This invention relates to thermochemical scarfing of oxidation resistant metals with a stream of oxygen assisted by preheat flames and combustible metal (steel) powder, and more particularly to hand scarfing with external powder feed.

It has been proposed to machine scarf stainless steel bodies with external powder feed in a single, relatively wide (over three inches) pass, but the equipment is too heavy for hand use, is expensive to manufacture and is uneconomical unless entire body surfaces are scarfed. Hence, such wide-pass machine scarfing with external powder feed has not yet gone into commercial use. However, external powder feed scarfing is much superior to internal powder feed scarfing. For example, slabs of stainless steel scarfed with a six-inch wide continuous slotted nozzle equipped with external powder feed were subsequently hand-spotted with a blowpipe with internal powder feed to remove intersections between overlapping passes. Following scarfing, preparatory to rolling, such slabs were thoroughly flame-decaled and then heated. At this stage they were comparatively free of furnace scale on the surfaces scarfed with externally fed powder, but dark with heavy furnace scale on those areas which had been scarfed with internally fed powder, indicating that the two surfaces react in different ways in the furnace atmosphere and that perhaps the surfaces differ metallurgically. The surfaces produced with external powder feed, rolled into a good product; while the areas that were hand-spotted with internal powder feed, contained shadows and shinners.

This difference may be due to the fact that internal powder feed increases the iron content of the oxide coating on the slab surface, making non-uniform rusting or oxidation possible in numerous selected small areas where abnormal contamination of the base metal is concentrated. Another possibility lies in the increased carbide precipitation, resulting from the lower speeds obtained with internal feed, and consequent lower melting point in localized areas. These areas absorb heat more rapidly than the remainder of the slab and, if overheated, can result in objectionable shinners in stainless steel.

The most logical solution, however, appears to lie in the friability of the slag produced by the two different methods of powder feed. With internal powder feed the powder is entrained in the cutting oxygen stream and travels past the preheat flames at a velocity approximating 700 ft. per second; whereas with the improved external powder feed this velocity has been decreased to within a range of 150 to 200 ft. per second. This increases the contact time between the preheat flames and the powder. External powder feed produces a more completely oxidized slag as has been proven by metallurgical examination. This slag, because of its increased brittleness, is easy to remove and does not become bonded to the slab surface at the points of pass intersection as is the case with internal powder feed. Since shadows and shinners always appeared at pass intersections it is logical to assume they were caused by the comparatively high metallic slag of the internal powder feed scarfing process being rolled into the base metal of the slab surface at such points.

The main object of this invention is to provide an improved process and apparatus for thermochemically scarfing oxidation resistant metals with externally fed powder. Another object is to provide a novel powder nozzle which discharges the powder in such a way that the process is more stable and less expensive. A further object is to provide a hand scarfing assembly that is light in weight, inexpensive to manufacture, and easy to manipulate. Other objects will appear from the following description.

According to the invention there is provided a hand blowpipe comprising the combination of an oxy-fuel gas scarfing nozzle, a powder nozzle, and a bracket-skid assembly which holds such nozzles in position and is also adapted to ride on the work being scarfing. The scarfing nozzle is swaged to discharge a relatively wide and flat stream of cutting oxygen between upper and lower substantially parallel rows of preheating flames. The oxygen is streamlined in flow through the smooth-walled passage of the nozzle, the edges of which passage are rounded, thereby aiding considerably in the formation of smooth cuts or passes having clearly defined edges or pass intersections. The powder nozzle consists of a tube having a flattened end portion which is connected to a tubular inlet portion by a flared portion which is cramped to assure uniform cross-distribution of the powder, and to provide a recess fitting the bracket-skid assembly. The latter secures the scarfing nozzle in place between the powder nozzle and the skid, so that when the blowpipe is held in proper position, with the skid resting on the work, the longitudinal axes of the scarfing and powder nozzle form acute angles with each other and the work surface, and the transverse axes thereof are substantially parallel with each other and such surface.
The process comprises powder scarfing of oxidation resistant materials, such as stainless steel, by the introduction of a relatively thin, flat stream of combustible metal powder which is less than three inches wide through suitable preheating flame onto the leading edge of a thin, flat stream of oxygen the width of which is approximately equal to that of the powder stream which then projects or throws the powder toward the work in such a way that most of the powder is consumed at the leading edge of the advancing reaction zone without completely passing through the relatively cool oxygen stream which trails the reaction zone in a substantially pure undiluted (by powder) state. This produces a friable more easily removable slag and prevents shiners in the surface of the rolled product, because any adherent slag contains oxides high in FeO with little or no FeO and substantially without free iron.

