

## MECHANICAL DEFECTS IN RAILS.\*

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Mr. Howard has shown us that he finds evidence of unsoundness in all of the rails that he has examined. Some of these rails have, nevertheless, done magnificent service. This demonstrates that when conditions are favorable, either by accident or by intelligent control, the defects unavoidable in our present rail-making processes can be tolerated without undue risk.

I have heretofore discussed the three types of defects named above before other associations, but I wish here to extend what I said at our last annual meeting and to put on record my later convictions on the subject.

White streaks generally run into fissures if followed far enough. They do not extend very deep, generally not over  $\frac{1}{8}$  in., and they occur at different depths, sometimes at the surface, generally a little ways inside the surface. They occupy the zone of the ordinary gas-holes that occur so generally in ingots. Their plane is generally parallel to the axis of the rolls; that is, perpendicular to the surface of the base and top of head and parallel to the surface of the web and sides of head. On the fishing surface of head and base the plane of the seams is dragged by the rolls into positions practically parallel to the surface. The fissures accompanying this type of seams are very straight and they frequently have a granular appearance as though they had been weakly stuck together before rupture, like soldered surfaces. I attribute these seams and fissures to gas bubbles in the plastic steel of the ingots, and from this supposed origin I call them gas-seams.

Gas-holes or blow-holes, as called by some, have been discussed by many metallurgists, notably by Prof. H. M. Howe and Mr. E. Von Maltitz before the Am. Inst. of Mining Engineers. I commend the paper on "Blow-Holes in Steel Ingots" by the latter author to all interested in this subject. (Inst. Mining Engineers, Toronto meeting, 1907.) Our member, Robert Job, illustrates these seams in a paper before the New York R. R. Club, November, 1906, and they show on many lantern slides prepared by Mr. Howard. If these gas-holes are deep-seated in the ingot, so that the seams will be from  $\frac{1}{8}$  to  $\frac{1}{4}$  in. inside the surface of the finished rail they do not seem to be of vital significance. They appear to form at the junction of the columnar crystalline shell of the ingot and its amorphous central core. Proper means for deoxidizing and quieting the steel coupled with moderately slow teeming to the molds has the effect of decreasing the number of gas-holes and causing them to be deep-seated instead of near the surface.

Rolling-flaws are actual figures in the surface of the rail. They are generally somewhat crooked and their planes are frequently inclined to the normal to the surface. Their sides are generally fluted and look bluish like mill scale. They are frequently very minute, but are sometimes easily visible on a new rail as a distinct mark several feet long.

In all of the crescent base breaks that I have examined, including those occurring in service and those produced artificially, it has always been possible to detect the longitudinal seam from which the break started. In the great majority of cases the seam has been of the class that I call rolling-flaws. Most of the rest have been gas seams on the surface.

These flaws appear to me to be the result of checks, cracks or tears in the skin of the ingot or bloom, such as Captain Hunt told us about at our 1907 convention. I believe this class of defects to be responsible for more broken rails than all other classes combined. Their remedy is obvious.

Inclusions of manganese salts, called slag inclusions by Dr. P. H. Dudley and others, are very common and very fatal when near the surface of the head. This feature was well discussed and illustrated in the discussion last year by Dr. Dudley. Manganese sulphide in particular is very brittle and

is probably the cause of most of the failures from split heads. On the other hand, my observation has failed to indicate that these inclusions have very much to do with base breaks, the flaw from which the break starts being, with very few exceptions indeed, a smooth seam face instead of a fracture. Dr. Dudley and Mr. Maltitz show that by adding the spiegle when the bath is hot and allowing sufficient time for the reactions to complete themselves and the resulting salts to rise into the cinder before the metal is teemed into the ingot molds, the danger from these inclusions will be lessened. It stands to reason that if the deoxidizing agent is added to the more or less cooled bath in the ladle that the reactions will be sluggish and that nodules of oxides, silicates and sulphides will be caught in the solidifying mass in the ingot, and when rolled will be drawn into seams, such as we see in split heads and the like.

A fourth type of unsoundness is due to segregation. This leads to crushing of the head, flow of metal and rapid wear rather than to absolute breakage. It can be controlled to some extent, according to Professor Howe, but it is inevitable to a greater or less extent when steel passes from a liquid to a solid state. Segregated material in the head of a rail especially if near the surface, is very objectionable, but if confined to the base will lead to but little trouble. Two ways of attaining this end are open, viz., by throwing the ingots down before freezing is complete and controlling the turns so that the top of the ingot, as it lies in the soaking furnace, shall be formed into the base of the rail, and, second, by rolling the ingot to a slab about 7 in. by 15 in. and splitting it at the last pass by cutting disks or otherwise, and rolling each billet into rails in such a way that the base shall be formed from what was the central part of the slab.

The rails examined by Mr. Howard and those that I have opened up with a hammer show excellent metal where sound. The deleterious effects of improper heat treatment, after the metal has solidified, do not seem to be in evidence to an important extent. In fact, I believe that our recent requirements of shrinkage for heavy rails of the A. S. C. E. pattern are inconsistent and all wrong. It is unsound steel that we should guard against. Dry air for the converter blast and proper deoxidizing and careful teeming will do much towards keeping gas-holes deep-seated and preventing slag inclusions; reasonable treatment in the rolls will prevent rolling flaws; the ever-present segregation can be made harmless by confining its location to the base and web of the rails; and all of these requirements can be covered without decreasing the output of a mill if the plant is built and organized with these points in view. Moreover, more of the melt will finish as No. 1 rails than under present methods.

I believe the investigations that Mr. Howard has started should go on. We need examinations of rails rolled under rational regulations of the recarburizing process, as, for instance, those made under Dr. P. H. Dudley's specification. We want examinations of open-hearth rails. We need to have the imperfections of each of these classes compared with those of the ordinary Bessemer rail of to-day, and we want all kinds of rails available, tested for rolling flaws. We want the scoring of the base that results from the higher speed of the edge of the roll over that of the rail investigated, to see if its effect is deep-seated. We want the effects of the straightening gag fully explored, and we want these features photographed, discussed and correlated so that they can be fully understood. We want blooms and cobbles examined to find, if possible, the origin of these various defects, and we want ingots opened up in order to study the various phenomena of cooling. Especially we should have a quarter of an ingot opened on the diagonal to show the conditions of columnar crystals and entangled gas-holes at the corner where crystals from two sides interfere. The difference in this feature between ingots with square and well rounded corners should be observed.

It is possible that shelly corners of the rail may be due in large measure to the conditions caused by the corners of ingots being too nearly square. We want the chemistry of the streaks and segregated portions thoroughly examined, and we want all this done by disinterested and unbiased parties, who

\* Discussion of Mr. Howard's paper, presented at the Convention of the American Society for Testing Materials.