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Post-molding processing is a unique requirement for VideoDisc

The "wash-lube" portion of VideoDisc manufacturing process is the final touch that protects the disc-stylus interface.

The processing required to manufacture a CED VideoDisc does not end with the VideoDisc molding operation. Two additional process steps—chemical surface treatment and lubrication—are required to make a highly reliable, long-lived product.

The component additives (lubricants, stabilizers, plasticizers, and process aids) in the disc-formulation compound provide good molding and release characteristics, but are also potential candidates, as are polyvinyl chloride (PVC) degradation products, for migration to the surface of the disc. A thin surface film and/or debris can accumulate under certain conditions. These imperfections will raise the stylus from the surface, thus drastically reducing the signal level. When the carrier level drops enough, the video and audio signals cannot be recovered and extremely poor picture and sound results upon playback through a TV receiver. This phenomenon is known as carrier distress and occurs on an untreated disc as an aging, moisture-sensitivity, or temperature-stress problem. A chemical surface treatment stabilizes the disc surface and protects it against aging and environmentally-caused failures (Fig. 1).

The disc surface is played with a diamond stylus and, if the disc surface is untreated, both the disc and the stylus will suffer from wear. To prevent this, a thin film of lubricant is applied to the disc in the final process step before insertion into the caddy and packaging (Fig. 2).

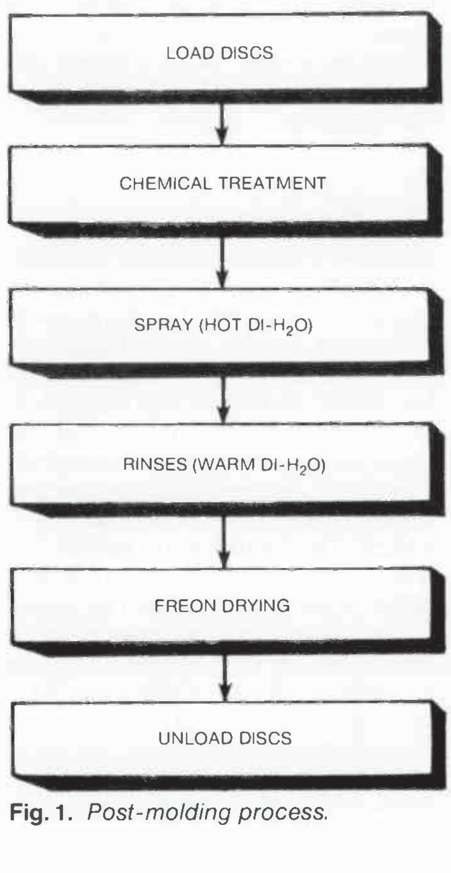

Fig. 1. *Post-molding process.*

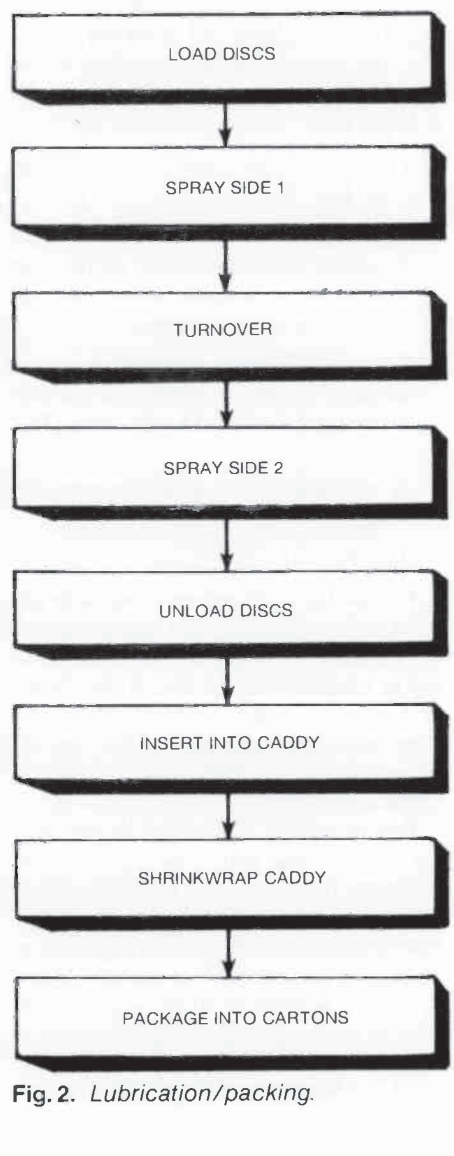

Fig. 2. *Lubrication/packing.*

Abstract: *The author reviews the VideoDisc chemical surface treatment and lubrication process steps. The chemical reasons for the treatments are given, and the chemical solutions used are described. Moreover, the author discusses the equipment considerations and environmental tests undertaken to prove out the process.*

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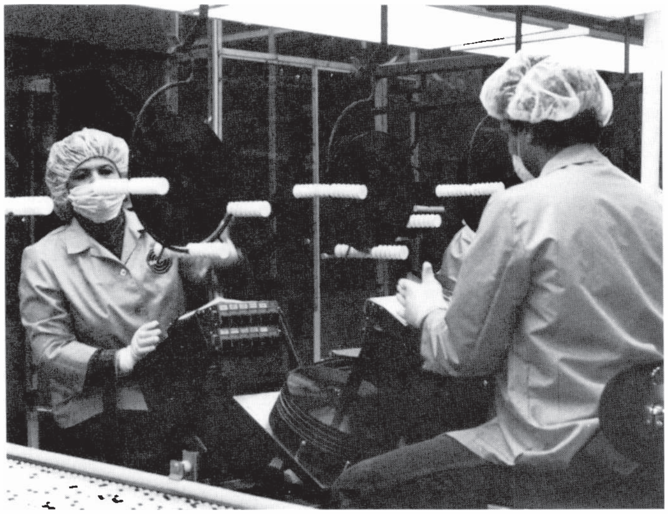

Fig. 3. *Conveyor loading. The surface-treatment-line conveyor is loaded with VideoDiscs.*

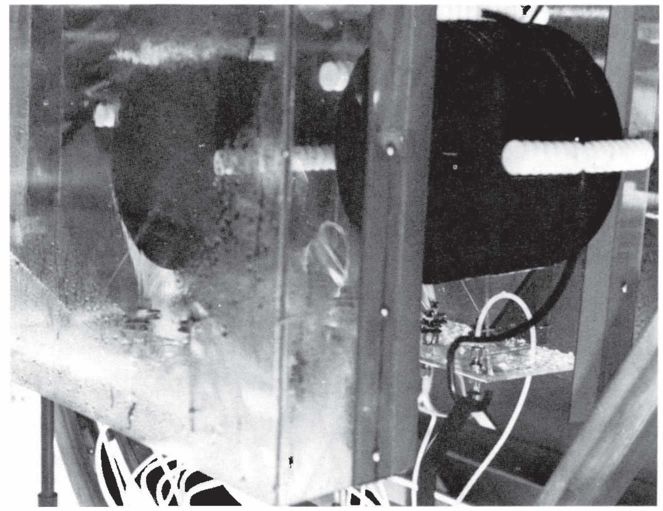

Fig. 4. *Spray chamber. The discs are sprayed with hot deionized water to remove surface contaminants.*

Chemical surface treatment

The primary purpose of the treatment process is the removal and near-surface depletion of undesirable organic additives, degradation by-products, and metal-salt impurities that can migrate to the surface of the disc. Discs are treated in a process sequence as follows:

1. Discs are loaded onto conveyor racks (Fig. 3).
2. The discs are immersed in a chemical treatment bath containing amine and surface-active components that provide uniform chemical treatment.
3. The residual film is removed through a series of highly purified, filtered, deionized water sprays and dip rinses (Fig. 4).
4. A chemical vapor dryer removes the water film by displacement drying.
5. The discs are unloaded from the rack.

