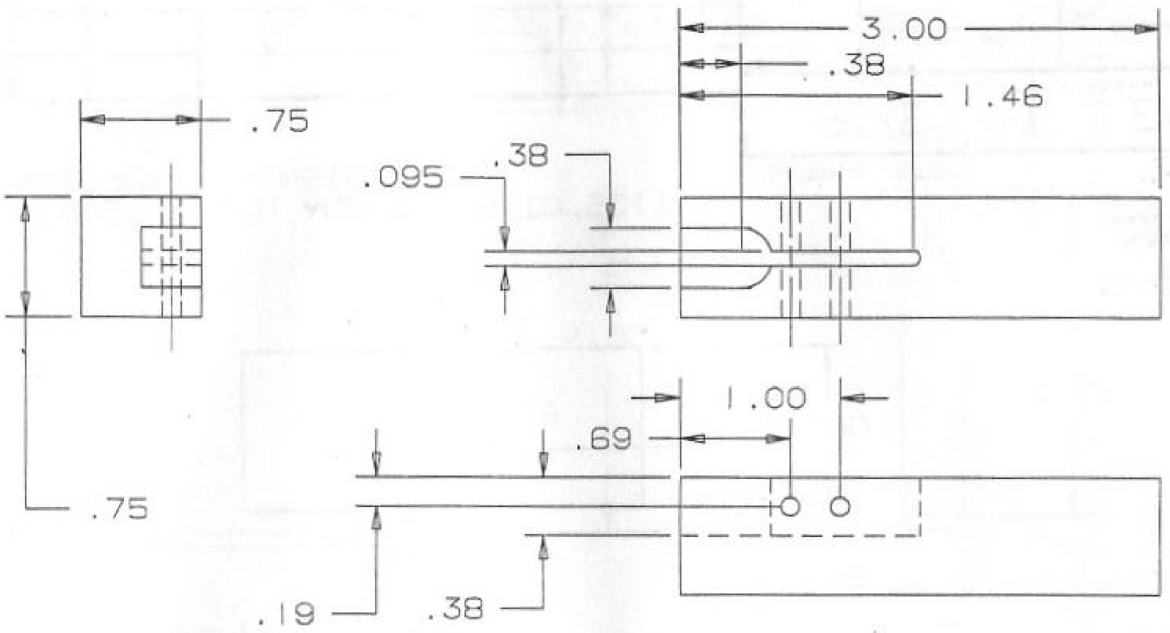
DECIMALS: (3 PLACE) ±.005 (2 PLACE) ±.015

MATERIAL: STEEL

SYM	ECO	REVISION	BY	DATE
–	–	–	–	–

PIKE LAKE & EASTERN
Hartford Shops

DWN TA	DATE 8-1-94	FILE –	SCALE 1
CKD –	DATE –	DWG –	1-100
TITLE FORMING BLOCK, STIRRUP			NO. CD-133



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TOLERANCES
UNLESS OTHERWISE SPECIFIED:
ANGLES ±1°
DECIMALS: (3 PLACE) ±.005
(2 PLACE) ±.015

MATERIAL: STEEL

SYM	ECO	REVISION	BY	DATE
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PIKE LAKE & EASTERN
Hartford Shops

