Temperature, deg F	YS, 178 Bhn Type 304 Measured	Predicted	YS, 156 Bhn Type 347 Measured	Predicted	YS, 148 Bhn Type 347 Measured	Predicted
75	57,500	52,800	45,400	44,700	35,900	28,500
400	46,030	43,000	37,300	37,000	27,600	22,900
600	42,800	39,200	36,700	34,000	25,400	20,800
800	39,600	36,100	33,600	31,600	25,000	18,300

prevailed between different heats of a given type of steel. Further consideration suggests that there may be some basic mechanism that provides a relationship between k and b.

It was also found that yield strength is related to the Brinell hardness number "B." A fairly strong linear relationship was found connecting log YS with B. Also, b and k can be separately expressed linearly in terms of B. Application of the least squares method gave the following estimates:

Type 304	Type 347
$b = -1.331 + 0.00506\,B$	$b = -1.448 + 0.00669\,B$
$k = 10^6\,(3.570 - 0.01664\,B)$	$k = 10^6\,(-0.751 + 0.00768\,B)$

Thus from a knowledge of B the coefficients k and b may be determined. The yield strength YS is then obtained from the relationship

$$\text{YS} = kT_K{}^b$$

The above table illustrates the comparative values of measured YS and the YS predicted from a knowledge of B.

While these results are not spectacular, they do indicate the feasibility of being able to predict the YS at a given temperature from a simple room temperature hardness measurement. Further considerations in the determination of the coefficients k and b and the possible introduction of some variable other than B may improve the predictions. In any event, these results do illustrate that the YS can be predicted much better from a knowledge of hardness (B) than without it.

DISCUSSION

W. L. Fleischmann[6]

As usual, the authors have done a very systematic laboratory investigation which explains the differences in the tensile properties of annealed austenitic stainless steel. They arrived at three major conclusions:

1 The prime source of these variations is attributed to differences in annealing treatment.

2 In order to obtain reasonably consistent properties from one lot of a given type of steel to another, it would appear necessary to specify the annealing treatment and/or the annealed hardness.

3 An appreciable strength advantage, without a serious loss of ductility, could be realized by utilizing the higher hardness levels.

The discusser wishes to elaborate on these points from the point of view of the engineer who wishes to take advantage of the data of that report.

Control of the hot working operations and of the subsequent annealing treatments are necessary to obtain consistent mechanical properties in the austenitic stainless steels. However, rather than specifying the final annealing treatment, it appears more desirable to establish limits for the mechanical properties especially for the significant and sensitive property, the yield strength. By including a maximum value for the yield strength in the specification, the final heat-treatment is controlled by an attribute measurable by the consumer. By this method, the consumer does not assume any responsibility for correct processing but rather places the burden to meet the requirements of the specification upon the mill.

The second point the authors made is that in the temperature range between room temperature and 800 F advantage of stainless steel with higher yield strength than that obtainable in the annealed condition can be taken. Such an advance which is perfectly feasible requires that fabricators using the austenitic stainless steel in the hot cold-worked condition appreciate the fact that such material softens more readily in thermal treatment than the annealed stock. Thus certain limitations in the fabrication of components using hot cold-worked material have to be imposed.

In summary, the work of Wessel and Pryle points the way to better utilization of expensive material, and it is hoped that the results of such work will lead to additional classes of austenitic stainless steel in the ASME Boiler and Pressure Vessel Code.

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Authors' Closure

The authors are indebted to Mr. Fleischmann for his timely discussion. The point suggesting the inclusion of a specification for the maximum allowable yield strength in lieu of an annealed hardness is well taken. This alternative is particularly favorable from the designer's or consumer's viewpoint since it rightfully places the burden of responsibility upon the steel producer.

Regarding the second point which Mr. Fleishmann discusses, the authors did not intend to imply that the steels be used in the as-hot-worked condition. Rather, it was suggested that the higher hardness levels (higher strength) of apparently annealed material might be employed. Steel "G" of Fig. 1 and steel "H" of Fig. 2 are examples of the hardness and strength levels that the authors had in mind. As-hot-rolled hardness and yield strengths would be of the order of 98 R_B and 80,000 psi. These two particular steels had, in all appearances, a fully recrystallized microstructure which is generally indicative of having been annealed. However, in spite of any possible confusion relative to the terminology of "annealed," Mr. Fleishmann's words of caution to the steel fabricators are certainly appropriate.