Publication

Complete hot-dip tinning lines from a single source

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Tin-coated strip of copper and its alloys is an important primary material for the manufacture of electrical and electronic components.

It has been found that, for purposes of "good solderability" and "low insertion force", a tin coat between 2 and 5 µm is highly suitable [1,2]. This coating thickness range reflects two opposite effects. On the one hand, the intermetallic phase grows slowly but continuously starting from room temperature. It is this layer which impairs solderability over time, and this indicates that tin coatings should be made as thick as possible. Especially where a good solderability is required even after an extended storage period, thicker coatings up to 10 µm are necessary. On the other hand, the insertion force rises with the coating thickness.

The above-mentioned tin coat thickness range of 2 to 5 micron provides an optimum balance between low insertion and extraction forces, a high corrosion resistance and good solderability while ensuring a low contact resistance. These are typical demands imposed, e.g., by the automotive industry for its electrical components.

Established coating methods in today's market include galvanic tinning and hot dip tinning. For the manufacture of tinned strips for the electrical industry, hot-dip tinning has three key advantages:

1. The coating thickness achievable economically by galvanic tinning is limited to no more than about 3 µm. This results in a lower product service life, which is a major drawback in electrical connector applications. On the other hand, given the very thin coatings which can be produced to highly accurate tolerances by this method, galvanic tinning is widespread in steel sheet and strip coating ("tinplate"). This is because, firstly, thinner coatings are sufficient on steel and, secondly, because tin is considered physiologically safe [3].

2. In hot-dip tinning, a reaction layer (referred to as 'intermetallic phase') will form all by itself, resulting in good adhesion of the tin layer to the strip material. As a result, unlike its galvanically applied counterpart, a hot-dip tin coating will not become detached from the substrate metal even when the latter is intensely deformed.

3. Due to the intermetallic phase automatically produced in hot-dip tinning, the risk of 'whiskering' is clearly reduced. Whiskers are small crystalline outgrowths on metal surfaces which may form both spontaneously and after extended product use. Whiskering in electrical components may typically lead to short circuits. Adding lead can prevent the phenomenon, but this practice has been banned since the EU RoHS Directive took effect in 2006. In galvanic coating, a complex and costly reflow treatment is often added downstream of the process. In this reflow cycle, the galvanically applied tin layer is thermally fused and re-solidified. OTTO JUNKER has supplied equipment for such applications as well.
For Otto Junker GmbH, hot-dip tinning lines are a useful and logical expansion of its product portfolio. On the one hand, when it comes to strip conveying and drive technology, the company can draw on its many years of market leadership in cleaning, annealing and pickling copper strips. For the melting pot, on the other hand, OTTO JUNKER benefits from its technology leadership in melting furnace design.

The strips used in hot-dip tin coating generally consist of low-alloyed copper, brass, tin bronze or nickel silver. Strip gauges range from 0,12 – 1,2 mm, while widths vary up to around 460 mm. **Fig. 1** shows an OTTO JUNKER hot-dip tinning line in use since 2007.

The copper strip to be tin-coated is first uncoiled and then subjected to a thorough cleaning and, optionally, pickling cycle [1]. Thereafter, its entire surface is wetted with a fluxing agent suitable for the application, usually a standard commercial product. This flux or "soldering fluid" activates the strip surface in preparation of the tinning process.

The so-called fluxing bath is followed by the heated tin bath. Typically this is a resistance-heated pot, but for high outputs the use of an induction-heated vessel may also be considered. Here the molten tin is held at the specified temperature, and the amount of energy removed by the coated strip is substituted. Gas heating systems have likewise been built but tend to be disadvantageous due to their installation complexity. Strip speeds reach up to 200 m/min; the tin bath has a temperature of 250-290°C (the melting temperature of tin is ≈230°C). Given the relatively low heat conductivity of tin, bath temperature management needs to be carefully addressed.

Downstream of the tin bath, which must be adequately sized, we find the core of the system: the design and process integration of the wiping and blow-off unit is decisive for the coating thickness and uniformity over the width and length of the strip. In designing this system, OTTO JUNKER draws on many decades of experience and cooperation with the Technical University of Aachen (RTWH) in the field of flow control and aerodynamics. Optionally, the air...
wiper can be coupled with a non-destructive inline coating gauge. This forms a closed control loop ensuring uniform product quality.

From the air wiper the newly coated strip enters a non-contacting high-convection cooling zone and then passes through the coating gauge before it is wound up again on the recoiler.

The special operating regime of OTTO JUNKER’s tinning line in stop-and-go-mode provides a dramatic reduction in tin-coated reject material. The uncoated substrate metal can usually be returned to the foundry straight away. The more sophisticated design as a continuous processing line, which has likewise been realized, will therefore be interesting, as a rule, only with very high utilization rates.

References: