Physical and technological approaches to systemic film moistening

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Abstract. This article discusses the physical and technological approaches to systemic film moistening. The features of storage and operation of film in various conditions are considered. A number of features and facts are presented that affect the organization of both systemic humidification and the maintenance of long-term storage of film materials on analog media. The article presents the main factors that affect the quality of the working surface of 35 mm and 16 mm film: the specifics of the composition of the film; the effects of a temporary, natural and technological nature on motion pictures; sophisticated technology for servicing analog film projectors, rewinding devices and film checking facilities. The analysis of the sequence of manipulations of technological equipment and chemical compositions for stable operation without gusts, drying and burnout of film materials is carried out. The article gives the physicochemical content of work on the stages of film moistening, taking into account the specifics of the applied filmstic liquids. In the step-by-step process of moistening, after the end of each stage, the main results obtained are assessed by visual comparison of the image projections, followed by the digitization of the image and the correction of the result obtained in graphic editors. To eliminate artifacts, scratches and other elements of entropy, the authors recommend using neural network approaches for working with film materials.

1. Introduction

Film and photographic materials, like other documents of the state archives, are subject to eternal storage, which is ensured by their translation into digital format. In the work [1-3], the authors propose to use polymer varnishes in the preparation of materials based on ether cellulose for digitization for...
subsequent long-term storage. This method [2] can significantly reduce the complexity of correcting scanned images when converting them from analog to digital. However, it should be borne in mind that when preparing for scanning, the film is very different, and color, and black and white, and damaged, and faded. And in order for a film copy to be properly stored and further exploited, it is necessary to determine what exactly and in what state gets into the film storage.

2. Materials
It is quite simple to work with “narrow” 16-mm film and without visible entropy (Soviet-made triacetate or diacetate or ORWO produced by the GDR from Filmfabrik Wolfen from Wolfen near Bitterfeld, or AGFA of a European company from Mortsel, Belgium). With 35 mm film, serious processing difficulties are possible (see, for example, GOST 20904-82. Film 16 mm. Dimensions and control methods and GOST 4896-80. 35 mm film. Dimensions and control methods).

Modern lavsan-based film meets both cyan blue phonogram, and red-brown phonogram, and magenta. Such a phonogram, by the way, was printed until the mid-2000s and is perfectly reproduced both on Soviet cinema equipment and on foreign-made film projectors [4-7].

Soviet film produced by the production association "Svema" (Photosensitive materials of the Shostkinskiy chemical plant), or "Tasma" (Tatar photosensitive materials of the Kazan chemical plant named after Kuibyshev) on a triacetate basis, as a rule, is very reddish (see figure 1), however, the gradation of red, saturation and tone depend on the year of release (less purple and crimson - film from 1985-1989, and the most scarlet - from the beginning and mid-1990s).

![Figure 1. Color characteristics of film saturation and tone.](image)

If the copy was viewed and shone through mainly on projectors with xenon lamps, then the film print is usually much redder than when viewed on equipment with incandescent lamps. In [6], a model range of such cinematographic installations is presented.

Also, the triacetate film can dry out very quickly, becoming at the same time brittle and unstable at folds and perforations, therefore it is the triacetate film that requires special storage conditions: temperature not higher than +20, humidity not less than 60%. In a film warehouse, it is quite difficult to create such storage conditions, since the main heating system was installed in the 80s, therefore triacetate film is stored in the coolest and at least relatively dry and ventilated room (in closed 35 mm cans, so that the film did not dry out, and was neither in the sun nor near the convectors).