DWN	DATE	FILE	SCALE
TA	8-1-94	–	1
CKD –	DATE –	DWG –	1-100

TITLE: FORMING TOOL, STIRRUP

NO. CD-134

Large Scale Model Railway Engineering

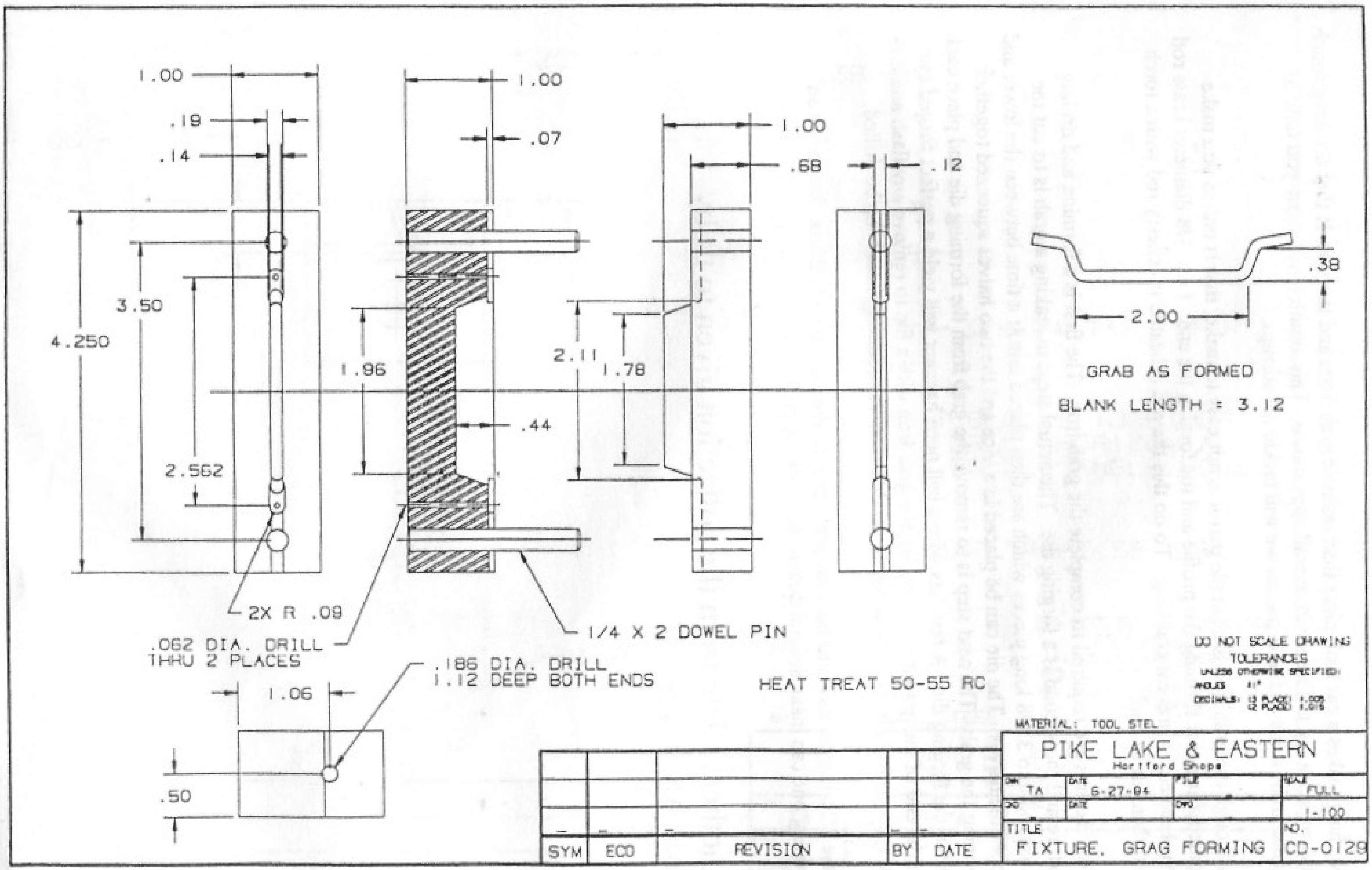
Nothing makes a car look nicer than realistic grab irons and stirrups. It that finishing touch that makes a big difference in overall appearance. This month I will show you how to make grabs irons and next month we will tackle the stirrups.

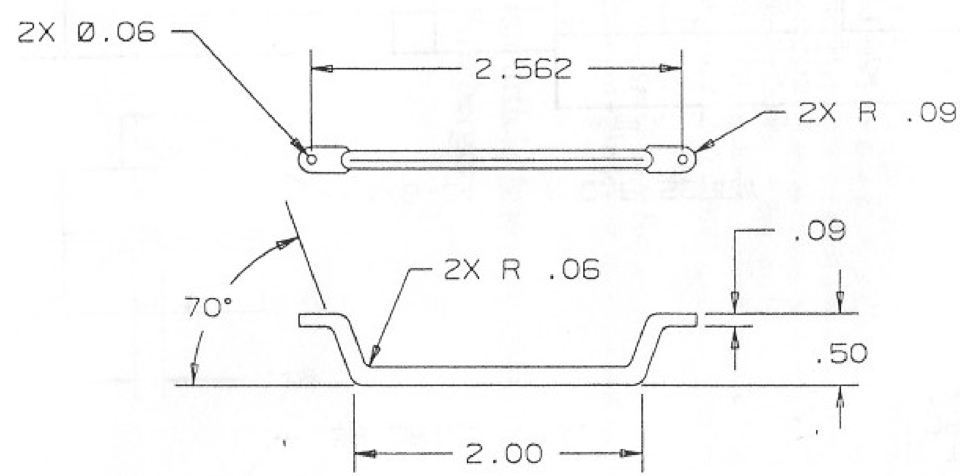
Although the grab iron is a simple part it is not easy to make, that is unless you make some fixtures for forming the profile and for forging the end. I use 1/8 diameter brass rod that I anneal to prevent cracking. To do this the rod is heated up cherry red with a torch and then left to cool.

Two fixtures are required to complete the grab iron. The first is a forming and drilling fixture and the second is a forging die. The actual steps in making a grab is to cut the brass rod into 3 1/8 long pieces which are then placed one at a time between the lower and upper die halves. The die can be placed in a vice and the two halves squeezed together forming the grab. The next step is to remove the grab from the forming die and place each end in the forging die. A few hits with a ball peen hammer will yield a perfect forged eye on the end of the grab iron. Clean up the grab iron with a file to remove any flash and it is ready to go back into the forming die so that the two mounting holes can be drilled.

