Technology exists today to mark and permanently attach a durable stainless steel tag onto a hot steel coil immediately after downcoiling. The tag can contain text, barcodes and/or logos, and is applied to the coil by either manual or automatic methods. The tag survives cool down and subsequent annealing while maintaining excellent readability.

Tagging of Hot Bands

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HOT band traceability and quality requires accurate, permanent coil identification immediately after downcoiling, before the coil manufacturing sequence becomes shuffled.

Historically, workers using chalk, paint sticks or punched stencils, have manually marked hot coils with human-readable characters. More recently, coils have been automatically marked by automatic ink spray equipment. Manual marking methods, using chalk or paint sticks, are prone to human error and are often illegible. Automated ink spray equipment utilizes accurate downloaded information but, if the marking equipment is not adequately maintained, the markings may be difficult to read.

When workers downstream read human-readable characters, data reading errors often occur. Transpositions, misreads, and data logging errors are a few of the common mistakes.

OCR (Optical Character Recognition) vision-based automatic reading is not reliable for variably positioned coils with fluctuating marking quality. Also OCR is not suitable for inventory collection in the storage yard.

Automatic identification in the form of bar codes can significantly reduce errors if the hot coils are identified with robust, high quality bar codes. Bar codes can easily be scanned in the storage yards and during subsequent operations using inexpensive, industry-standard bar code scanners.

Manual bar code tag attachment to cold (ambient to approximately 300°C) coils is commonplace. For such cold coils, paper tags and plastic tags are commonly attached using wire, adhesive or a plastic pouch. They are usually durable enough to survive shipment and short term storage. However, currently there is no commercial adhesive that will adhere a metal tag to hot coils having surface temperatures greater than 500°C.

Identification of hot coils requires a tag which can survive temperatures that approach 980°C (approximately 1800°F) and can be securely attached in a manner which will survive cool-down and annealing while maintaining readability. In many cases, the tag must be able to survive outdoor storage without image or contrast degradation.

Such tags must be applied either to the outside wrap of the coil (where crane operators can see them) or to the coil side face or inside diameter (where they can be read on coils that are stacked). Tags that are stiff and “foldable” can easily be attached so that they are viewable from two directions.

Laser Tags

Laser tags have recently been developed for the identification of hot coils (as well as for hot slabs, billets, blooms and beam blanks). These tags are typically made from 0.2 mm (0.008”) thick 430 grade (magnetic) stainless steel which is coated on one side with a white ceramic coating. The coating is resistant to high temperatures and is specially formulated to enable blackening by laser marking. Such tags provide a durable, high contrast, easy-to-read black-on-white bar coded tag that will survive 980°C (approx. 1800°F).

These tags can be either printed on-site using an on-demand printer, or supplied in lots that are preprinted with sequential “license plate” tracking numbers.

Tag attachment methods

Tags are attached to a hot coil by either band attachment or resistance spot weld attachment Each method is discussed as follows:

Band attachment - For band attachement, tags are provided with elongated slots that facilitate tag attachment when the coil banding operation is performed. Manual or automatic attachment is possible.

A “C” slotted tag (not shown) can be manually affixed even after the band is clinched.

Fig. 1 — Band attached tag

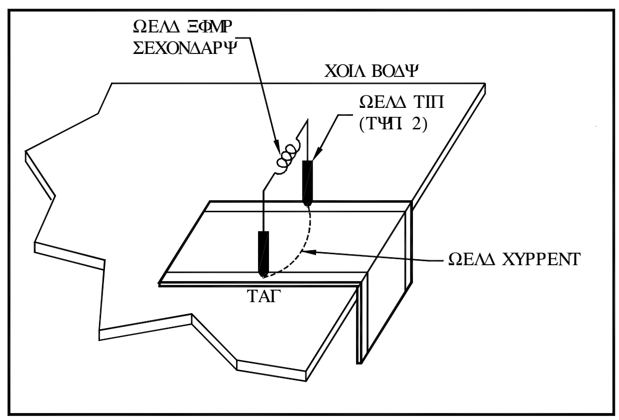
Spot Weld attachment - Immediately after downcoiling, the coil surface is usually smooth with little or no mill scale. Here the tag is attached to the coil using either manual or automatic coil tagging methods. The preferred welding method is resistance spot welding. Two or more small resistance spot welds made through a single layer of the tag material are adequate for tag attachment.

