Cast Iron in Structural Uses.

In the middle of the past century, as cast iron became extensively applied to structural purposes, its physical properties were studied with great care, and the experiments of Hodgkinson and Fairbairn in England and their contemporaries yielded a fund of information on the subject. Seeking a section of beam which should exhibit the highest ultimate strength in proportion to area of cross section or of the weight of metal employed, Hodgkinson advocated a section in which the tension flange exceeded the compression flange about six to one in sectional area, the web usually tapering in thickness from the tension flange, diminishing toward the other flange. This form of beam was largely adopted and took precedence as long as cast iron was used for beams in structures. We find that the same method of reasoning influenced the machine designer in disposing cast iron to seeming advantage in the construction of machines, massing the metal to resist tension and permitting high unit stress on metal in compression. Especially is this observed in machines of the open jaw or gap type, such as presses and punching and shearing machines. The writer believes that usually the unit stresses should be little if any higher in compression than in tension, for the following reasons: In machinery rigidity or stiffness is usually the chief consideration. Many machines do not fulfil the intended purpose properly, not by failure through fracture, but by a want of sufficient stiffness. Deflection has to be limited, and when that is done breaking from excessive tension is sufficiently guarded. Remembering that cast iron yields to compression as much as with the same unit stresses it yields to tension, it follows that the compressive stress should not exceed the tensile strength per unit of section if it is desired to dispose a given mass of metal with least deflection. It is believed that rupture sometimes occurs in a machine apparently through tension, where the origin of the weakness could be traced to a want of material sufficiently to resist compression, the improperly supported tension side severing by cross bending or transverse stress.

Taking for example an open gap machine with frame as shown in the accompanying illustration—tension at T and compression at C, if the section is so shaped that compressive unit stress is six times that of the tensile unit stress, then, elastic moduli being equal, the frame will yield at C six times as much by compression as it does by tension at T. This permits an oscillation of the mass at T around its center. If this oscillation becomes dangerous, by extent or frequency, the frame will break by cross bending at the mass T, giving the impression that more material is needed to resist tension; whereas the fact may be that more material should be placed at C to prevent excessive yield by compression.

Theoretical Calculations Not Borne Out

Owing to the peculiar physical characteristics of cast iron, it has not been found practicable to harmonize experiments with the theory of flexure. Many reasons are offered for this, and modifications of the usual accepted theory have been propounded which will not be discussed here. It has been found necessary to introduce into the equations moduli or coefficients which have no apparent relation to the direct strength of the metal, and which vary widely for different dimensions and shapes of cross sections. As the cross sections under consideration are frequently of unsymmetrical and irregular shape, the computation of flexural moments is tedious and frequently useless if the computer has not a correct modulus to apply to satisfy the conditions of the section under consideration. It is, therefore, desirable for the designer to keep a record of experiments and of failure of castings under known loadings, and from these results derive coefficients by means of which the strength and stiffness of various sections can be approximately known without recourse to the usual calculation for the resisting moments of the section.

In machinery the working stresses are usually impulsively or suddenly applied, sometimes with actual percussion or impact, and frequently alternate stresses of equal intensity in opposite directions occur in rapid reciprocation. As it is known that a load so rapidly applied as to permit the unimpeded effect of gravity will produce a deflection double that due to the static effect of the same load, it can be seen that the total amplitude of vibration due to rapidly alternating loads must be very considerable. To prevent excessive vibration the structure should be designed with the limitation of deflection in view, and the amount of this limitation is derived solely from experience and should be governed largely by the nature of the service to which the material will be applied. For machinery under ordinary circumstances we might assume, in order to obtain satisfactory stiffness, that the deflection should not exceed one-twenty-five-hundredth part of the span, and under certain conditions should be much less than this. Indeed, it is quite probable that a deflection in direct proportion to length is not advisable, but that the ratio of deflection to length should decrease as length is increased. For long members in compression the sectional area must be augmented as the ratio of length to cross section increases, but for members under variable tension alone the section should be increased also, or the stress per unit of cross section reduced, as the ratio of length to cross sections increases, for the purpose of reducing vibration due to successive extensions.

When rapidly alternating stresses occur, it is acknowledged that provision must be made for something more than the greatest stress in one direction alone. There are still differences of opinion and practice on this subject among bridge designers. Some maintain that when the alternations are of slow recurrence, so as to permit actual rest between reversals, no special increase of section is required. Others specify that the sum of the sections required for the stresses in opposite directions should be used to suit the conditions. There can be little doubt that the latter estimate is little enough for machinery when the oscillation of the forces occurs with great rapidity, and especially when the metal under consideration is cast iron, with a modulus of elasticity about one-half that of steel or wrought iron. It is a safe general rule for ordinary cast iron in machine structures to limit tensile stress to 4,000 lb. per square inch of section under the most favorable circumstances, to 3,000 lb. when loads are suddenly applied and to 2,000 lb. when the force alternates in direction. These unit loads should be further limited to suit the ratio of length to section, as required for columns or any members in alternate extension or compression. For beams or members subjected to alternating transverse stresses, the unit stresses on the material should be limited so that the sum of the deflections in opposite directions will not exceed one-two thousand five hundredth part of the span, or such other limitation as, according to the judgment of the designer, will provide sufficient stiffness for the intended purpose.

The Chemical Engineer in Iron Trade

Facts in Connection with Analytical Chemistry and Chemical Engineering in Iron Trade—Criticism of Training Received in Colleges.

By George Auchy.

The term chemical engineer is given by the writer a very wide significance, being used to designate one who is, or who aspires to be, a manager, superintendent or director, not only in the making of chemicals but in any line of industry whatever, and who has a groundwork of chemical knowledge to start with.

The object of this paper is to call the attention of the iron trade to certain facts connected with analytical chemistry, and with chemical engineering, and also to criticize our colleges for the methods and scope of the training they have so far been giving in these lines.

What the Works Ask for and What they Get.

Taking a particular instance, the writer respectfully makes the charge that our colleges have not been meeting, intelligently and fairly, the demands that the iron and steel trade has made on them. The works have asked for analytical chemists simply, and have been given chemical engineers instead, who, it is true, are analytical chemists also, but only in a perfunctory and superficial way, and whose highest ambition is to