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Manufacturing Bi-Metal Strips for Aluminum Bearings

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1. Introduction

Most aluminum based bearing materials have bi-metal structure: aluminum alloy bonded to a steel back.

Bonding of the two layers is performed by cold rolling of a continuously cast strip of aluminum bearing alloy together with a strip of low carbon steel (carbon 0.08-0.12%).

Technology of manufacturing bi-metal strips for aluminum bearings:

- **Annealing cast strips of aluminum bearing alloys**
- **Cladding aluminum bearing alloy with pure aluminum**
- **Rolling aluminum strip**
- **Roll bonding aluminum and steel strips**
- **Annealing bi-metal strips**
- **Inspection of bi-metal strips**

2. Annealing Cast Strips of Aluminum Bearing Alloys

Most methods of continuous castings of aluminum based bearing alloys result in internal stresses therefore the castings are annealed prior to cladding with pure aluminum.

3. Cladding Aluminum Bearing Alloy with Pure Aluminum

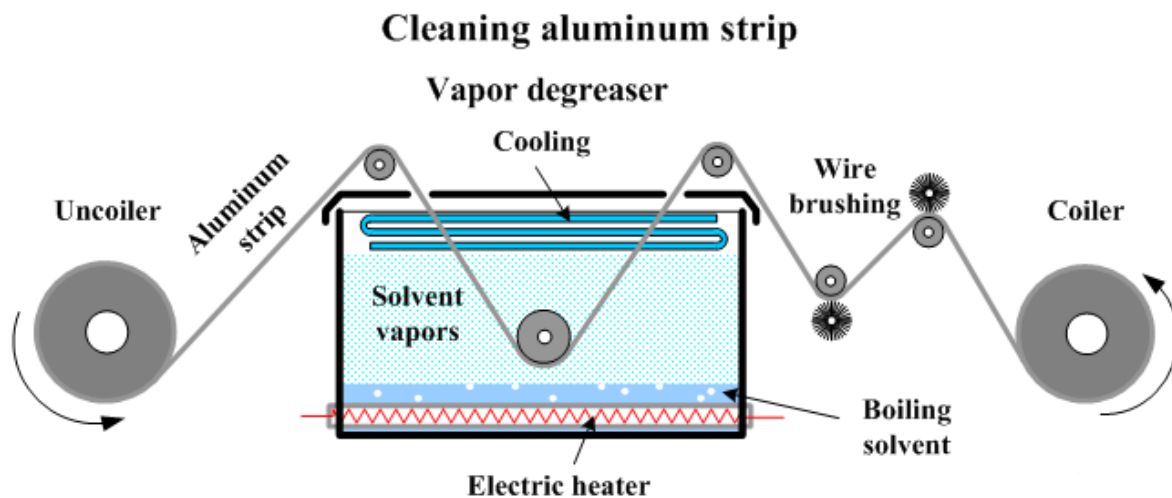
Tin contained in aluminum bearing alloys prevents achievement of good adhesion between the bonded strips.

The most popular method to avoid the adverse effect of tin is cladding aluminum strip with a bonding layer of pure aluminum (technically pure alloy with 99.5-99.7% Al, e.g. 1060) prior to steel backing.

Two pure aluminum layers may be clad from both sides of the casting: the bonding layer and the protection layer preventing tin “sweating” on the aluminum surface during the final annealing of the bi-metal strip.

Prior to the cladding operation the coiled strip of pure aluminum is degreased, mechanically cleaned and brushed in a cleaning line where the aluminum strip passes through a solvent degreaser, vapors of which dissolve oils (commonly protection oils) on the strip surface. Chlorinated solvents such as trichlorethylene, methylene chloride or perchlorethylene are commonly used in vapor degreasers.

Degreased strips are cleaned by rotating steel wire circular brushes and re-coiled on drums. Only the surface, which is to be bonded to the alloy strip is brushed.



Coils of clean aluminum strip are transferred to the cladding line.

A coil of a continuously cast strip of aluminum bearing alloy is installed on the uncoiler. The casting surface should be clean, contains no oil residuals and no cast defects.

Clean and annealed cast strips are uncoiled, straightened and brushed from both sides by steel wire circular brushes, which remove oxide film, residuals of burnt oil and other foreign substances.