Spot welding attaches the tag to the outer or inner wrap of the coil by pressing the tag and coil wrap substrate together with sufficient force, while passing a high weld current thru the tag-to-coil interface, to form a melt pool and thereby bond the two steel surfaces together.

Tag geometry for a given application is designed so that the tag material is uncoated at the weld location on the tag. Usually the tags are coated using a method that leaves bare metal edges for welding. The machine weld tip geometry is designed to match the tag bare edge geometry.

Two spot weld configurations are discussed following:

Figure 2 depicts a two-point, series spot welding method, whereby current flow passes between two weld tips and through the coil bulk. This approach is most commonly used for manual attachment. Both the weld tip contact resistance and the interface resistance between the tag and coil surface must be balanced for



good welds. Two welds are made at one time.

Fig. 2 — Tag welded with a two point spot weld

Figure 3 depicts a “contact probe” configuration that produces 4 weld points as usually would be made by automated equipment. The contact probe provides weld current for two welding tips at a time as welder secondary #1 and welder secondary #2 are sequenced. This configuration minimizes the effect of unbalanced interface resistances of weld tip contact, and tag-to-coil interface.

Resistance spot weld size is nominally about 3 mm (approx. 1/8”) diameter. Two or four welds are typically used, depending on the expected severity of service. Spot weld attachment durability is excellent. If the tag is intentionally removed by peeling it off, the tag material around the weld will tear before the solidified weld pool fails. This leaves a weld remnant (typically a 3 mm diameter cylinder which is the height of the tag thickness) attached to the coil outer wrap after the tag is removed. In cases where the outer wrap is scrapped, this remnant is not an issue. In other cases, any remaining weld may need to be cropped or removed by grinding prior to leveling or roll reduction. In some cases, mill operating procedures can be changed to position the tag as close as possible to the tail end, without requiring the scrapping of a complete wrap.

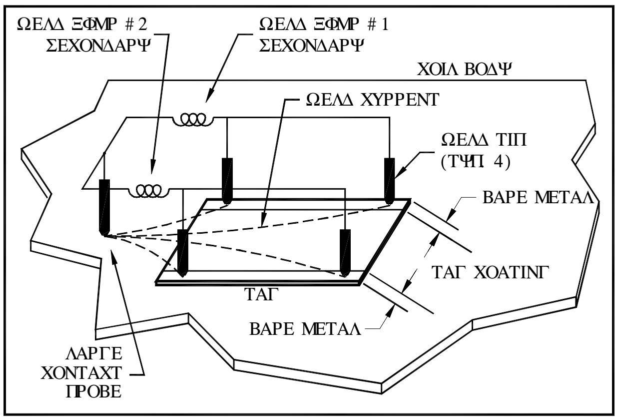


Fig. 3 — Tag welded with a four-point spot weld

Manual tag application - An operator using a handheld wand applicator can manually apply tags to hot or cold coils (Fig. 4). Preprinted sequentially numbered “license plate” tags are used, or an on-demand laser tag printer (Fig. 5), located near the marking station, is used to produce tags on demand. The operator affixes the bare edge tag to a (magnetic) tag applicator mechanism at the end of the wand, presses the tag firmly against the outer wrap or inside surface of the coil, and then operates a finger trigger to initiate the weld.

Fig. 4 — Tag application using a wand applicator

When spot welding tags onto hot or cold steel, it is important to keep the weld cable length short (less than 2.5 meters) and to apply a firm weld tip pressure (more than 15 kg. per tip). A jib arm with cable balancer is used in applications where the weld transformer and cables must be traversed to reach coils along a walking beam conveyor.

Fig. 5 — On-demand Laser Tag Printer

Automatic tag application - Tags can also be automatically applied to a coil by an automatic tagging machine (Fig. 6).

The tagging machine shown is designed to apply a tag to a coil that is oriented eye axis horizontal with conveyor travel parallel to the eye axis. A drawbridge-type machine design is used. Machine designs to apply tags to other coil orientations will be available in the future.

The machine consists of three functional modules - tag preparation, tag transport and tag application.

The tag preparation module is located at the rear of the machine, shielded from the direct radiant heat from the coil. This module consists of the following components:

- laser marker, to mark the tag stock
- spool mechanism to feed the tag stock into the laser marker for marking
- shear mechanism for shearing the just-marked tag
- bending mechanism for bending the tag
- transport platen to present the prepared tag at the correct position for pickup by the tag application carriage.