Under difficult storage conditions with high temperatures, low humidity, when storing film without tin boxes, or not in special boxes or special boxes for parts of the film, the film dries up, becomes fragile, easily torn and deformed. An example of storing a triacetate film is shown in figure 2. Also, due to shrinkage of the film, the tape in the tape drive mechanism of the projector stops moving normally, as a result of which, due to a decrease in the perforation pitch, problems arise with the meshing of the conveying gear parts, the grab or Maltese mechanism.
This is especially true for 8 mm film with 8 mm or 8 Super perforated edges (Super 8 frame area is increased by reducing the perforation size and increasing the frame pitch to 4.23 mm). Requirements are presented in GOST 8761-75. Film reels 8 mm, dimensions, control methods. Perforations measuring 0.92 x 1.14 mm are located long side along the film, rather than across as in the standard 8 mm format, and are very often damaged and torn.

During storage of films, including processed films, shrinkage begins, and the amount of shrinkage is strongly influenced by the nature of the rolls packing, winding density, temperature and humidity in the room. Elongation of the longitudinal dimensions of the film sometimes occurs, for example, when stretched during processing in a developing machine.

Temporary changes in the dimensions of films are understood as shrinkage or elongation due to the influence of humidity in the ambient air. A change in air humidity by 1% causes almost twice the change in size compared to fluctuations in temperature by 1 °C, but these processes are reversible.

According to GOST 19-62-76, films must be stored at an air temperature of 50 ± 5 ° and a relative humidity of 60 ± 10% for up to 15 days; at a temperature of 20 + 2—5 ° C and a relative humidity of 60 + 5—10% —up to one year; at a temperature of 15 ± 5 ° and a relative humidity of 50 + 15-10% - up to three years; with a temperature of 10 ± 5 ° C and a relative humidity of 50 + 10% —more than three years.

Before being transferred to a warehouse for storage, the films are wound on standard «special device» with a photographic layer outside and placed in metal or other special boxes. They are stored on shelves or in metal cabinets in a horizontal position.

The temperature and humidity conditions of film storage are monitored using psychrometers at least once a day.

In work [8], the analysis of the gearing of the drum teeth with perforation (methodological guide for film screening) is carried out. Shows the engagement of the drum teeth and perforations in normal film. In this case, all perforations work stably, the force is evenly distributed. Also shown is the engagement of dried film with increased shrinkage. It was demonstrated that in this case only the lower perforation works, the rest slip or, more accurately, are skipped by the mechanism and, as a result, film wear, perforation breaks and frequent tape splices increase.

3. Physical and technological methods
For the choice of physical and technological methods, it is important to know the signs by which it can be determined that it is time to moisturize the film. Based on these signs, decisions are made that this or that film copy requires increased attention and certain technological manipulations for restoration.

The answers to the questions posed can be obtained after a simple visual inspection of the part. Sometimes additional equipment is used, for example, a special cinema magnifier with an optical double lens to enlarge the frame.

The main signs that the film is "time to moisturize" are as follows:

- the film is very brittle, it can easily break even from a small force, the roll of the part is not round, but turned into a polygon with almost equal edges (see figure 4);
• the film glides unstably in the projector, horizontal jumps and jumps of the image on the movie screen are noticeable, there is increased noise and entropy in the form of stripes and defects during projection, it happens that the film jumps off the toothed drums and you have to recharge it into the projector;
• in the process of gluing, the film is difficult to put on the press teeth. Or, often when trying to make gluing, the edges of the perforations on the teeth are damaged.

Moisturizing significantly helps to restore the quality of the film. You can almost always try to make a dry film strip work by moisturizing with a special composition, however, it will be very difficult to save a film spoiled by improper moisture, therefore it is necessary to carefully follow the rules of the humidification process. Obviously, dampening is always a risk, but a justified risk if used work is done by experienced film reviewers.

To humidify films, they are placed in special humidification chambers (hydrostats) or special humidifier cabinets. This operation is carried out at a temperature of 15-20 °C and a relative humidity of ~75-85%. Film to be wetted should be lightly wound with the photographic layer outward. For moisturizing, saturated solutions of sodium chloride or potassium bromide are used. Duration of moistening is 2-6 days, depending on the thickness of the photographic layer and the degree of overdrying.

