

OPERATION OF LEERS¹

C. E. FRAZIER

ABSTRACT

The *muffle* and *open types of leers* are compared. The latter has the following advantages: (1) More uniform temps. in the annealing chamber; (2) prevents ingress of cold air beside pans and thus avoids consequent cracking of the ware; (3) better control of temp. and greater reliability of pyrometric indications; (4) less fuel per gross of ware.

Size of leers: Leers 8 ft. wide and 65 ft. from center to center of sprockets are recommended for the average glass.

Leer chains: Chains having a working strain of 5800 lbs. at 200 ft. per minute are recommended.

In the discussion, L. H. Adams points out that the *exact annealing schedule* required for any glass can be computed from the annealing constants of the glass which are known or can be determined in the laboratory.

The object of this discussion is to bring out the essential factors that enter into the proper annealing of glass articles rather than to discuss the technical side of the question, and in order to treat the matter intelligently, we must first determine the causes of annealing troubles.

The purpose of the leer is to remove the strains in glass articles which are necessarily introduced during the manufacturing operations. Since the plungers and the molds must be maintained at a temperature lower than that of the glass the conditions in the pressing operation are favorable for the production of strain and it is obvious that the greater the difference in temperature between the glass and the mold or the plunger, the greater will be the strain from this source. After removing from the mold the article is further chilled until it may be carried to the leer without distortion, but if this chilling is allowed to proceed too far, for example, through negligence of the carrying-in boy, the strains are unduly increased and the annealing is thereby made more difficult. The size, shape and weight of the article are

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also important factors which determine the quantity of the strain produced and which must be considered in the operation of the leer.

To remove these strains it is necessary to raise the temperature of the article to a point which is higher than that at which the strains were created, and to maintain this temperature (soak) for a sufficient time to allow the glass to become thoroughly and uniformly heated. After this it must be cooled gradually to a temperature below which strains can not be introduced by rapid cooling. Experience has shown that the initial temperature of the annealing chamber should be from about 800°F to 1100°F (425°C to 595°C), and that the time necessary for "soaking" is from forty-five minutes to one hour twenty minutes, depending on the shape and weight of the article and on the method of manufacture. The exact conditions in the leer can be determined only by experience with the article to be annealed.

Even though the temperature and treatment in the hot end of the leer be correct, the ware may easily be destroyed by incorrect treatment as it passes through the leer. It is not uncommon to observe ware, which has been "melted down" in the hot end, coming through the leer in a broken condition. This indicates that the temperature of the hot end was high enough to remove the strains and that at some point after leaving the hot end, the article was cooled too rapidly. This may result from a draft of cold air or from cold pans. To eliminate these disturbing conditions in the open type of leer it has been customary to apply auxiliary heat underneath the pans, and while this method has improved annealing, it has been quite expensive from a fuel standpoint and at the same time has caused rapid depreciation of the pans. This heat under the pans serves another purpose than that mentioned above: it causes more uniform temperature in the annealing chamber and consequently results in better annealing.

To properly anneal any piece of glass, the following conditions are necessary: proper mold design, proper working temperatures, proper temperature in annealing chamber, proper "soaking" time, and gradual cooling of ware after it leaves the hot end of the leer. This latter condition is very necessary on any type of leer, whether open or muffled, continuous, or hand pulled pan type.

The muffled leer has many advantages over the open type, some of which are as follows: more uniform temperature in the annealing chamber, elimination of the cold air coming up by the side of or between the pans, better control of temperature, and greater capacity.

While a muffle leer will use more fuel than an open leer, it has been thoroughly demonstrated that the cost of fuel per gross of ware is less than with an open leer. Another feature that is of great importance in the packer's trade is that a muffle leer eliminates the necessity for the washing of the ware, when operated with raw producer gas. There are several designs of muffle leers on the market any of which will give better annealing than the open leer.

A very common trouble with the open leer is that the pyrometer couple is invariably placed in the center of the crown extending through the brickwork a few inches. It is a well known fact that in such a position the pyrometer will register a higher temperature than the temperature at the pans, and this difference is dependent entirely on the height of the crown and the kind of a flame employed. This temperature has been known to vary as much as 250° and it has been found that by changing the location of the couple so as to give a more nearly correct record of the temperature at the pans, breakage was practically overcome.

In one instance in the writer's experience, the pyrometer couple extended through the crown of the leer and the pyrometer indicated a temperature of 1200°F while the pan temperature was 800°F owing to the fact that the couple was so placed as to receive the direct heat from the flame. After changing the couple so that the pyrometer indicated the correct temperature, and increasing the temperature of the annealing chamber, the trouble was overcome.

Another experience worth mentioning was an investigation for the purpose of overcoming breakage on fruit jars which had stood what is known as the hot water test. It was proved that this trouble was caused by a drop of 200° to 250° in the first arch back of the fire box and it was entirely overcome by reducing this drop in temperature to about 75°. It has been found that the correct rate for cooling ware is obtained with a temperature

drop of about 50° to 60° for every five feet after the ware leaves firebox until it reaches a temperature of about 350°F , after which time rapid cooling does not harm, and with some classes of ware rapid cooling from 500°F is permissible.

The correct length of the leer has been a matter of controversy for years. After a very careful study, it has been decided that 65 feet from center to center of sprockets is sufficient for the annealing of the average glass, although there are exceptions. In one installation a 65 foot leer was built along side of an 80 foot leer and after a year's operation on the same kind of ware, the owner cut fifteen feet from the 80 foot leer and purchased two more 65 foot leers which makes his equipment now stand four (4) 65 foot muffled leers.

Experiments have been made with leers 5, 6, 7, 8, 9, and 10 feet wide and it has been concluded that the 8 foot leer gives more real satisfaction than any other width. The reasons for this are as follows: It gives more uniform temperatures in the annealing chamber than wider leers, has more mechanical strength than wider leers and is also more flexible. It is needless to state that different shaped articles as well as articles of different weight require different treatment and it is therefore not advisable to attempt to anneal articles differing considerably in shape and weight together in the same leer. Experience has shown that three 7 foot leers are preferable to two 10 foot leers and four 8 foot leers are better than three 10 foot leers. The reason we recommend 8 foot leers is because an 8 foot leer costs very little more than a 7 foot leer and gives practically the same flexibility and uses no more fuel.

We had a client a little over a year ago who had installed three 5 foot hand pulled leers of the open type and had installed an automatic feeder which greatly increased his production. He wished to install a continuous leer but these could not be installed on account of the time limit. We therefore arranged to muffle his old leers to give him the capacity required while the new leers were being manufactured, and much to our surprise he annealed successfully in these 3 leers 400 gross of milk bottles in 24 hours and accomplished it more satisfactorily than he had been able to anneal 250 gross in the open leers.

Any of you who have had experience with continuous leers have no doubt had the annoying experience of the leer chain pulling in two after the leers had been in use for a year or two. This results, first from side loading the chain, and second because the chain is too light for the work in question. After it has been subjected to the heat for some time it becomes too weak for the duty it has to perform and eventually breaks.

The chain used on the first continuous leers had a working strain of 2000 lbs. at 200 feet per minute; the next chain was of 2300 lbs. working strain at the same speed; and the next was a chain of 3600 lbs. at the same speed, but a change in design of the leer caused side loading on the chain, which, investigation proved, reduced the safe working strain by 50%. This meant, in effect, a weaker chain than the original and although the design was greatly improved, the chain was too weak to withstand the strains which caused the continual breaking of the chain. Chains now in use have a working strain of 5800 lbs. at 200 feet per minute and we have never heard of one pulling in two.

Discussion

By L. H. Adams.—This paper is an interesting account of some of the factors connected with glass-annealing, and such discussions as Mr. Frazier's are valuable aids in the design of leers.

It would seem, however, that in considering the principles underlying the annealing of glass, it is essential to take account of the physical nature of the annealing of glass. In the first place it is desirable to adopt some standard of annealing, that is, the maximum amount of strain (in definite units) that can be tolerated in the given class of ware. In the second place the problem of glass-annealing can be dealt with intelligently only by starting with the known (or determinable) annealing-constants of the particular kind of glass used. When the constants of the glass are known, it is a very simple matter to determine in advance exactly the temperature-cycle to be followed. The annealing-process naturally divides itself into two stages: first, the existing strain must be removed, and next, the glass must be cooled in such a way that the new strain introduced does not

exceed the allowable limit. There are several ways by which this may be done. The glass may be heated to the temperature at which strain disappears almost instantaneously (about 550° C for ordinary soda-lime glass) and then cooled slowly. Or, on the other hand, the glass may be heated to a lower temperature for a longer time and then cooled at a much faster rate than by the first method. The second method is the better one for reasons which, for lack of space, it is not possible to enumerate at this time.

As indicated by Mr. Frazier, below a certain temperature the cooling may be much more rapid. This is true no matter what kind of a temperature cycle is used. Below about 400° for ordinary soda-lime glass and about 300° for lead glasses the permanent strain is not influenced by the speed at which the glass is cooled, and hence below these temperatures the cooling rate is limited mainly by what the glass will stand without breaking as it is cooled.

The calculation of the maximum cooling rate is one of the simplest of problems. The rate is inversely proportional to the square of the thickness and for a sheet of glass $\frac{1}{2}$ inch thick is 80°C per minute. In the later stages of the cooling, therefore, cooling may be *regular, i. e.*, it is not sufficient that the average rate be within the limit specified; the rate at any moment must be below the given amount.

Finally it should be noted that the statement "It is necessary to raise the temperature of the article to a point which is higher than that at which the strains were created" is meaningless for the reason that strain is not created at any particular temperature. Actually the strain makes its appearance at comparatively low temperatures, its amount being (mainly) determined, however, by the cooling rate of the glass at the higher temperatures, *i. e.*, by the rate throughout a certain range, which for ordinary soda-lime glasses is between 400° and 550°C.

SIMPLEX ENGINEERING CO.
WASHINGTON, PA.