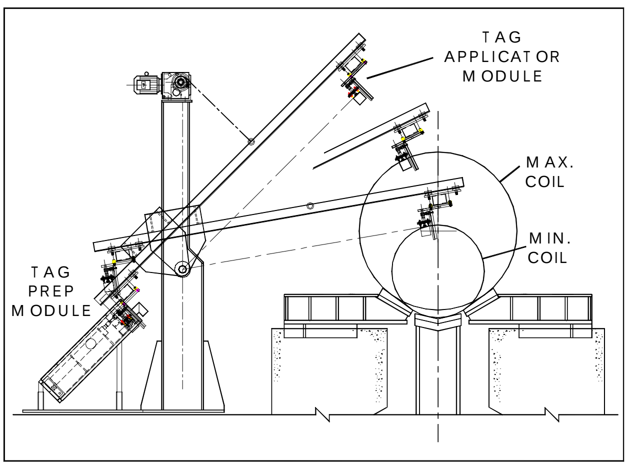


Fig. 6 — Automatic tagging machine

The tag prep module is loaded with a roll of bare edge tag material prior to coil processing. For each coil, the laser marker advances the tag stock and marks an appropriate length of tag material. The tag is then sheared and bent. The tag preparation platen then positions the finished tag at a position where the tag applicator carriage can pick up the tag.

The laser marker utilizes an internal 50W CO_2 laser, sealed inside an enclosure. The laser marker is rated Class I, which completely prevents human exposure to the laser beam during the tag marking process.

The tag transport carriage is mounted on the drawbridge boom. The transport carriage is a motor-driven carriage used to transport the tag applicator from the tag prep module (after the applicator has picked up the finished tag) to the end of the boom for lowering onto the coil.

Suspended beneath the tag transport carriage is the motor-driven tag applicator carriage that is used to pickup the tag from the tag preparation module platen. The tag applicator acquires the tag, and then is carried underneath the transport carriage out to a safe position where the boom lowers the applicator into the clear zone between coils. The boom lowers to contact the coil OD at the marking position. The tag applicator carriage then moves laterally in to find the side face of the coil and then welds the tag onto the coil outer wrap surface with four (4) resistance spot welds. The machine includes an automated wire brush that cleans all weld tips after each weld.

The machine applies significant weld tip force during welding; typically more than 50 kg per tip. This force aids in producing robust welds on certain difficult-to-weld grades (e.g.- stainless) where the higher surface temperature and material chemistry produce a tight insulating scale and higher resistance paths.

Tag Geometry - One of many possible tag geometries is shown is shown in Fig. 7. For this application, the total tag length is 250 mm long x 100 mm wide (10” x 4”). The tag has a 13 mm (1/2”) uncoated metal bare edge at the top and bottom of the tag width to accommodate good resistance weld current conductivity. The coated (marked data) area of the tag measures 250 mm x 75 mm (10” x 3”). The tag is bent and applied so that a 150 mm (6”) tag length is attached to the outside diameter wrap surface of the coil. The remaining 100 mm (4”) length is folded-down at 90°. This tag geometry provides a 2-axis view of the tag by both the crane operator and an observer in the storage yard standing at the eye of the coil. Different length and width tags are possible.

Fig. 7 — Coil tag with fold-down

Tag stock is provided in a boxed roll containing approximately 91.5m (300') of tag material and weighing about 19 kg (41 lb). A new roll can be loaded in the machine in less than one minute. Approximately 350 coils can be tagged from one roll, when using 250 mm tags.

Bar codes and automatic coil tracking

Bar codes provide the missing link that is necessary to facilitate automatic tracking in the coil mill. The bar code typically encodes a Piece Identification Number (or "PIN", also sometimes referred to as a "license plate number"), which is used to access a mill database containing a complete history of manufacture (or "pedigree") for that coil. This same PIN, in human-readable form, is also typically marked as a backup for the bar code, in the event that the bar code cannot be scanned for any reason. Separate bar codes can also be marked (with appropriate human-readable data labels) to encrypt other information, such as the heat, grade, customer order number, etc.