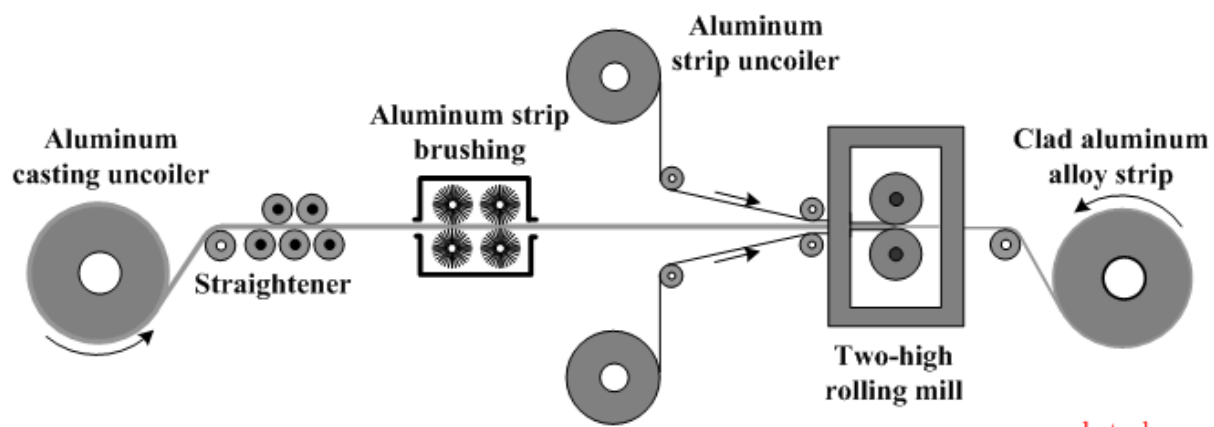
Simultaneously two strips of pure aluminum are also un-coiled.

Three strips enter the rolling mill where they adhere to each other as a result of Solid State Welding (SSW). The pressure necessary for achievement of bonding is obtained at relatively high thickness reduction for on-pass rolling operation.

The second rolling pass with lower thickness reduction provides stable bonding with the value of adhesion stress close to the tensile strength of aluminum.

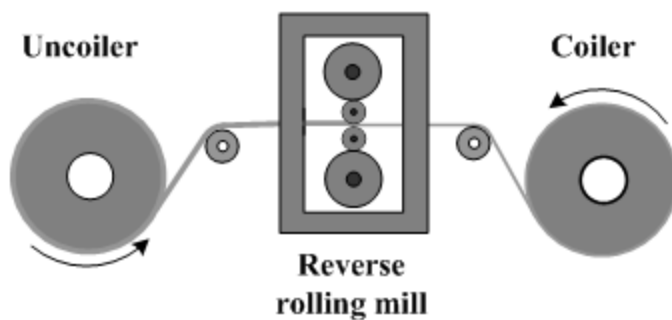
Two-high rolling mills are used for aluminum cladding operations.

Aluminum cladding line



4. Rolling Aluminum Strip

Aluminum rolling line



The strip of aluminum alloy clad with pure aluminum is then cold rolled to the final thickness for several rolling passes prior to bonding with steel back.

Reverse rolling mills (either two-high or four-high) are used for rolling aluminum strips.

After the final thickness of the aluminum strip has been achieved it is cut by a slit to remove defective edges and produce the required strip width.

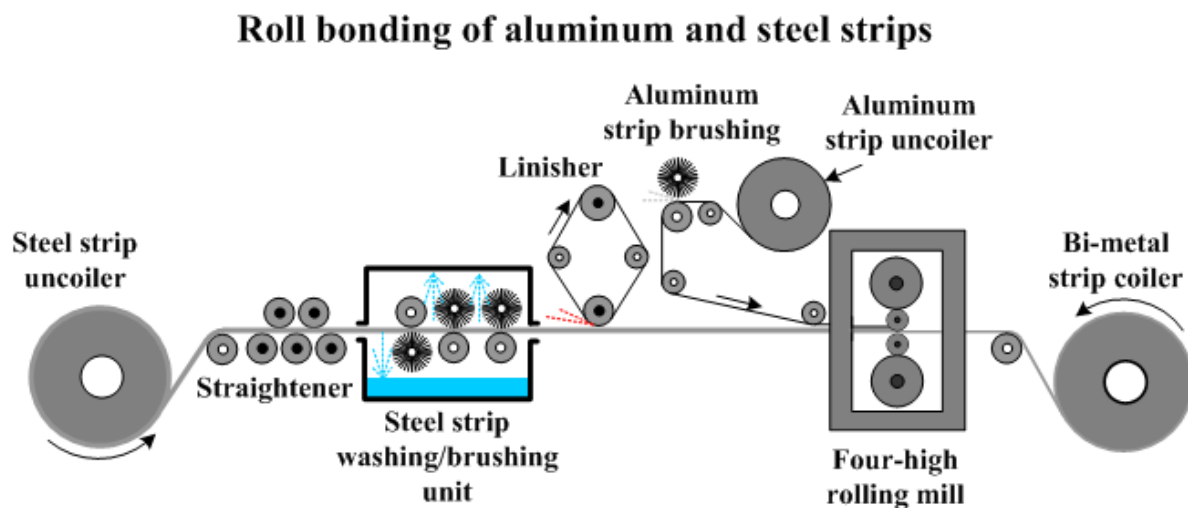
5. Roll Bonding Aluminum and Steel Strips

Prior to bonding with steel clad aluminum strip is degreased, mechanically cleaned and brushed by rotating circular brushes (either nylon or steel) in a cleaning line where the aluminum strip passes through a solvent degreaser (similar to the line for cleaning pure aluminum strip). The drum with the coil of clean strip of aluminum bearing alloy is then installed on the bonding line. Coil of a steel strip is installed on the uncoiler of the bonding line. The steel strip is uncoiled, straightened, cleaned by circular rotating brushes in the washing unit using a hot alkaline solution and then grinded by rotating abrasive belts.

