HOW WE MAKE ANALOG AUDIO TAPES ?

RECORDING THE MASTERS

Abstract

Mulann is committed into the Long-Term Audio project to carry the torch of the audio analog recording, and will continue to produce and distribute the tapes for audio professionals who like their audio technical and emotional properties. The mythical BASF tapes are now manufactured by Mulann and distributed under the new brand “Recording The Masters”.

This paper describes how the audio tapes are manufactured at the Mulann’ factory plant located in France and the care devoted to their production.

HOW WE MAKE ANALOG AUDIO TAPES ?

By Laurent Perdrieau - CTO Mulann - May 2016

Audio magnetic tapes have been the mass-medium giving access to individual music listening and recording during the 70’s and the 80’s. After the explosion of the digital music at the start of the decade, the audio magnetic tapes for studio recording and mixing, but also among the hobbyists, are regaining theirs credentials for theirs ability to make the music sounds differently.

At Mulann, we manufacture audio tapes for the music recording studios but also for the instrumentation industries (defense and spatial) and for the cinema. All of our audio tapes are distributed under the new brand name “Recording the Masters”.

Mulann owns the original formulations of the historical BASF and EMTEC tapes such as the mythical SM900 tapes well known and appreciated from the recording studios.

Overview

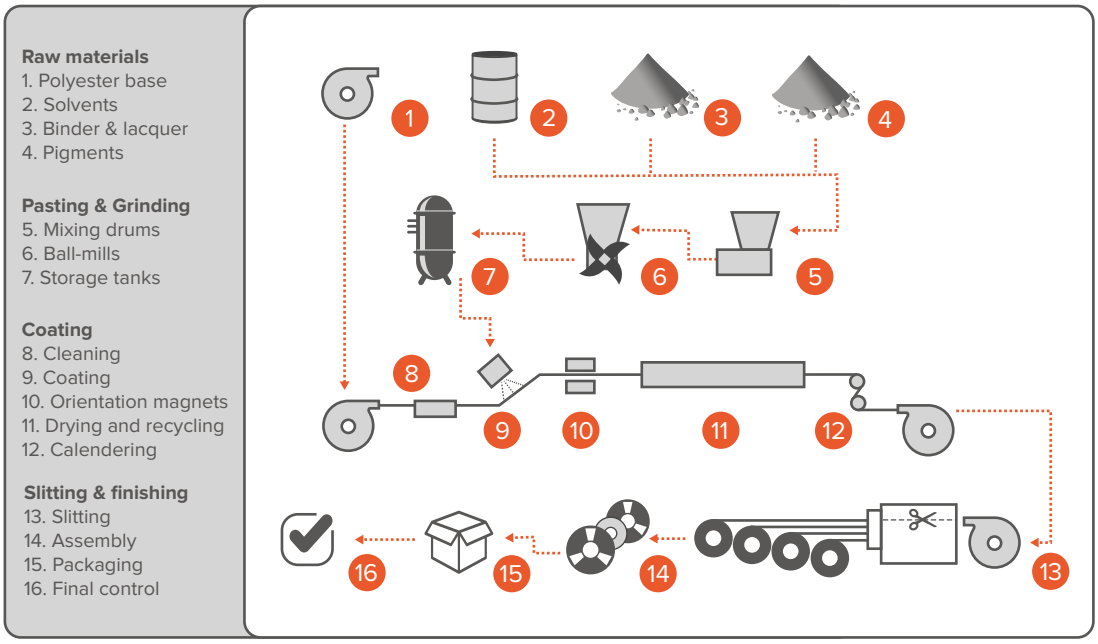

Figure 1 : Details of the 4-stage tape manufacturing process

The audio tapes use low coercivity ferroxide magnetic pigments for an accurate rendering of all the analog music tone variations. The coercivity can be seen as the measure of the ability of a ferromagnetic material to withstand an external magnetic field without becoming demagnetized. Therefore audio tapes are sensitive to external demagnetization fields but also to dust and finger prints. They must be handled carefully (see figure 2).