Bar codes can significantly reduce the number of occurrences of wrongly identified steel. As stated previously, human reading errors in the steel mill environment are common. Tests show that manual reading errors resulting from the combination of poor markings and fallible human workers in a hot mill environment are as high as one in 300. Large robust bar codes scanned by relatively inexpensive hand-held bar code scanning equipment can reduce the misread error rate to less than 1 in every 250,000 read attempts. Long distance bar code scanning equipment can be used to scan bar codes in environments unsuitable for humans.

Good bar code practices must also be observed in order for identification methods to succeed. The bar code should be robust enough to survive the mill environment while still maintaining good scanability. The bar code size is a tradeoff between long range scanability and tag size (and therefore tag cost).

The following bar code "ground rules" are recommended for a robust bar code identification system:

- Keep the PIN short - 8 digits maximum is recommended. Bar code quality and associated long-range scanability degrades as more characters are added.
- Use numbers only for the PIN, not alphas - this will allow use of a simple, low-density bar code symbology such as Code 128C.
- The PIN should be used as a pure tracking number; don't try to encode the entire coil history into the bar code. The PIN should simply be the "key" used to open the database record for the coil.
- The total number of available PIN numbers (and the corresponding number of database records) is calculated according to time duration needed to track a given coil population. The PIN number and database record for a given coil is archived after the coil has left the population. The PIN number and database record for the (retired) coil can then be reset and reused to identify a new coil entering the population. An 8 digit PIN will serve a typical coil mill for a ten year duration (99,999,999 PINs available).
- Maintain a good "clear zone" (white area with no marking) at both ends of the barcode. To be safe, the clear zone width dimension should be a minimum of 15 narrow bar widths if possible.
- Maintain good white-to-black contrast - "off-white" tags with black bars, or, white tags with "fuzzy" bars, do not scan as reliably as tags with good white-to-black contrast and sharp image quality.
- Maintain good bar width control - the narrow black bar widths should equal narrow white space widths, also wide black bar widths should equal wide white space widths (blackened bar width is a function of the laser beam power and is controlled by a laser tag printer software parameter).
- Other bar codes can be marked for other types of data (e.g. - the heat number) - but keep the PIN bar code as a separate, more prominent, bar code. Label each bar code fields on the tag with human-readable labels so that the worker who scans the tag clearly knows which code to scan.

Examples of "robust" and "poor" bar codes are shown in Fig. 8.

87965843

ABCDE123

Fig. 8 — “Robust” bar code (top) vs. “poor” bar code (bottom)

In the previous figure, PIN “87965843” is marked in Code 128C symbology. Note the low density and distinct “fat” bars with good separation. A wide “clear zone is provided at both ends of the bar code. This is a very robust code that is well suited for the steel mill environment.

PIN “ABCDE123” is marked in Code 39 symbology (partially because of the requirement to print alpha characters). Note that the same number of characters are marked as in the top code, but more width, and a much higher density, is required, resulting in more narrow bars with very fine separations. This code may be satisfactory for the auto plant, but not for the steel mill.

Cost Justification

If a hot coil is not identified promptly after downcoiling, the coil’s traceability back to the parent slab or heat is in doubt downstream. Any resulting mixed steel resulting from the incorrect identity produces real costs that sometimes do not appear on a cost justification spreadsheet for identification methods and equipment.

Examples of costs and liabilities related to mixed steel include:

- Customer returns or backcharges
- Lost customers
- Legal liability due to mixed steel
- Unnecessary work-hours spent unraveling mix-ups
- Shipping delay costs
- Downgraded (or scrapped) steel
- “Lost” coils in storage

The cost of tags, plus the cost of the automated machinery to apply the tags, amortized over 3 years, is estimated at about $220,000 USD per year in a 175,000 coil/year facility. Many coil manufacturing facilities have historic “mix-up costs” far in excess of this $220,000 USD per year value. The justification for coil identification budgets should take into account the added value of improved steel identification and traceability.

Summary

The technology exists today to automatically mark, and permanently attach, a durable stainless steel tag to hot steel coils immediately after downcoiling. The tag can clearly display human-readable information, logos and bar codes. The tag should contain a bar code PIN that is used to uniquely identify each coil, and to access (or add information to) a database containing the coil’s entire manufacturing history, or pedigree. Additional data fields can also be encoded with additional bar codes if needed. The tag can be applied to hot or cold steel and can survive cool-down and annealing. Resistance spot welding is the preferred attachment technique. The tag can survive outdoor storage while maintaining good readability.

The reduction in occurrences of incorrectly identified steel results in real cost savings that can easily justify implementation of the technology.