Mechanics.

THE PHILOSOPHY OF WELDING.

Alexander L. Holley recently read a very interesting paper before the Philadelphia Institute of Mining Engineers, from which we give the following extracts: The generally received theory of welding is that it is merely pressing the molecules of metal into contact, or rather in such proximity as they have in the other parts of the bar. Up to this point there can hardly be any difference of opinion, but here uncertainty begins. What impairs or prevents welding? Is it merely the interposition of foreign substances between the molecules of iron, or of iron and any other substance which will enter into molecular relations or vibrations with iron? Is it merely the mechanical preventing of contact between molecules, by the interposition of such substances? This theory is based on such facts as the following:

1. Not only iron but steel has been so perfectly united that the seam could not be discovered, and the strength was as great as it was at any point, by accurately planing and thoroughly smoothing and cleaning the surfaces, binding the two pieces together, subjecting them to a welding heat, and pressing them together by a very few hammer blows. But when a thin film of oxide of iron was placed between similar smooth surfaces, a weld could not be effected.

2. Heterogeneous steel scrap, having a much larger variation in composition than these irons have, when placed in a box composed of wrought-iron side and end pieces laid together, is (on a commercial scale) heated to the high temperature which the wrought-iron will stand, and then rolled into bars which are more homogeneous than ordinary wrought-iron. The wrought-iron box so settles together as the heat increases, that it nearly excludes the oxidizing atmosphere of the furnace, and no film of oxide of iron is interposed between the surfaces. At the same time the enclosed and more fusible steel is partially melted, so that the impurities are partly forced out and partly diffused throughout the mass by the rolling.

The other theory is, that the molecular motions of the iron are changed by the presence of certain impurities, such as copper and carbon, in such a manner that welding cannot occur or is greatly impaired. In favor of this theory it may be claimed that say 2% of copper will almost prevent a weld, while, if the interposition theory were true, this copper could only weaken the weld 2%, as it could only cover 2% of the surfaces of the molecules to be united. It is also stated that 1% of carbon greatly impairs welding power, while the mere interposition of carbon should only reduce it 1%. On the other hand it may be claimed that in the perfect welding due to the fusion of cast-iron, the interposition of 10% or even 20% of impurities, such as carbon, silicon and copper, does not affect the strength of the mass as much as 1% or 2% of carbon or copper affects the strength of a weld made at a plastic instead of a fluid heat. It is also true that high tool steel, containing 1½% of carbon, is much stronger throughout its mass, all of which has been welded by fusion, than it would be if it had less carbon. Hence copper and carbon cannot impair the welding power of iron in any greater degree than by their interposition, provided the welding has the benefit of that perfect mobility which is due to the fusion. The similar effect of partial fusion of steel in a wrought-iron box has already been mentioned. The inference is, that imperfect welding is not the result of a change in the molecular motion due to impurities, but of imperfect mobility of the mass—of not giving the molecular a chance to get together.

Should it be suggested that the temperature of fusion, as compared with that of plasticity, may so change the chemical affinities as to account for the different degrees of welding power, it may be answered that the temperature of fusion in one kind of iron is lower than that of plasticity in another, and that as the welding and melting points of iron are largely due to the carbon they contain, such an impurity as copper, for instance, ought, on this theory, to impair welding in some cases and not to affect it in others.

The obvious conclusions are: 1st. That any wrought-iron of whatever ordinary composition, may be welded to itself in an oxidizing atmosphere at a certain temperature, which may differ very largely from that one which is vaguely known as "a welding heat." 2nd. That in a non-oxidizing atmo-phere heterogeneous irons, however impure, may be soundly welded at indefinitely high temperatures.

The next inferences would be that by increasing temperature we chiefly improve the quality of welding. If temperature is increased to fusion, welding is practically perfect; if to plasticity and mobility of surfaces, welding should be nearly perfect. Then how does it sometimes occur that the more irons are heated the worse they weld?

1. Not by reason of mere temperature, for a heat almost to dissociation will fuse wrought-iron into a homogeneous mass.

2. Probably by reason of oxidation, which, in a smith's fire especially, necessarily increases as the temperature increases. Even in a gas furnace a very hot flame is usually an oxidizing flame. The oxide of iron forms a dividing film between the surfaces to be joined, while the slight interposition of the same oxide, when diffused throughout the mass by fusion or partial fusion, hardly affects welding. It is true that the contained slag, or the artificial flux, becomes more fluid as the temperature rises, and thus tends to wash away the oxide from the surfaces; but inasmuch as any iron with any welding flux can be oxidized till it scintilates, the value of a high heat in liquifying the slag is more than balanced by its damage in burning the iron.

3. But it still remains to be explained why some irons weld at a higher temperature than others, notably, white irons high in carbon, or in some other impurities, can only be welded soundly by ordinary processes at low heats. It can only be said that these impurities, as far as we are aware, increase the fusibility of iron, and that in an oxidizing flame oxidation becomes more excessive as the point of fusion approaches. Welding demands a certain condition of plasticity of surface; if this condition is not reached, welding fails for want of contact due to mobility; if it is exceeded, welding fails for want of contact due to excessive oxidation. The temperature of this certain condition of plasticity varies with all the different compositions of irons. Hence, while it may be true that heterogeneous irons, which have different welding point, can not be soundly welded to one another in an oxidizing flame, it is not yet proved nor is it probable that homogeneous irons can not be welded together, whatever their composition, even in an oxidizing flame. A collateral proof of this is, that one smith can weld irons and steels which another smith can not weld at all, by means of a skilful selection of fluxes and a nice variation of temperatures.

Compression by Steam in Casting.—In some recent French experiments it was noticed that when a lid of cast iron was placed upon a mold after casting, the ingot produced generally showed a zone of blow-holes near the surface and on all sides, while within it the block was entirely sound. Whenever the mold was not covered the entire mass contained blow-holes. This, it was urged, was due to the pressure of the gases, and consequently experiments were made by Bouniard with more than 100 tons of steel, which proved that a pressure of 6 to 10 atmospheres acting upon the interior of the ingot would make the metal solid. The mold is covered with a lid in which there is a central casting opening. It has a pipe through which steam may be introduced. The steel is cast through the central orifice, which is closed, and then steam is admitted. A copper wire is used for packing the lid. The work must be rapidly done and the mold be previously heated. In order to make the action of the pressure affect the interior of the ingot the chilling of the surface must be prevented, which is done by heating, before casting, the fire-brick lining of the inner surface of the lid. The ingot thus cast shows a depression on its upper surface. It was found that in using steel for cannons the number of compressed ingots rejected was only one-third of the number of ordinary cast ingots. Experiments made to apply the same principle to steel castings showed that although the application was more difficult, the result was the same.

Polishing Brass.—The following reply to a question is given in the *English Mechanic*: The final polish is obtained by burnishing with steel burnishers, after which the articles are heated in a stove, and the lacquer applied with a camel's hair brush. If the temperature is too cold a dullness of surface is produced, which is not removed by re-heating. I have sent a recipe or two for the lacquer, if you like to make your own, which must be warmed as well as the articles;—For a good gold coloured lacquer, take seed-lac (unbleached), 3 oz.; turmeric powder, 1 oz.; dragon's blood, ¼ oz.; methylated spirits of wine, 1 pint. Bruise the lac and dragon's blood before mixing them in the spirit, and let it remain for some days, shaking it frequently; afterwards drain off the liquor, or, if necessary, filter it. Ingredients for a brass lacquer: Shellac, 8 oz.; sandarac, 2 oz.; annotto, 2 oz.; dragon's blood resin, 1 oz.