Scarfing speeds obtained with the invention are 2–3 times greater than with internal powder feed, making powder scarfing according to the invention more economical than grinding. In the drawing:

Fig. 1 is a fragmentary perspective view of a hand scarfing blowpipe with external powder feed illustrating the invention;

Fig. 2 is a view mainly in side elevation of such blowpipe in use;

Fig. 3 is a top plan view of the powder nozzle, a portion being broken away to show the interior;

Fig. 4 is an enlarged fragmentary view of such nozzle, shown partly in side elevation, and partly in section on line 4–4 of Fig. 3; and

Figs. 5 and 6, and 7 and 8, are fragmentary top and side views, respectively, of two powder nozzle modifications.

As shown in Figs. 1–4 of the drawing, a hand scarfing blowpipe 10 is provided which comprises an oxy-fuel gas scarfing nozzle 12, and a powder nozzle 14 which are held together by a bracket 16 which also includes a skid 18. The skid is in the shape of a rod provided with a ball-shaped bearing 20 at one end which is adapted to ride directly on the scarfed surface 22 of the work W. The other end of the rod is provided with a jaw 24 which with a mating jaw 26 on the bracket 18 and bolts 28 provides a clamp 29 which securely engages the nozzle 12. The bracket 16 is also provided with a clamp 32 which securely engages the powder nozzle 14 holding it in place with respect to the nozzle 12. The clamp 32 consists of a plate 34 engaging the bottom of the nozzle 14, and a U-shaped staple 36 engaging the top of such nozzle in a recess 38 formed by a clipped section 40 thereof. The arms of the staple 36 are threaded, extend through suitable holes in the plate 34, and are provided with nuts 42.

The nozzle 12 is provided with a slotted orifice 44 which is adapted to discharge a relatively flat stream 45 of cutting oxygen toward the work W at an acute included angle of between 30° and 60°, when the blowpipe 10 is held with the skid 18 resting on the work, and the transverse axis of the stream substantially parallel to the work surface. The nozzle 12 is also provided with rows of gas ports 46 for discharging preheating-flame-supporting gas jets 47 above and below the cutting oxygen stream 45 in substantially parallel adjacent relation therewith. The gas jets are composed of a mixture of oxygen and acetylene, or any other suitable fuel gas, such as natural gas.

The powder nozzle 14 is a tube of suitable metal such as stainless steel, swaged to the desired shape to provide a relatively flat exit portion 60 which merges with a flared inlet portion 52 by way of the cramped section 50. The nozzle 14 is crimped or pinched about 0.1 inches from the flattened exit mouth so that the narrowed throat section area at this point lies below the centerline of both the powder exit slot and the swaged upstream portion of the tube. This is done to impinge the powder stream on the inclined lower wall of the tube downstream of the throat to flatten out the powder stream and obtain good powder distribution in the stream as it leaves the slotted exit orifice.

The longitudinal axis of the powder nozzle 14 is preferably disposed at an acute dihedral angle of about 3 to the corresponding axis of the scarfing nozzle 12. However, good results may be obtained in a range of 25–45 degrees. The dihedral angle between the oxygen nozzle axis and the work surface may vary over a considerable range, also, viz., 30–60 degrees. This makes possible a range of 65–90 degrees in the angle between the powder tube axis and the work surface.

In order to obtain better powder distribution at the edges of the powder nozzle slot and also to get a powder spread equal to that of the oxygen stream, the flattened powder nozzle is flared at the exit mouth. The cramped section, besides producing good powder distribution, also performs another important function. It is used to enable the powder nozzle to be assembled to the slotted oxygen nozzle by means of the bracket.

The powder nozzle above the oxygen nozzle directs powder into the oxygen stream, so that it is effective only on the leading edge of the reaction zone which contains a mixture of oxygen, acetone, and powder. Behind the advancing reaction front in which substantially all of the powder is consumed, a relatively pure portion of the advancing oxygen stream then cleans up. In the case of internal powder feed a core of relatively cool powder is carried in the center of the oxygen stream. In effect, this dilutes the oxygen by displacing a good percentage of it and also has an inhibiting effect on its heat absorption and burning, with the result that shiners are formed in the scarfed surface due to deposit thereon of partially consumed iron powder. In the subject improved external powder feed method, on the other hand, most of the oxygen stream is free of powder, the powder being confined to the upper region and leading edge of the oxygen stream for the most part. It is believed that the surfaces obtained after rolling with the new method are free of shiners, because the adherent slag contains complex oxides high in FeO with little or no FeO and substantially free of iron.