To moisturize the film, film inspectors use several compositions [9]: based on glycerin and acetone and glycerin with the use of isopropyl alcohol.

The percentage of moisturizing (filmstatic) liquid No. 1 is shown in figure 3:

• 25% glycerin,

\[
\text{Chemical formula: } \quad \begin{array}{c}
\text{O} \\
\text{H} \\
\text{C} \\
\text{H}_2 \\
\text{O}
\end{array}
\]

Figure 3. Chemical composition No. 1.

• 15% acetone,

\[
\text{Chemical formula: } \quad \begin{array}{c}
\text{C}_3\text{H}_7\text{O}_2
\end{array}
\]

• 60% distilled water.

\[
\text{Chemical formula: } \quad \begin{array}{c}
\text{H}_2\text{O}
\end{array}
\]

The percentage of moisturizing (filmstatic) liquid No. 2 is shown in figure 4:
- 40% glycerin,

![Chemical formula: C₃H₆O₃, HOCH₂CH(OH)CH₂OH](image)

- 13% isopropyl alcohol,

![Chemical formula: H₃CCH₃](image)

- 47% distilled water.

![Chemical formula: H₂O](image)

**Figure 4.** Chemical composition No. 2.

The duration of hydration is up to two days.

A moisturizing element is placed inside an ordinary frequent jar - usually it is a lining made of a porous material, for example: cloth, felt, cotton cloth, cardboard, etc.), which is moistened with a filmostatic liquid.

Placed on top is an aluminum disc with 7 mm perforated holes. (see figure 5).

**Figure 5.** Perforated aluminum disc.

Then a roll of film is placed on top, as shown in figure 6. The film should not come into direct contact with the dampening liquid and the pad, that is, not a single drop of filmostatic liquid should get on the film. The result of such contact is the gluing of a roll of film and such tape will most likely need to be
disposed of. Before laying the film, it is advisable to press the aluminum disc a little against the spacer, and see if the filmstatic liquid comes out through the holes. Subject to the release of the moisturizing composition through the perforations, excess liquid is removed, and the disc is wiped.

Figure 6. Placement of film for dampening.

According to the recommendations of specialists, it is useful to pack film rolls in plastic bags with a thickness of 0.12 mm or more, since thin polyethylene is hygroscopic. The size of the bags should be such that there is almost no free space left after placing the rolls in them. Film packaging should be changed at least once a year, putting it into new bags under conditions that prevent moisture condensation. Sometimes films are recommended to be placed in a vacuum, in inert gases, or other special conditions. In practice, however, it is sufficient to place the film in a tin can of parts for film.

If the film has been stored in a too damp room for decades, then mold often appears on it. Then the film should be treated with fungicidal solutions on special machines. To restore the lost properties of damaged negatives, countertypes, intermediate positives and to clean them and bring them to their original (or close to the original appearance), restoration processing is already used. In particular, it is possible to use film restoration machines (for example, of the RT-3 type [9]), designed to eliminate mechanical damage (scratches and abrasions) on the film substrate that occurs during multiple demonstrations of the film.

The main components of the RT-3 machine: tape drive mechanism, glass or metal drum, drying chamber.

To eliminate damage, the processed film is cleaned on both sides with the help of, for example, carbon tetrachloride, washed, then polished with suede discs under a water shower and enters the drying chamber, where the remaining moisture is removed.

4. Conclusion
The physical and technological methods of film moistening, presented in this work, make it possible to preserve the material in a state where new approaches developing on the basis of digital technologies can be applied to it. Today, it is important, taking into account the development of technologies, the use of artificial intelligence methods, neural network approaches in image processing by digital and quantum methods [10-12], not to lose the experience gained over many decades of work in the film-checking direction. It is these developments and well-established working methods for “courting” analog media that today provide the opportunity for effective scanning and digitalization of the historical heritage inherited from previous generations.

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