AMPEX

MAGNETIC TAPE TRENDS

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ABRASIVE CHARACTERISTICS OF TAPE

Under normal operating conditions, precision magnetic tape is not considered in terms as being abrasive and a major factor in headwear. As recording techniques evolved, higher performance machines were developed to meet the demand for shorter wavelength applications. The logical approach to achieve these higher performance levels was to go to faster tape speeds. In addition to the increase in tape speed, head designs were considerably improved to record and reproduce shorter wavelengths accurately. Head gaps on the latest instrumentation heads are less than half of the conventional 80 - 100 μ inch gap prevalent in the standard line of instrumentation equipment. The combination of ultra precision heads and higher tape speeds focus more attention on tape inflicted head wear.

Computer headwear is also becoming more important. Higher transfer rates, greater programming rates, and higher speed machines make an understanding of head wear imperative.

To understand the basic relation between headwear and tape surface characteristics, a knowledge of the tape's structure and composition is required. Magnetic tape consists of a thin oxide coating firmly bonded to a flexible base material. The coating thickness generally represents 20-30% of the total tape thickness. This of course varies with different products, particularly in recently developed thincoat tapes.

The purpose of the base film generally speaking, is twofold. One, to provide dimensional stability and means to move the oxide coating past the heads in an orderly, controlled fashion. Secondly, the base film provides a layer-to-layer insulation to protect the magnetic integrity of the oxide.

The heart of all magnetic tape is the oxide particle itself. In virtually all precision tapes, the oxide used is a gamma ferric Fe_2O_3 (Γ) oxide particles which are acicular in shape, approximately 0.1 micron thick and 0.7 micron long. These particles are held in the binder in much the same manner as almonds are held in a chocolate bar. Pigment loading is the term used to describe the amount of oxide that is present in a given formulation. The per unit volume of magnetic intensity and thus the output and response levels, is directly proportional to the pigment loading. High output tape, all other things being equal, will have a higher pigment loading than regular wear tape. On the average, the pigment loading or % of oxide, makes up approximately 60% of the formulation. The remaining portion is the binder.

Oxide particles are highly abrasive by nature, and each individual particle must be completely coated with the binder formulation. The binder must perform various functions,

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the most important being to bind the particles to each other with a cohesive band, and also to provide an adhesive band of the coating formulation to the base film. A typical binder system consists of the following general constituents.

BINDER - holds the particles to each other and to the base film.

PLASTICIZERS - provides the needed flexibility in the coating.

RESINS - keeps the binder pliable and prohibits cracking and flake off.

ANTI-STATIC ELEMENT - carbon black is introduced to make the coating conductive.

WETTING AGENTS - "Wets" each oxide particle to make it more conducive to receive the other binder ingredients for a uniform mix.

LUBRICANTS - minimizes abrasive effects of the oxide particles.

SOLVENTS - promotes the mixing of all ingredients to assure smooth, even dispersion.

ANTI-BLOOM AGENTS - prevents coating from shedding excess powdery residue.

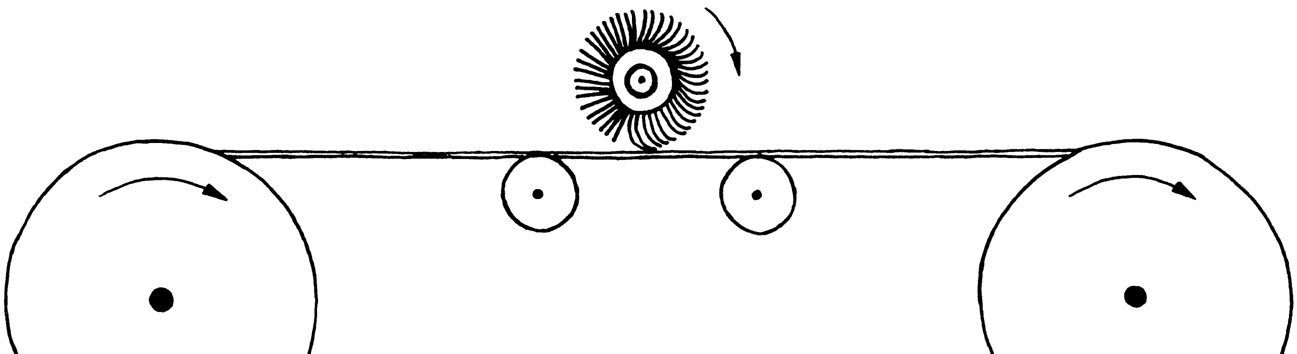
ANTI-FUNGUS AGENT - retards the growth of fungus.

Wear characteristics of a tape are determined solely by the binder. The oxide particles per se, never wear out. A tape fails (wears out) because the binder system degenerates and loses its ability to hold the particles in the coating. This wear is a result of the frictional forces and the associated heat that builds up during the operation of the tape.

Proper tape design must consider all aspects of its performance cycle. A long wearing tape with an extremely hard surface could be designed to last indefinitely. But, it would be unacceptable if it were not softer than the heads or machine components. If any two materials are rubbed together, the softer of the two will be the one to show more wear. In the case of tape and magnetic recording components, the tape should wear faster than the heads. This is why a slight amount of oxide shed will be present on any transport after a tape has been run.

The manufacture of precision magnetic tape involves the coordination of many closely controlled operations. Oxide preparation, and mixing of the binder is one of the most important. Dry oxide is carefully processed until each individual particle assumes its inherent, natural shape. This is the acicular shape previously described, each particle being roughly 7 times as long as it is thick. The oxide must be thoroughly mixed with each ingredient in the binder system. The resulting mix must be perfectly homogeneous and uniform. Each individual oxide particle must be coated completely with the binder. The mix at this stage resembles the consistency of highly refined paint. It is coated on the base film, and slowly dried in a temperature controlled oven. During the drying process the solvents escape from the coating in the form of gas, and this process leaves small craters and surface irregularities. This necessitates a surface treatment, which is usually performed on the tape immediately after the drying process.

The surface finishing technique is very important, and many times will determine the ultimate performance characteristics of the tape. The ultimate objective in treating the tape's surface is to achieve a highly polished, smooth surface. This can be done by polishing or buffing the tape surface with an abrasive wheel to remove the high spots.



TAPE SURFACE TREATMENT BY BUFFING

FIG. 1

Another method would be to pass the tape back over itself under pressure and let the oxide coating polish itself.

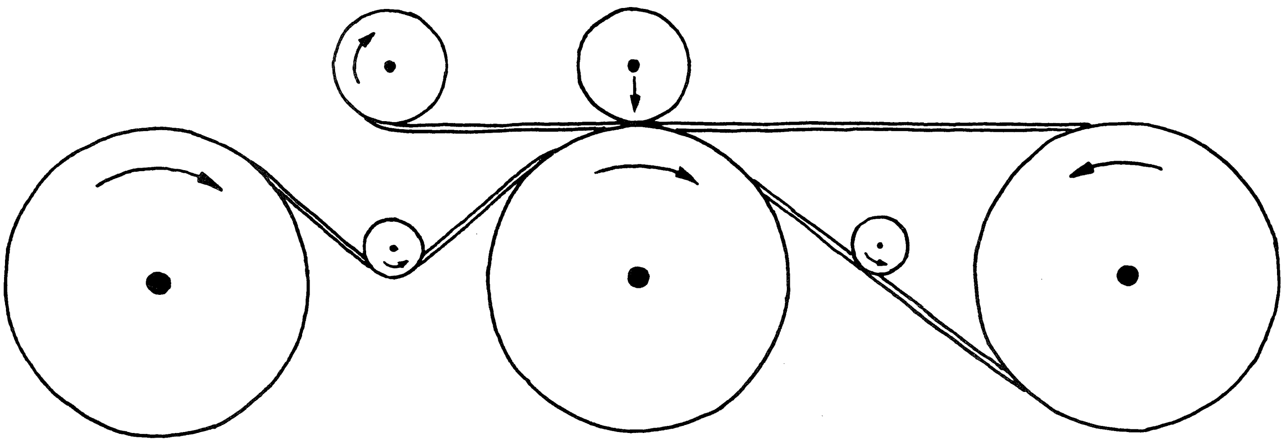
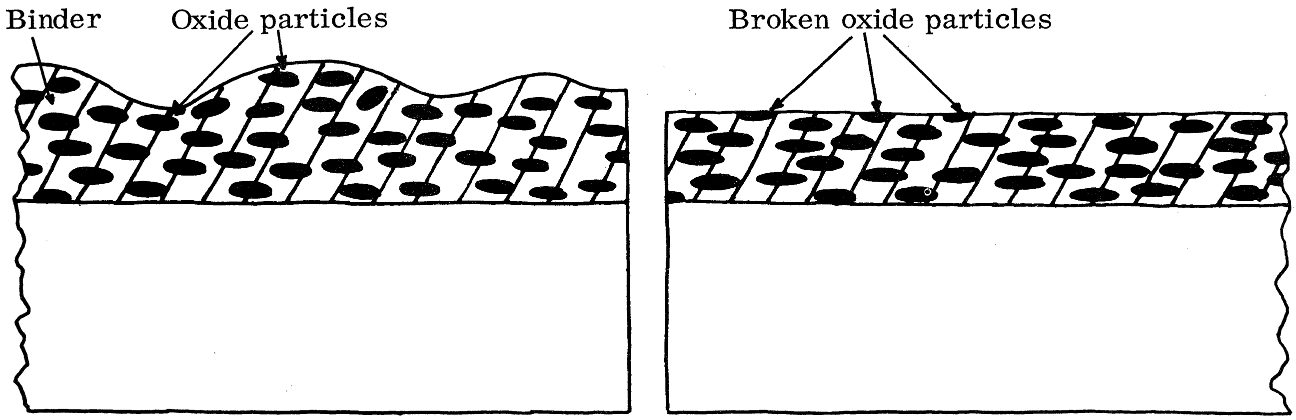


FIG. 2

Both of these methods will give a surface with the peaks and valleys minimized. However, this will not necessarily insure that the tape surface will be smooth and non-abrasive. The most important aspect in evaluating a tape's surface for abrasiveness is not the physical displacement of the surface (relative magnitude of hills and valleys), but the actual nature of the surface that will contact the machine components. If abrasive methods are used to treat the tape surface, it is possible that many of the oxide particles will be fractured. This would expose the bare oxide which would give the tape a highly abrasive surface, although the surface appears optically smooth. An additional disadvantage resulting from fractured oxide particles is the increased noise level resulting from non-uniform fields from the fractured particles.

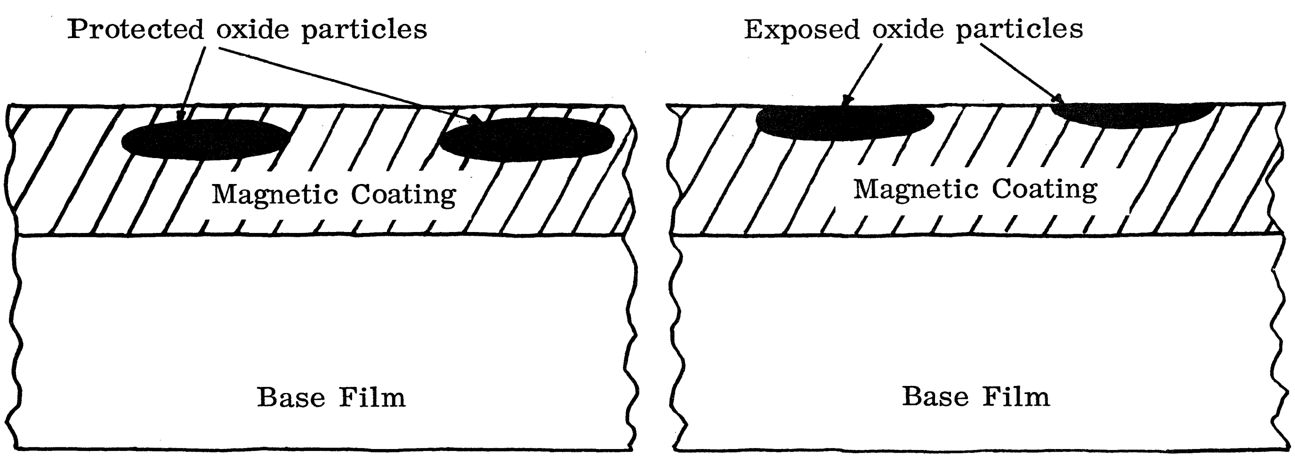


BEFORE SURFACE FINISHING

AFTER SURFACE FINISHING

FIG. 3

An ideal tape surface has only the binder exposed. All individual oxide particles are completely encapsulated in a protective covering of the binder. Because of the abrasive nature of the oxide particle, this binder coating must be maintained around each bit of oxide. The binder will not wear the heads at all, but if it is scraped away during the surface treatment, the abrasive oxide will be exposed.



IDEAL SURFACE
with only binder exposed

ABRASIVE SURFACE
with portions of bare oxide exposed

FIG. 4

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Excessive machine component wear is the cumulative result of many variables working together. First and foremost is the nature of the tape surface. Other factors are tape tension, tape speed, head wrap, type of head, guide adjustment, design of tape path, ambient temperature, condition of transport (cleanliness), performance cycle, operator technique, tape storage, etc.

Many attempts have been made to devise a comprehensive test and specifications to accurately classify tapes by their abrasive characteristics, but due to the myriad of variables ever present, it has been impossible to develop a universal criteria. On specific machines, under a specific set of controlled conditions, it is possible to compare the abrasive qualities of different tapes. This can be done by running the tapes, reel to reel, a given number of passes and accurately measuring the head profile before and after. A shuttle test over a short section of tape is not recommended because unrealistic temperatures, tensions, and other conditions are introduced. The test described herein sounds simple, but it is very time consuming. Each head design varies in its respective wearing rate, but a general indication of magnitude would be about 20 to 100 microinches per 100 passes.

Some tests have been conducted with relative soft metals. Different tapes were evaluated by pulling them over a soft cylinder a given number of passes, and weighing the cylinder before and after. This provides a figure of merit for each tape on a relative basis. Here again, abnormal conditions are introduced and the test does not necessarily duplicate actual operating conditions.

It should be pointed out that although this discussion deals with the abrasive nature of tape, it should not be construed as an indication of imminent severe machine component wear resulting from use of the present precision tapes. The concept of tape life and tape inflicted machine component wear is unchanged. The purpose of this article is to provide a better understanding of the contributive factors in this relation to provide assistance in optimizing total system performance.

At present it is most difficult to generate a set of definite specifications for the abrasiveness (or lack of abrasiveness) for given tapes. Essentially all high quality precision tapes commercially available today have acceptable surfaces. In unique, specialized applications, overall system performance is enhanced by the use of certain tapes having less abrasive surfaces.