As an example, a hand scarfing blowpipe consisting of a swaged scarfing nozzle having 13% inch by 1-inch slotted oxygen passage, and a powder nozzle having a 1½ inch slot for directing steel powder at an acute angle toward the cutting oxygen stream, was employed to scar stainless steel slabs manually at speeds greater than 20 feet per minute, or about double that possible with standard internal powder feed scarfing nozzles. The scarfed surfaces were flame-cleaned without difficulty so that only a negligible amount of tightly bonded scale re-
When rolled, the finished surfaces of the slabs were considered to be the best produced up to that time from powder conditioned slabs, and equal in quality to those rolled from ground surfaces.

The powder nozzle may be provided with double crimps at 54 and 55, Figs. 5 and 6, to insure more uniform distribution of the powder; and it may be bent slightly, as shown in Figs. 7 and 8 for the same purpose.

The invention has the following advantages:

The scarfed surface obtained with it is conducive to production of a good quality rolled product free of objectionable chiners.

This is accomplished at speeds up to 2-3 times those now obtainable with internal powder feed, making powder scarfin substantially more economical than grinding. Moreover, grinding, in the case of some straight chromium grades of stainless steel, leaves a pattern of grinding marks which is not the case with scarfed slabs.

With external powder feed the slag is more easily removable.

In reheating, burning of the slab surface, in the case of some molybdenum stainless steels, is eliminated on a scarfed slab because the dull finish obtained with the new process absorbs heat more quickly and uniformly than that of the shiny surface obtained by grinding.

It will be understood by those skilled in the art that any other suitable gas can be used instead of air or oxygen to carry the powder. Also, the hand equipment of the present invention may be used in a scarfing machine if necessary or desirable. By confining the width of the powder and scarfing oxygen streams to less than three inches, the equipment is suitable for hand scarfing. The powder may be any of the compositions disclosed by Wagner 2,451,422.

We claim:

1. A scarfing blowpipe comprising the combination of a scarfing nozzle provided with a slotted flared central cutting oxygen exit between parallel rows of preheat flame gas ports, a powder nozzle consisting of a flattened tube having a slotted flared exit orifice and a crimped section upstream thereof for uniform powder distribution, a bracket clamping said powder nozzle at such crimped section to said scarfing nozzle so that the latter is disposed between the powder nozzle and the work and inclined with respect to the work at an acute angle when the powder nozzle is inclined with respect to the scarfing nozzle at an acute angle, and a work riding skid integral with said bracket located between said scarfing nozzle and the work.

2. A blowpipe comprising the combination of a scarfing nozzle, a powder nozzle, and a bracket skid assembly which holds such nozzles in fixed relative position and is also adapted to ride on the work being scarfed, said scarfing nozzle being shaped to discharge a relatively flat stream of cutting oxygen between upper and lower substantially parallel rows of preheating flame gas ports, said powder nozzle consisting of a tube having a flattened end portion which is connected to a tubular inlet portion by a flared portion which is longitudinally crimped to assure uniform cross-distribution of the powder, and to provide a recess for fitting the bracket skid assembly in place between the powder nozzle and the skid, so that when the blowpipe is held in proper position with the skid resting on the work, the longitudinal axes of the scarfing and powder nozzles form acute angles with each other and the work surface, and the transverse axes thereof are substantially parallel with each other and such surface.

4. A powder discharge nozzle for external powder scarfing, consisting of a tubular inlet portion which merges into a flared portion which is gradually flattened to provide an outlet portion having a slot-like powder exit, said flared portion having a longitudinally cramped section providing at least one slot-like powder passage substantially parallel to such exit, whereby the powder is substantially uniformly distributed transversely of the stream upon its discharge from such nozzle.

5. A powder discharge nozzle, as defined by claim 4, in which the nozzle is slightly curved between such tubular inlet and outlet portions to obtain more uniform cross-distribution of the powder.

6. A powder discharge nozzle, as defined by claim 4, which is composed of stainless steel.

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