## BREWING INDUSTRY RESEARCH FOUNDATION

# EFFECT OF TEMPERATURE ON THE SPECIFIC GRAVITY OF WORTS

By L. H. Hawkins and P. E. Gough, B.Sc., A.R.I.C.
(*Brewing Industry Research Foundation, Nutfield, Surrey*)

*Received* 15*th December*, 1962

**A study of the effect of increase in temperature on the specific gravity of brewer's worts has been made with special reference to instrumentation in a continuous brewery. A linear relationship is obtained between specific gravity and the square of the temperature (° F.).**

## Introduction

With the development of systems for continuous mashing,[2,3] a demand has arisen for instruments which will record and, if desired, control the specific gravity of a stream of wort, the temperature of which may range up to 160° F. Obviously the wort could be cooled to 60° F. for the estimation but this, in a continuous process, would be both cumbersome and uneconomical as the wort would have to be reheated for the next stage. The difficulty would disappear, however, if it were possible to relate the observed specific gravity at the higher temperature to the specific gravity at 60° F.

Tables have been constructed[4] showing the corrections on account of temperature to be applied to the specific gravity of worts as indicated by means of a metal saccharometer over the range 36–100° F. and a formula has been given[1] to indicate the adjustment required. In the present work specific gravities of worts of original gravities ranging from 1030° to 1080° have been measured at temperatures up to 160° F.

## Experimental

The specific gravities (60°/60° F.) of boiled, filtered pale-ale wort samples were measured using a 50-ml. specific gravity bottle. Using a water bath, the temperature of the wort in the bottle was raised by 10° F. and wort was allowed to overflow until no more was expelled. The bottle was then cooled to 60° F. and weighed at this temperature. With duplicate samples at each temperature this procedure was repeated, heating the wort by successive increments of 10° to 160° F. and cooling each time to 60° F. before weighing. The apparent specific gravity at each temperature is given by:—

Apparent specific gravity = (Wt. of wort filling the bottle at the relevant temperature) ÷(Wt. of water filling the bottle at 60° F.).

Worts having original gravities of 1030, 1040, 1060 and 1080 brewer's degrees were examined along with water. The water used in the estimations had been previously boiled to expel dissolved gases.

A source of error in the procedure described above may be introduced by the expansion at the elevated temperature of the specific gravity bottle itself. If on heating the volume increases, slightly less wort will be expelled than if the volume had remained constant, and correspondingly a somewhat higher figure for the specific gravity will be obtained. In order to correct any such effect, the results obtained experimentally for water itself were compared with published data[5] after the latter had been adjusted for unity at 60° F. instead of 4° C. A series of corrections for the expansion of the bottle with increase in temperature was in this way obtained for each relevant temperature and applied to the results (Table I). A further error could result from the failure of the bottle to return to its original volume after heating and subsequent cooling. Experiments were therefore carried out to investigate this possibility. The specific gravity bottle was filled with water and weighed at 60° F., heated to various temperatures, refilled with water and reweighed at 60° F. No consistent effect was noted, the variations

obtained representing changes in volume between +0·0005 ml. to −0·0003 ml. Thus this effect in terms of gravity is comparatively small, and is ignored for the purposes of this work.

specific gravity of continuous streams of wort at variable temperatures can be facilitated.

It is noticeable that the curves or lines (Fig. 1) are not quite parallel. Fig. 2

