Workshop # 5 **March 2011**

Ventilated Rotor Brake Temperature – Repeated Heat Flux

The purpose of WS5 is to review detailed applications of the finite difference method and to do parameter evaluations and brake temperature sensitivity studies. Disc brake details see webinar at: http://www.mcicoach.com/service-support/webinars.htm "Getting to know your disc brakes". **PC-BRAKE TEMPERATURE – "Repeated Braking"** is available from the website.

See Section 3.1.10.3 of 3rd edition of ***Brake Design and Safety***/SAE International 2011. The rotor and bearing geometry is illustrated in Fig. 3-14. The actual working sketch of Fig. 3-14 is attached. The temperature response of Fig. 3-15 is for 30 cycles of varying braking severity (70 mph). The convective heat coefficients were reduced to account for the rust buildup in the cooling vanes (node 2, Fig. 3-8) and tight packaging of the brake limiting effective cooling air flow.

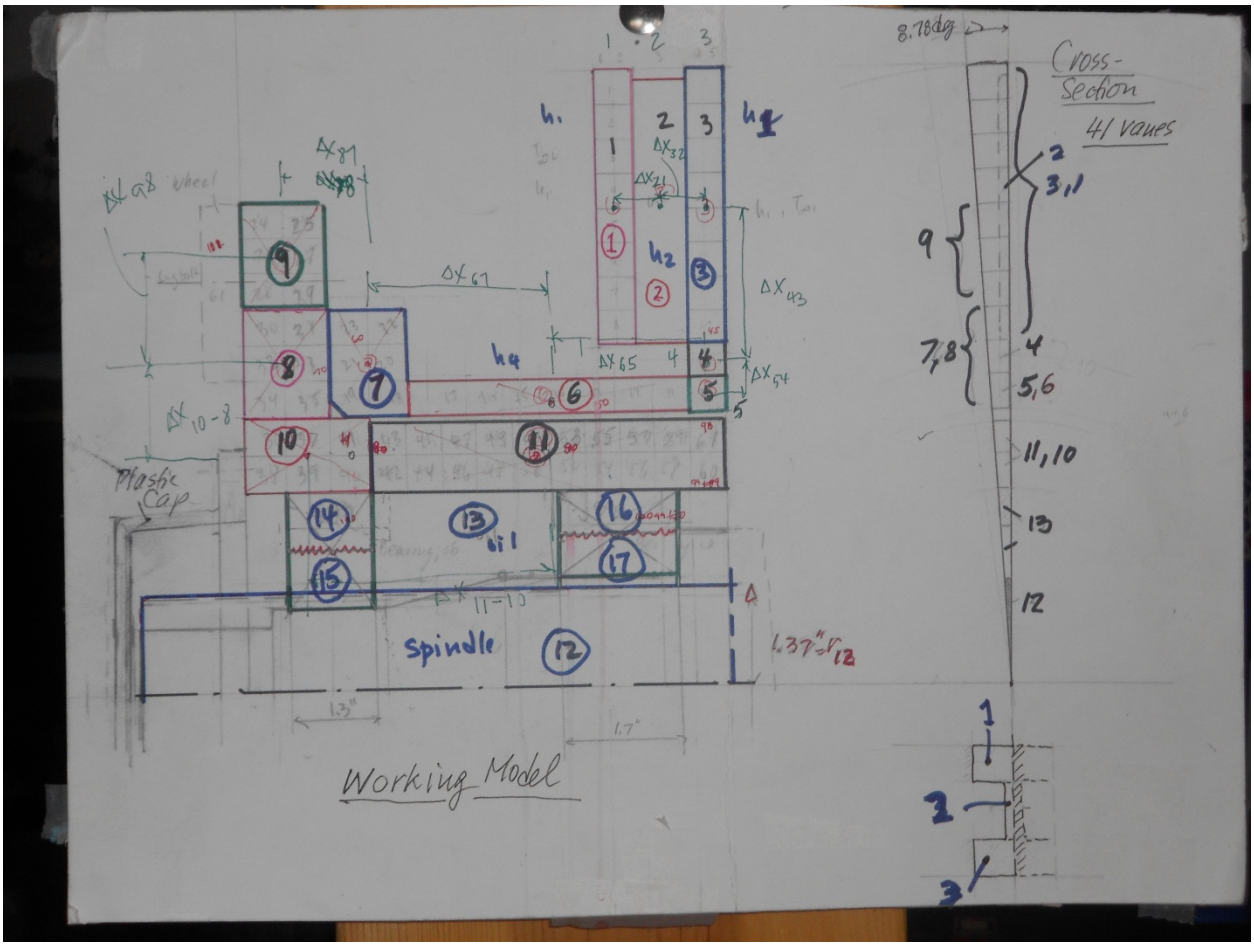
Eq. 3-58 shows the temperature of the inboard node #3. The number of nodes used (Fig. 3-14) is sufficient to study the temperature response for repeated braking. All nodal equations are available in the formula bar of the spread sheet. The computer program attached applies to repeated braking followed by cooling. The input data are shown on Tab NsCC and in **Step 4** below.

Step 1. Use Eq. (3-40) or (3-41) to calculate/estimate convective heat transfer coefficient h_1 for friction/cooling surface of nodes #1 and 3 at 100 ft/sec.

Step 2. Use Eq.(3-42) or (3-43) to calculate/estimate convective heat transfer coefficient h_2 at 100 ft/sec. If needed, choose a truck tire size for wheel revolutions at 100 ft/sec. See Eq. (3-35).

Step 3. Use attached software/spread sheet to study thermal problem. Evaluate temperature chart. Which nodes store most of the thermal energy/heat?

Step 4. Use the data that follow: W = 56000 lb, k = 1, s = 0.012, V = 100 ft/s, a = 25 ft/sec^2, Φ_{front} =0.167, γ = 0.92, n = 10, A_s = 1.13 ft^2, cooling time t_c = 65 sec, braking time t_b = 100/25 = 4 sec.

Step 5. Change the program to a repeated braking/cooling for brake burnishing (FMVSS 105). Use V = 60 ft/sec, a = 12 ft/sec^2, n = 200, t_b = 5 sec, t_c = 95 sec. (See Example 3-5). Use smaller h since speed is lower. Determine after how many braking cycles the friction surface temperature does not increases anymore? What is the purpose of brake burnishing prior to testing the brakes? Bearing heat may have to be reduced since speed is lower. For the wheel loads carried on the tag axle and 70 mph bearing heat used in Figure 3-15was for inboard: 1 Btu/min; outboard: 0.66 Btu/min.

The sketch is the working model for the finite temperature analysis. It is the same as for WS#4 and Figure 3-14.