Tom,

Reference: Locomotive Firebox Grates

While driving home from your place on Sunday, I kept thinking about the failure of the firebox grates in the locomotives. Why was this happening? Surely cast iron was used in the full-scale coal burning locomotives, and they were put too much more rigorous use than what we were doing. What happened here?

After a few more miles, I remembered that back in the "70's I did quite a bit of work in foundries. Many of those foundries were operating cupolos to re-melt cast iron engine blocks to cast new parts. If you are not familiar with a cupolo, it is a refractory lined, steel column approximately 15 - 20 ft in diameter and roughly 6 stories high. Used cast iron, coke, and limestone are charged into the top in layers to fill the column. Once the coke is ignited, and hot air is forced into the column at various points, enough heat is generated to melt the cast iron and produce a continuous flow of molten metal out of the bottom to support the casting line. Now why is this important? Well if burning coke, which is basically coal that has had the volatiles removed from it, will melt cast iron, how can a cast iron grate support a coal fire burning on top of it???

After doing some reading these past two weeks, I learned that cast irons have a working maximum temperature of around 1200 °F, and melt around 1700 - 1800 °F, depending upon how it is alloyed. A coal fire can burn as hot as 3000 °F + depending upon the amount of draft, air temperature, and the oxygen content. So again I'm perplexed as to how can a cast iron grate support a coal fire with out melting or weakening as yours did?

After much reading about how to set and control coal fires in stoves, power plants, heating plants, industrial boilers; and as a last resort talking with some of my full scale steam locomotive friends, I may have discovered the answer/secret. Evidently the trick is to always keep a layer of ash between the grate and the actual burning coals. The ash insulates the grate enough to keep the cast iron within its operating limits. One description of firing a locomotive states that the ideal fire temperature is 950 °F, and that this temperature is maintained/controlled by controlling the depth of the coal bed, and the amount of draft.

Anthracite or hard coal is the best type of coal to burn from the standpoint of the amount of heat, ash, tars, and soot produced from the burn. Pennsylvania contains the largest US deposits of Anthracite coal, so it should not be a problem for you to obtain. However, Anthracite coal requires more effort to ignite, and a good draft to keep burning. One suggestion for lighting an Anthracite coal fire is to soak some coal in kerosene for a few days before starting a fire. Start your fire using some combustibles (paper, wood, etc.), and then add in some of the kerosene soaked coal. As soon as it lights, add in some un-soaked coal.

Several of the articles state that a coal fire should have some depth to it; and once set and burning properly, should be left alone, i.e., no or very little stirring. Now the correct depth of the bed of coals is somewhat debatable. However, there is some relationship between the size of the coal nuggets and the depth of the bed. The larger the nuggets, the thicker the bed has to be, yet, the thicker the bed the cooler the fire. Since your grate failed in the center section only, I would assume that coal was piled lowest in this area. This somewhat makes sense since this area is right in front of the firebox door, which made it easy for the fireman to stir the fire, pushing more of the coals to the outside, so he could visually see the burning coals. If this were true, it seems to indicate that more attention needs to be paid to making sure that there is an even bed of coals across the entire grate, and that there are burning coals across the entire grate. Possibly using smaller size nuggets would be more advantageous in accomplishing this, requiring a shorter bed height in the somewhat shallow firebox. I believe that there are smaller sizes (barley, rice) commercially available that are smaller than what you are currently using. The rest will be fireman's training and practice, of course.

A good draft coming into the firebox from under the grate also seems to be very important to a coal fire. The draft provides oxygen to support the combustion process. After the combustion takes place, the exhaust gas flow transfers/removes the heat from the fire and transfers it to the crown sheet/tubes, and eventual exits out the stack. However, equally important, this flow of air tends to cool the grate from the bottom side. This indicates the importance of keeping the stack blower operating efficiently, especially when the locomotive is not moving. While underway, steam exhausted from the cylinders, and piped to the smoke box and out the stack usually will provide enough draft. Allowing too much ash to build up under the grate is also detrimental. Just as ash can insulate the coal from the grate, it can also insulate the grate from the cooling air (combustion air) coming in underneath it. This indicates that the ash pan needs to be checked and cleaned often.

After reading all of this and discussing it with the railroad enthusiasts within the steam team, you may decide that, since the locomotives will be operated by a variety of people, operating a coal fire under these conditions might be asking a little too much. We could make things a little easier on everyone if the grates had a higher working temperature. If this idea is attractive to you, we could construct a pair of grates from RA 330 stainless steel. RA 330 has an operating temperature of 1800 °F, which would give everyone a larger operating window. RA 330 however is only available in plate and bar forms. The grates would have to be fabricated rather than cast, but since we only need two pieces, this shouldn't be a problem. If this approach sounds interesting to you, let me know. I have some connections and can probably have them fabricated for you. I will need an old grate to use as a pattern.

Being an old time railroad engineer, you probably knew everything that I have learned during my investigation of coal fires. If so, I'm sorry to have taken up your time. If not, well maybe we both learned something. Anyway, hope this helps.

Scott Cruse