I use 1/16 copper rivets to hold my grab irons to the car but its builders choice. In an evening one can make several dozen nice looking grab irons to dress up a fleet of cars.

Another article from the collection given to us by Tom.Artzberger


1.00
.19
.14
4.250
3.50
2.562
2X R .09
.062 DIA. DRILL
THRU 2 PLACES
1.06
.50
1.00
.07
1.96
.44
.186 DIA. DRILL
1.12 DEEP BOTH ENDS
1/4 X 2 DOWEL PIN
1.00
.68
2.11
1.78
.12
HEAT TREAT 50-55 RC
.38
2.00
GRAB AS FORMED
BLANK LENGTH = 3.12
DO NOT SCALE DRAWING
TOLERANCES
MATERIAL: TOOL STEL
PIKE LAKE & EASTERN
Hartford Shops
TA
6-27-84
FULL
1-100
TITLE
FIXTURE, GRAG FORMING
NO.
CD-0129
SYM
ECO
REVISION
BY
DATE



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TOLERANCES
UNLESS OTHERWISE SPECIFIED:
ANGLES ±1°
DECIMALS: (3 PLACE) ±.005
(2 PLACE) ±.015

MATERIAL: 1/8 ROUND BRASS

SYM	ECO	REVISION	BY	DATE
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PIKE LAKE & EASTERN
Hartford Shops

DWN	DATE	FILE	SCALE
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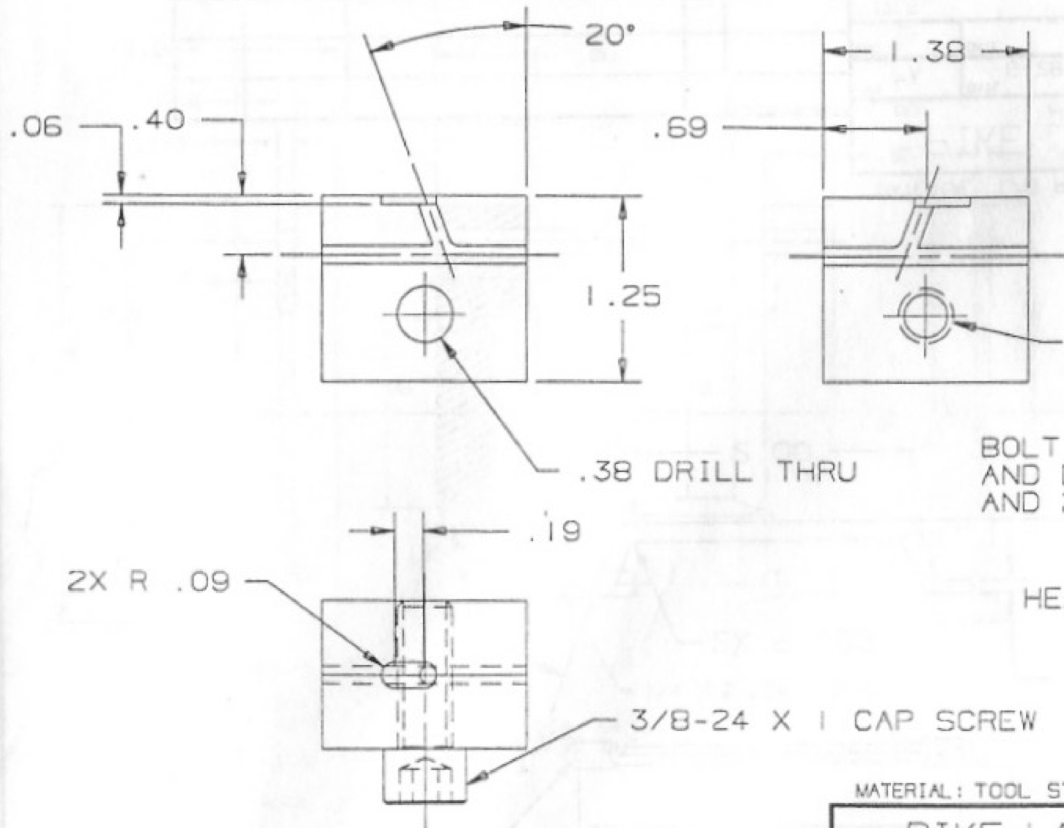
CKD –	DATE –	DWG –	1-100
TITLE: GRAB			NO. CD-130



BOLT BLOCKS TOGETHER
AND DRILL HORIZONTAL
AND 20 DEG ANGLE HOLE.

HEAT TREAT 55-60RC

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TOLERANCES
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ANGLES ±1°
DECIMALS: (3 PLACE) ±.005
(2 PLACE) ±.015

MATERIAL: TOOL STEEL

PIKE LAKE & EASTERN Hartford Shops				
DWN TA	DATE 6-29-94	FILE _	SCALE 1	
CKD _	DATE _	DWG _	1-100	
TITLE DIE, GRAB FORMING			NO. CD-131	

SYM	ECO	REVISION	BY	DATE
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