Because the video and audio signal amplitudes are so minute (~850 angstroms and ~90 angstroms respectively), the fluids coming in contact with the disc surface must be particulate- and colloid-free. The water must not only be deionized, but also requires submicron-filtration and colloid-removal steps.

Process control is achieved by monitoring the chemical bath concentrations, the pH in the rinse tanks, the pH in the chemical vapor dryer (to monitor decomposition resulting in acid), and the organic and particulate contaminants in the rinse tanks.

Surface analysis of plastics is difficult at best. However, during the development of the process, research based on Secondary Ion Mass Spectrometry (SIMS) confirmed the existence of a depletion layer of metal-ion salts that results from the treatment process.[1,2] Further, Fourier Transform Infrared Spectroscopy (FTIR) coupled with a reflection sample device was used to monitor the surface enrichment of certain formulation additives relative to bulk concentrations.[3] Indications are that a "native" lubricant layer is also removed in the treatment. Variations in spatial uniformity and thickness appear to depend on the press process. The amount of wetting and spreading of the lubricant on the surfaces of untreated discs varies significantly.[4] The chemical treatment step has the side benefit of making a more uniform surface that more readily accepts the subsequently applied lubricant.

Disc lubrication

After the chemical treatment operation, the VideoDisc is loaded on a carrier mounted on a conveyor belt. The disc is carried into a spray chamber. At this point, a solvent containing a low concentration of lubricant is atomized through a spray nozzle directed at the disc (Fig. 5). The disc leaves the chamber and is automatically turned over and repositioned on the conveyor. The other side of the disc is then lubricated in a second spray chamber. The conveyor then carries the disc to the next station, where it is inserted into the caddy.

The thickness and uniformity of the oil on the disc are the parameters of prime importance. Nominal oil thicknesses are in the range of 200 to 400 angstroms. At lower thicknesses, stylus wear can occur. At greater thicknesses, the oil does not conform as well to the disc surface and can act as a particle trap as well as cause a drop in signal level when the thickness becomes extreme.

The solution flow rate, atomization pressure, nozzle geometry, and nozzle oscillation rate are optimized for a given line-speed to provide for good oil distribution. The solution is filtered directly before atomization. The air used to atomize the solution is provided by a modified compressor designed to give particle-free air. Commercial oil-free compressors, even those for hospital use, have proven far too dirty for this application.

The solvent is tested to specifications even more stringent than for a reagent-grade material. The lubricant consists of two species. A silicone of the type

$$(CH_3)_3Si - O \left[\begin{array}{c} CH_3 \\ | \\ Si \\ | \\ R \end{array} \right]_n O - Si\,(CH_3)_3$$

is used to provide the lubricating qualities, while a modified silicone additive is used to enhance uniform oil spreading, even in moist environments. The lubricant material specifications are very demanding and the properties measured include the following:

- specific gravity;
- surface tension;
- viscosity;
- molecular-weight distribution;
- trace organic impurities; and
- trace inorganic impurities.

