10TH SEPTEMBER, 1903.

THE ALUMINOTHERMETICAL WELDING PROCESS OR, THE GENERATION OF INTENSE HEAT THROUGH THE COMBUSTION OF ALUMINIUM.

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Aluminium and Oxygen, two elements most abundantly found in the composition of the earth, possessed a very strong affinity for each other, this fact was the base of the process for generating the intense heat, which he intended to show and describe. On bringing these two elements under certain conditions together, a chemical re-action was started which was of such a rigorous and energetic nature that a temperature hitherto obtained only by electrical means, was generated almost instantaneously. The oxygen necessary for the combustion was obtained from the chemical combinations of the metallic oxides and not from the atmosphere.

It had been known to science for a long time that metallic chlorides and oxides when mixed with powdered aluminium set up rigorous chemical action under certain conditions of temperature, but the fury of these chemical actions could not be mastered. Dr. H. Goldschmidt, of Essen, after some years of costly experiments, had been the first who succeeded in making a practical use of them, and had opened an almost unlimited field of application in most branches of engineering and metallurgy.

Dr. H. Goldschmidt had named his patent admixture of powdered oxide of iron and aluminium—Thermit. The process itself was called aluminothermetical. By this process not only

Thermit used for welding was produced, but also a number of metals free from carbon which previously to Dr. Goldschmidt's discovery could only be obtained in very small quantities in the laboratory. He would mention, for instance, Chromium and Manganese, which were now manufactured by the ton. The former was the ideal of the steel manufacturer, the other was largely used as an alloy for copper, zinc, tin, bronze, gun-metal, &c., &c. Ferro-titanium and Titanium in the form of Titan-Thermit was also produced in large quantities, and was used in steel and iron foundries for producing a fine grained casting free from blow holes. Quarter per cent. of Titan-Thermit if added to the iron or steel when in the ladle, was sufficient to materially improve the metal.

The Thermit used for welding was a powder, and consisted of oxide of iron and aluminium mixed in certain proportions; it was not explosive. A heat about equal to melting steel was required to start Thermit; this was done by placing a very small quantity of a special powder called igniting powder, which consisted of powdered aluminium and barium-superoxide on the Thermit, igniting the former by a common wax match. The crucibles in which the Thermit was brought to re-action were of special make, they consisted of an iron shell covered inside with a basic lining of magnesium cement. Any refractory material of an acid nature, such as fireclay or the like, is not suitable, the highly basic nature of the molten alumina and its consequent corrosive action when in a molten state, required a basic crucible.

Thermit could be used in two ways for welding purposes—First, by using the heat only; second, by using the heat and Thermit iron combined. The former was especially useful for welding butt-jointed wrought iron or steel pipes and bars. The latter was used for making either an intermediate or all round cast, for welding steel rails, casting a collar round a shafting, or joining together any broken parts of either steel or iron, also for making steel casting, and for many other purposes which would at once occur to any engineer. Both processes were extremely simple, and differed materially very little from each other. For the first, the appliances for making a clean butt weld of a 2in. pipe or steel shafting, consisted of : A crucible, a pair of tongs, a clamp, a mould, the necessary quantity of Thermit and a match. The ends of the pipes or shafting to be welded, after having been cleaned, were placed between a clamp, which held them in position, a small mould was placed round the joint and well packed with moist sand. The required quantity of Thermit was then placed in the crucible and ignited by means of the previously mentioned barium powder. In a few seconds the reaction was complete, the crucible would then contain at the bottom the molten iron, covered with a layer of three times its volume, but equal weight of molten Aluminium Slag (Corrundum). This mass was poured into the mould, the Corrundum (Slag) flowed out before the iron, touched the pipe or shafting first, deposited a layer round it, and protected the pipe or shafting from contact with the molten "Thermit iron" tha followed. The Thermit iron and Corrundum now lying round the pipe brought the joint to a welding heat within about a minute, after which the clamps were drawn together, and the weld was complete. Such welds would stand as high a pressure as the pipe itself, and would cost less than any other method of joining them together.

The second process slightly differed, in this case the crucible was provided with an opening at the bottom, closed by a small iron disc which was covered with about ½ an inch of dry sand and was placed immediately above the mould. The method of igniting the Thermit, was similar to the one described previously. When the reaction was complete, the iron disc was driven up by a pin placed in such a position below that although it did not touch the plug, it could easily be forced up by means of a simple lever to allow the Thermit Ircn which being the heavier and had settled at the bottom of the crucible to flow out first into the mould and the Corrundun to follow. The Thermit Iron melted the surface of the metal as soon as it came in contact with and amalgamated with it, forming one homogenous mass of mild steel round it, which could easily be worked or welded.

By this method, shafting, girders, steel rails, heavy bar iron, etc., were welded together; most repairs were executed in that manner. The welding together of shafts could be done by two methods. First, by placing the two parts of the shaft about $\frac{1}{2}$" apart, and running the Thermit Iron between, or by casting a collar round the broken part, uniting the collar and the shafting to one solid mass of metal. In most instances, the second method was adopted, by which the broken part after having been welded would be stronger than before. Such welds could usually be made without dismounting the machinery. A special table had been prepared, giving in detail all the measurements and the quantity of Thermit required for such welds.

In a similar way cast steel or cast iron could be repaired. To cast, for instance, a broken tooth to a spurwheel, all that was required was to place a mould round the broken part, and allow the Thermit Iron to flow into such mould.

In larger castings 10 to 20 per cent. of iron punchings could be added to the Thermit without materially diminishing the heat of the fluid iron. The character of Thermit Iron, which resembled a mild steel, could be altered at will. If, for instance, a hard steel was required carbon could be added. This was done by mixing small pieces of a fine grained cast iron with the Thermit powder.

Thermit could also be used without a crucible altogether. For example, where a Roller Boss was broken off the cast iron roller was placed on end and a mould formed above it, into which about $\frac{1}{2}$'' of molten iron was poured on to the broken surface. Then Thermit was added at the rate of 30 lb. to the superficial foot, and was ignited by the usual ignition power, softening the metal of the roller, cast iron or steel in sufficient quantity to form the new boss was then added, and the whole well stirred. The whole boss could also be cast on to the roller from Thermit iron and punchings only. This would, perhaps, be a little more expensive; but in case of emergency, where delay was the most costly part of a mishap, this would matter very little indeed.

He would show by an experiment the intense heat which Thermit generated, by allowing some Thermit iron to flow on to a three-quarter inch iron plate through which it would run immediately it touched the plate. This experiment would show how large armour plates were pierced by the aid of Thermit.

By no other known means or process was it possible to produce within a few seconds, without any special apparatus, a pure liquid iron which possessed a temperature of about 3000 C, and which resembled a mild steel. A test bar forged out of pure aluminothermetical iron gave the following results:—

Tensile strength, 26 tons.
Elongation, 19 per cent.

The analysis gave the following results:—

C.	0·10 %	S.	0 03 %
Mn.	0·08 %	P.	004 %
Si.	0·09 %	Cu.	0·09 %

AL 0·07 %