In parallel the aluminum alloy strip is uncoiled and brushed by steel wire rotating circular brushes (only the surface, which is to be bonded to the steel strip is brushed).

Two strips enter rolling mill where they adhere to each other as a result of Solid State Welding (SSW). The pressure necessary for achievement of bonding is obtained at relatively high thickness reduction for on-pass rolling operation.

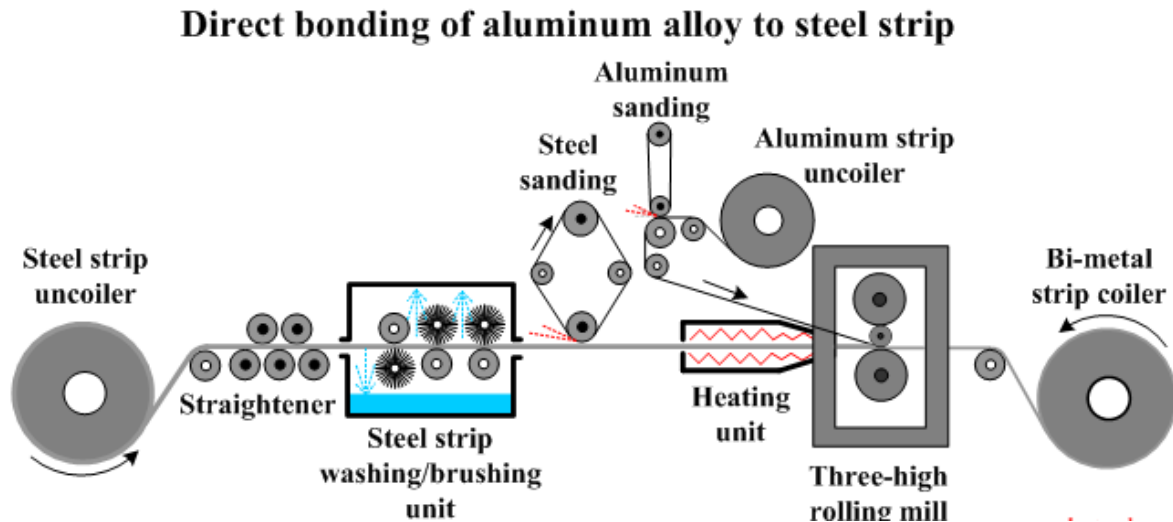
Four-high rolling mills are used for bonding aluminum alloy with steel strip.



Another version of roll bonding technology is presented in the scheme below.

Steel strip here is preheated in an induction heated tunnel just before entering three-high rolling mill. The line permits to bond steel strip with non-clad aluminum alloy with relatively low tin content (up to 8%), which was cast on twin-roll caster, annealed and then rolled to the required thickness.

Bonding of non-clad aluminum alloys containing higher tin concentrations (e.g. 20%) to steel strips is possible if the steel surface is coated by nickel (Nickel electroplating), which serves as a bonding layer.



6. Annealing Bi-Metal Strips

Aluminum bearing alloy on the bonded bi-metal strips has internal stresses and the stress on the boundary between the aluminum and steel strip. The stresses may lead to the bearings failure therefore stress relief operation of the bonded strips is necessary.

In addition to this the aluminum grains and tin plates adjacent to the grains surfaces are elongated along the rolling direction. Such microstructure is anisotropic with low strength in the direction perpendicular to the rolling direction. Isotropic microstructure may be obtained because of recrystallization. Full annealing of the aluminum alloy bonded to steel strip provides both stress-relief and recrystallization. Full annealing also changes the tin configuration, which converts into reticular (network) structure.

7. Inspection of Bi-Metal Strips

Inspection is the final stage of manufacturing bi-metal strips for aluminum bearings.

The bi-metal coil after annealing heat treatment is installed onto the inspection line where the strip is cleaned, checked, oiled and recoiled.

The strip is uncoiled then the tin “sweating” at the edges is removed, after which the steel and aluminum surfaces are brushed by rotating circular steel brushes.

Adhesion is tested by chisel and then the strip thickness is checked by a continuous thickness measurement appliance.

The defected parts are marked, the strip is oiled by a rust protection oils and recoiled.