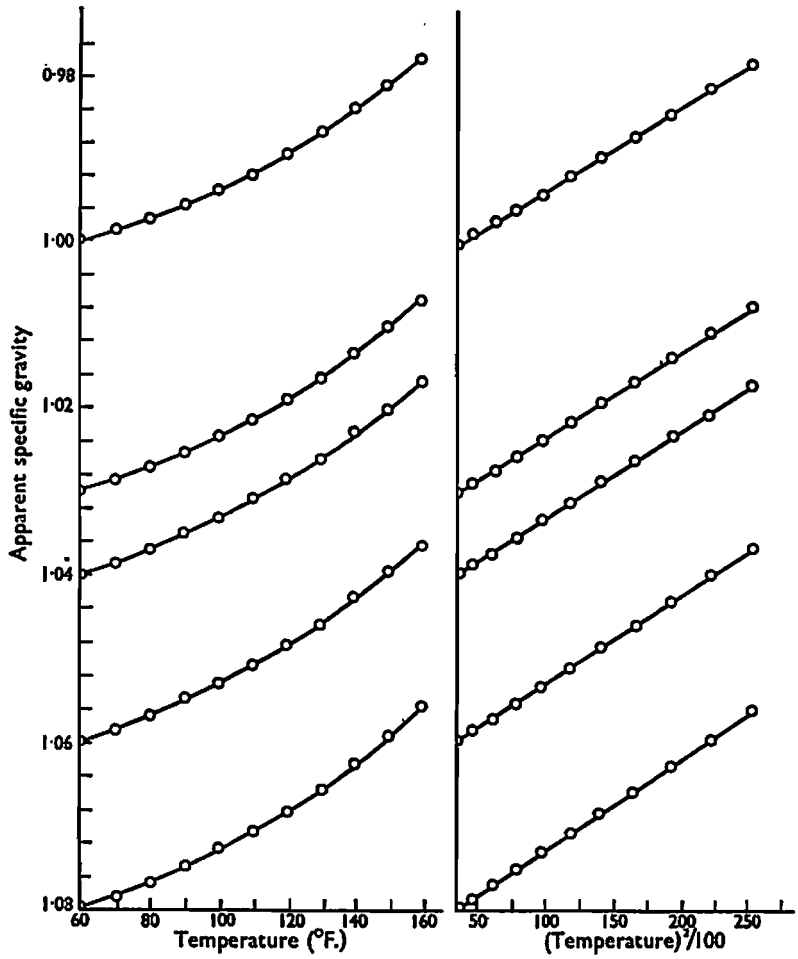


Fig. 1. Apparent specific gravities of different worts and water plotted against temperature (t) and $t^2$.

## Discussion

Fig. 1 shows the results obtained by plotting observed specific gravity against both temperature and the square of the temperature. In the former case, smooth curves are given. In the latter a straight line relationship is achieved, and it therefore appears that the problems of automatically measuring the

demonstrates this fact more readily, where the decreases in specific gravity for water and worts of different strength are plotted against the square of the temperature. The behaviour of each wort is therefore affected by its content of dissolved solids. Thus, in designing a specific gravity meter to deal with the run off from a conventional

TABLE I

APPARENT SPECIFIC GRAVITIES T/60

| Temp. (° F.) | Apparent gravity | | | | |
|---|---|---|---|---|---|
| 60 | 1·0000 | 1·0300 | 1·0400 | 1·0600 | 1·0800 |
| 70 | 0·9989 | 1·0288 | 1·0388 | 1·0587 | 1·0786 |
| 80 | 0·9976 | 1·0274 | 1·0373 | 1·0572 | 1·0770 |
| 90 | 0·9959 | 1·0256 | 1·0355 | 1·0552 | 1·0750 |
| 100 | 0·9941 | 1·0237 | 1·0335 | 1·0532 | 1·0729 |
| 110 | 0·9919 | 1·0216 | 1·0310 | 1·0509 | 1·0709 |
| 120 | 0·9896 | 1·0195 | 1·0286 | 1·0486 | 1·0686 |
| 130 | 0·9870 | 1·0168 | 1·0261 | 1·0461 | 1·0660 |
| 140 | 0·9842 | 1·0139 | 1·0232 | 1·0430 | 1·0629 |
| 150 | 0·9813 | 1·0108 | 1·0205 | 1·0400 | 1·0597 |
| 160 | 0·9781 | 1·0075 | 1·0172 | 1·0367 | 1·0561 |

mash tun, a device would clearly need to be incorporated to correct for large fluctuations in original gravity as well as for variations in temperature. However the output from a continuous mash tun is normally of almost constant gravity, and it is likely in this case that an automatic adjustment for wort strength would be unnecessary.

These results illustrate the general effect of the temperature on specific gravity of wort. It is likely that different specific gravity meters which were designed to compensate for temperature variation would each require specific calibration. The extent to which correcting devices would be elaborated would depend on the individual requirements of the brewer.

*Acknowledgement.*—The authors wish to thank Dr. A. H. Cook, F.R.S., Dr. W. P. K. Findlay and Dr. C. Rainbow for their help in this work.

## REFERENCES

1. Anon., *Brewers' Digest*, Feb., 1962, 55.
2. Ash, M. E., & Dummett, G. A., *Proc. Eur. Brew. Conv., Vienna*, 1961, 39.
3. Davis, A. D., & Pollock, J. R. A., this *Journal*, 1961, 33.
4. H.M. Customs and Excise, *Brewers' Survey Book*, No. 2.
5. Hodgman, C. D., Ed., *Handbook of Chemistry and Physics*, 32nd Edn. Cleveland: Chemical Rubber Publishing Co., 1950, p. 1789.

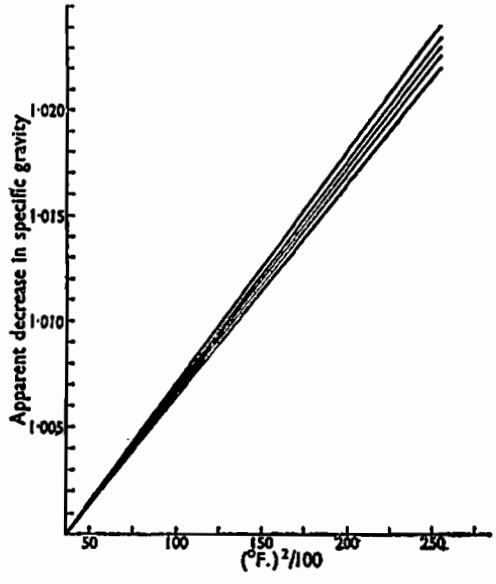


Fig. 2. Apparent decreases in specific gravity of different worts and water plotted against $t^2$. The five lines reading downwards are, respectively, for worts of S.G. 1080, 1060, 1040 and 1030 and for water.