A thin magnetic layer (about 15µm) is coated on one side of the support (film) and a back-coating is generally applied on the opposite side for ensuring a perfect reel winding. The basic stages of the audio tape manufacturing process are illustrated in the figure 1 above.

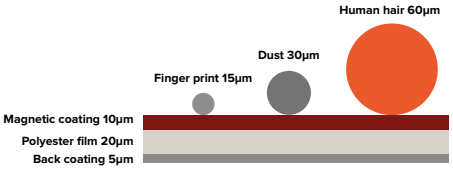

Figure 2 : Relative sizes of magnetic tapes and pollutions.

The Raw Materials

They are mainly four types of raw materials used to manufacture tapes: powders, liquids, supports and accessories.

Powders: mainly consist of the magnetic oxide pigments, the binders and colored pigments. The oxide pigments are low coercivity about 400 Oersted (32kA/m) ferroxide particles with needle shape (acicular).

Figure 3 : Samples of magnetic pigments: low coercivity (LoCo) pigment is used for audio tapes

Liquids: are solvents used for the emulsion dispersion. Solvents mixed with binder will make the magnetic particles sticking on the film support. For environmental and economic purposes, solvents are recycled.

Figure 4 : Technician qualifying raw materials before production

Supports: are rolls of polyester based films (also called jumbo) such as PET on which the coating emulsion will be casted. Polyethylene terephthalate or PET are petroleum derivatives easy to recycle and widely used in clothes or food containers. Depending on the type of application, the thickness of the base film varies from 7 to 30µm (1 µm is equal to 1/1000 of millimeter) and the film roll lengths from 6 to 21 kilometers according to its thickness. Specific supports are used for magnetic instrumentation tapes to withstand the extreme conditions and high temperature the 'black-boxes' can be exposed.

Accessories: includes items such as hubs, screws, plastic and metal flanges as well as packaging carton box.

All raw material deliveries are strictly checked on arrival to guaranty the constant quality and specifications consistency of the tapes.

The Pasting and Grinding

From the raw materials, two types of emulsions will be prepared: the magnetic slurries and the back-coating solution.

Magnetic slurries are prepared by dispersing the magnetic pigments into the binder. In chemistry, the dispersion is a mixture in which fine particles of one substance are scattered throughout another substance. Binders are finely granulated substances dissolved into solvents.

Figure 5 : Some of the emulsions are prepared in advance and stored in large tanks-agitators before use.

For optimum characteristics of the magnetic coating on the support, some additives are also added. The dispersion of the pigments is improved thanks to dispergators, slips agents are used for reducing the friction between the tape and components such as guides or magnetic heads in recording equipment and softeners ensure the coating flexibility. Additional ingredients are used to provide the best tape quality.

Each reference of audio tape requires a specific magnetic formulation. The first operation of the magnetic formulation consists of pasting (premixing) the raw materials into large drums. The next operation consists of grinding the previously pasted mixture into ball-mills.

The grinding operation is crucial because the magnetic properties of tapes are strongly related to the size distribution of the magnetic particles. The grinding will spread apart magnetic particles from agglomerates and the dispersion operation is aimed to cover each particle with binder.

Audio tape quality and especially the modulation noise of audio tapes are directly related to a good level of dispersion. Nevertheless, a too long grinding may fragment the acicular pigments and reduce the resulting coercivity. The viscosity of the magnetic slurry must be perfectly controlled for enabling the next operation which is the coating over the polyester support.

The coating

The emulation is drained from the vessels, carefully filtered and some hardener will be added. The mixture is pushed to the casting head at a well-defined pressure. On the coating machine, the PET film is unrolled from its coils and an automatic system continuously feed the machine with film by bonding the beginning of the next roll at very high speed.