Control of the oil thickness is monitored

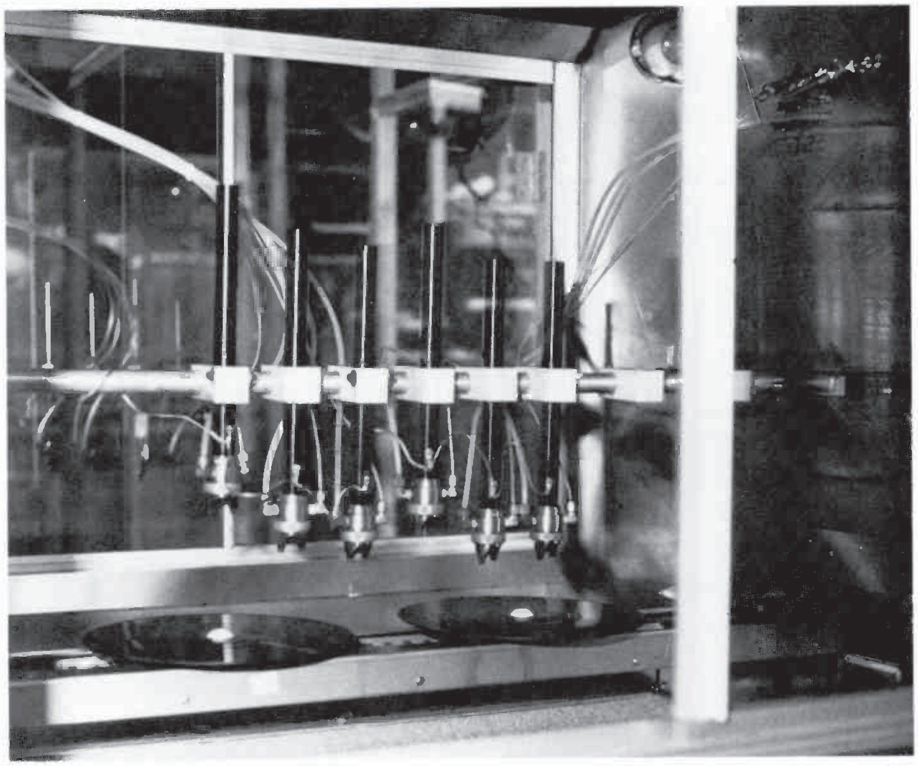

Fig. 5. *Lubrication spray chamber. A dilute solution of lubricant is sprayed on the discs.*

by our use of X-ray fluorescence spectrometry on a routine basis.

Equipment considerations

In addition to critical process conditions and chemical requirements, equipment-design considerations are important to successful operation of the surface treatment/lubrication process.

Rack design is critical in both protecting a disc against damage in transport through the treatment operations while also allowing effective rinsing and drying. Conveyors must be constructed so tank contamination is minimized or eliminated. Materials of construction are, in general, high-grade stainless steel or Teflon to minimize contamination.

The lubrication-line turnover demands that a delicate product be handled automatically at a high rate of speed. Nozzle design and layout are important in producing a uniform lubricant layer over the disc surface. Safe handling of the solvent necessitates strict grounding requirements coupled with an automatic vapor-detection/explosion-suppression system. Economics of the process are assisted by a highly efficient solvent-recovery system that not only prevents contamination of the environment, but permits reclamation of an expensive raw material.

Environmental tests

Post-molding processes are carried out for two major reasons:

1. reduced disc/stylus frictional wear, and
2. improved stability to extremes of environment.

The treatment process was developed to meet stringent criteria under a wide variety of environmental stresses. Examples include:

- Hot condensation stress (1 hr)
- High temperature and high humidity (48 hr)
- Low humidity (<15% relative humidity)
- High temperature (130°F), and low temperature (−40°F)
- New Orleans Worst Day tests (a 28-times repeat of a 24-hour cycle that includes both a 85°F, 95% relative humidity environment and a 105°F, 55% relative humidity environment).

After they are stressed, the discs must meet all physical specifications (for example, warp and acceleration) and playback criteria for carrier distress, skipping, and video and audio signal/noise.

These tests are used for process development and periodic process/product audits, and are not intended as routine quality-control tools.

Summary

The disc-lubricant layer increases stylus life by approximately two orders of magnitude. The incidence of carrier distress (under environmental stress) is reduced approximately two orders of magnitude as a result of the chemical surface treatment (20 to 30 seconds per side versus less than 0.2 seconds per side). Obviously, to make a quality product, both steps are critical. Much effort at VideoDisc Operations and the RCA Laboratories was expended in the development and successful implementation of the operations.

Additional developments will bring technological rewards. An improved understanding of disc-surface physics and chemistry, and their relation to formulation and molding process conditions, will result in a more efficient surface treatment and lubrication.

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David Hakala joined RCA Picture Tube Division, as a process development engineer, after receiving his PhD in physical chemistry from R.P.I. in 1976. After serving as group leader of the Analytical Laboratory for two years, he joined VideoDisc Operations as Staff Scientist working on material problems. Currently, he is Manager of Chemical & Process Development. He holds one patent and is the author of several publications.
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