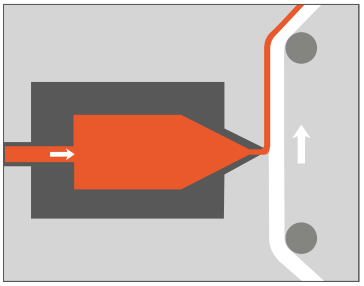

Figure 6 : The coating emulsion is applied on the passing support through the aperture of the casting head. Pressure and film speed are critical to determine the thickness.

After cleaning the support, the film reaches the casting head where the magnetic emulsion is coated on the film. The calibrated aperture of the casting head and the film speed are important in the final magnetic coating thickness (see figure 6). The precision is very high (±0.5%) and must remain consistent across the width and the length of the rolls as well as between rolls. Different casting heads may be used for coating the different types of emulsions.

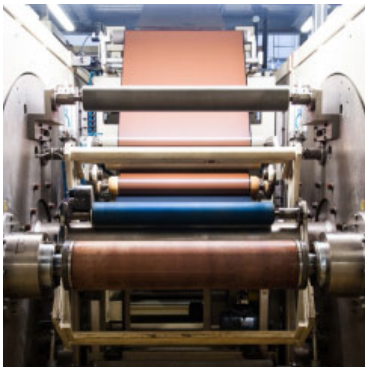

Figure 7 : Coating machine

Right after the coating operation, the film passes over smoothing magnets that helps the magnetic particles to reorient in the same direction because pigment particles are randomly oriented. Before entering into the dryer, whereas the coating is still liquid, there are strong magnets “pulling” all magnetic particles parallel to the direction of the tape. This ensures the best quality of the recording capability (see figure 8).

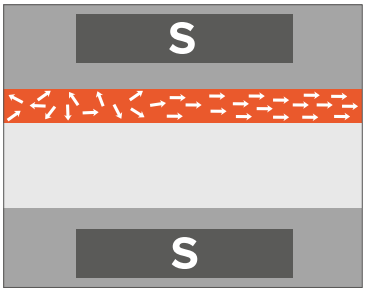

Figure 8 : Once the magnetic coating has been applied, acicular magnetic particles need to be aligned parallel to the tape thanks to strong orientation magnets.

Then, the film passes through the dryer which is an oven filled with an inert gas for extracting the solvents from the coated emulsion. The drying is an important operation where the cross-linking take place - long chais shaped molecules of the binder cross connections are created. This operation will leave about 30 to 40% of the emulsion on the film (dry extract). Therefore, a very accurate monitoring of the coating thickness is crucial during the casting operation. The drying gives the stability of tape that makes long-term storage possible.

Solvents are extracted from the heated gas by means of condensation and distillation. The inert gas is reused in the drying system into an environmental friendly recycling process (figure 9).

Figure 9 : Dryer of the audio tape coater

From a general standpoint, every liquid or vapor generated during the tape manufacturing process are recycled for a sustainable development.

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At the output of the dryer, the calender system made of several heated metal rolls applies a pressure on the coating to give its polished aspect (see figure 10). This is necessary to ensure optimum contact between the tape and the magnetic heads of the recording equipment. Moreover, the quality of the tape surface is responsible for the optimum high frequency response of the audio tapes. At the end of the coating machine, the film is rewound.

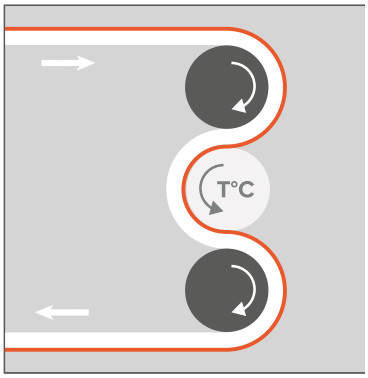

Figure 10 : The calender consists of two sets of a pair of elastic rolls pressing the surface of the coated magnetic side against a heated metal roll to smoothen the surface.

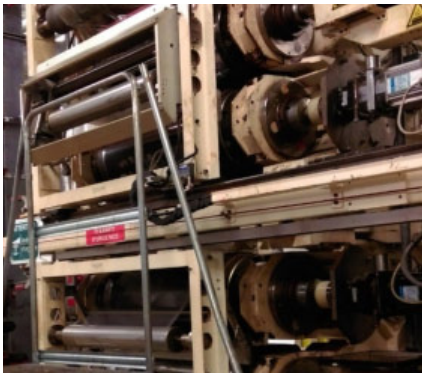

Figure 11 : Calendering rollers ensure the smoothness for tape-head contact and good quality response in high frequency for audio tapes

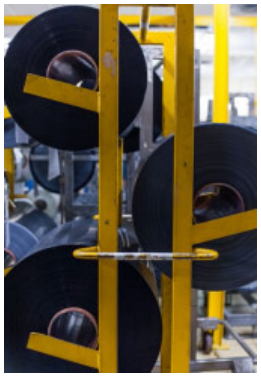

Figure 12 : After coating, jumbos are stored on trees waiting to be slit

The coating machines run continuously allowing empty and full rolls to be exchanged in an uninterrupted process. Running 24 hours a day it can guaranty constant quality. Once the magnetic layer has been casted on the film, the roll will pass through the machine to have the back-coating layer casted on its back side. The film will go through the drying operation again.

The Slitting

The next operation for manufacturing magnetic tapes is to cut the coated rolls into tapes with a width corresponding to the targeted application. Tape widths are normalized. Audio tapes for studio are 2 inches wide for recording 24 audio tracks but there are also 1 inch tape (e.g. 16-tracks), 1/2 or 1/4 inches. The latter width (1/4 in) is widely used for consumer audio tapes with stereo recorded tracks. Perforated audio tapes for the cinema have widths compatible with the 16 and 35mm format.

Figure 13: Slitting requires a very high precision to cut the rolls (jumbos) of coated film into tapes with a very accurate width

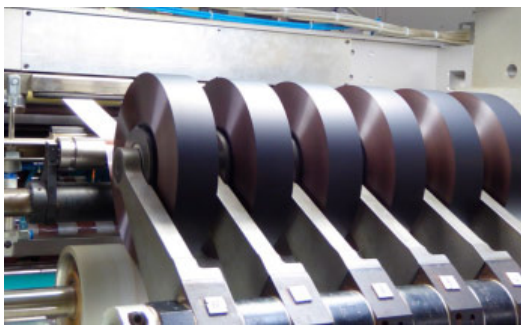

Figure 14 : During the slitting of the jumbos, tapes are winded either on reels or as "pancakes" – i.e. on a hub without flanges as on the photo.

Slitting operations are carried out into a clean from dust environment. Rotating blades of the slitters cut with very high precision the coated film to comply with the tolerance of the standards. Blades are mounted on two axes and overlap forming a pair of scissor.

Once cut, the individual tapes are guided to be wound on hubs or reels according to their final application. Studio tapes are wound on hubs whereas consumer tapes are generally wounded directly on plastic reels such as the well-known Trident reels.

The length of the tapes depends on its final application and can range from 900ft to 9000ft. Of course, the thickness of the tape will determine the diameter of the tape for a given length.

During the tape slitting operation, individual tapes are continuously inspected for defects and rejected if needed.

The Finishing

The finishing includes the final assembly and the packaging. Audio tapes for studio that have been wounded on hubs, will receive metal flanges. The audio wounded tapes are magnetically erased before packing to avoid background noise.

The Quality Control

All along the manufacturing process and even before, during the raw material reception, a wide set of quality control tests are performed.

In order to provide very high quality products, Mulann has invested into on-site quality control laboratories. One laboratory is dedicated to the control of raw material and a second one works with the production unit to sample the tapes at different stages all along their manufacturing down to the shipment.

All the tests performed are used for the final product clearance.

Figure 15 : Quality control

More about MULANN
Mulann has been historically involved in the control of magnetic stripes for more than 30 years and has gained a strong experience on magnetic tapes. The Mulann production site is the legacy of the historical BASF Magnetics. It has been in the magnetic business since 1946.

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