and charged to column 2. This column separates the entrainer (aniline) from the 88.6% aqueous hydrazine solution, which is taken overhead, the aniline bottoms being recycled to make up part of the feed to the first column. The enriched hydrazine solution from the second column is fed to column 3, where it is separated into anhydrous hydrazine as overhead and the hydrazine-water azeotrope as bottoms. The bottoms, which contain about 30% of the hydrazine feed to the first column, are recycled.

CONCLUSIONS

Aqueous solutions of hydrazine can be economically dehydrated by azeotropic distillation in a multicolumn distillation system with aniline as an entrainer. Although the ridge in the vapor-liquid surface of the ternary system necessitates some recycle of the hydrazine, under optimum operating conditions about 70% of the hydrazine charged to the system can be recovered in one pass through the columns as essentially anhydrous material. The process is patented (*7*).

ACKNOWLEDGMENT

This research was sponsored by the Mathieson Chemical Corporation at Battelle Memorial Institute. The authors wish to thank them for their permission to publish the results of this work.

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Presented at A. I. Ch. E. Louisville meeting

GAS ABSORPTION IN BEDS OF RINGS AND SADDLES

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New data are presented for the system carbon dioxide—sodium hydroxide. The effect of $CO_3^=$ build-up upon K_Ga values was investigated first and the data were then used to construct a curve by means of which all data were corrected to an arbitrarily chosen reference state of 25% $CO_3^=$ concentration. K_Ga values increased with increasing liquid rate but were not dependent on gas rate if the packings were operated below loading. For some packings examined in the loading range, however, K_Ga values increased with increasing gas rate.

K_Ga values examined in relation to specific surface area were found to be very irregular in connection with rings. The surface-area utilization pattern of the saddles was considerably more uniform. The ring and saddle data for the carbon dioxide–sodium hydroxide system were in good qualitative agreement with the ammonia absorption data of Fellinger and the water–water vapor data of Mehta and Parekh.

The object of this paper is to describe the behavior of rings and saddles in gas absorption. Capacity data have been observed for a wide range of conditions, and conclusions on surface-area utilization are presented. Another object of the paper is to ascertain the data level of capacity coefficients for the new Intalox saddle packing. The carbon dioxide–sodium hydroxide system was chosen for the comparison because equilibrium conditions are established quickly in the column, the analytical procedure is simple, and the liquid film seems to offer the controlling resistance. Since data sufficiently complete to permit a packing-behavior comparison are already available for the systems NH_3-H_2O (partly gas-film controlled and $(H_2O)_l — (H_2O)_g$ (wholly gas-film controlled), procurement of the present liquid-film–controlled data will permit a general packing-performance analysis.

LITERATURE

In a study of this kind, where the relative merits of packings are to be evaluated, careful attention must be given to the construction of the experimental tower, to the analytical procedure adopted, and to the range of variables explored. Above all, it must be shown that for the system considered, the broad findings of others and the corresponding new results are in substantial agreement. A summary of the principal experimental conditions and results of earlier reported work for the carbon dioxide–sodium hydroxide system is given in Table 1. The data of Blum, Stutzman and Dodds (*2*) are of only general interest, since the columns and packings were small. Of greater interest is the work of Stutzman and Dodds (*11*); although they reported cocurrent flow data, having worked with liquid and gas rates far in excess of the present flows, some of their quantitative effects of carbonate build-up upon the data level have been noted and incorporated. The tower of Greenwood and Pearce (*6*) was suitably large, but their operating pressure (5.4 atm.) was sub-

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stantially above the present atmospheric pressure and for this reason a direct comparison with the present data is not feasible. The Greenwood and Pearce work corresponds rather closely to that of Spector and Dodge (*10*), but whereas the latter report that capacity data are both liquid- and gas-film controlled, Greenwood and Pearce conclude that the gas-film alone offers appreciable resistance to mass transfer. Except for column height, the experimental conditions of Tepe and Dodge (*12*) correspond most closely to the conditions of the present work. Consequently most of their conclusions as well as the data level of their capacity data could be confirmed.

EXPERIMENTAL

The pilot plant unit is shown in Figure 1. The standard 8-in. pipe was charged in all cases with 9 1/2 ft. of packing. Before charging the tower was filled to 70% of its height with water and the packings were slowly poured from the container. Resulting packing densities and other properties are given in Table 2. The distributor was a sprinkler head, with holes sufficiently small to assure "full spread," even with the lowest irrigation rate. It was placed about 8 in. above the packing, and only the packing (not the wall) was thus initially irrigated. A series of strainers placed ahead of the distributor kept it clean.

Fig. 2. Twelve-Inch-Diameter Tower Section Packed with One-Inch Rings and Saddles.

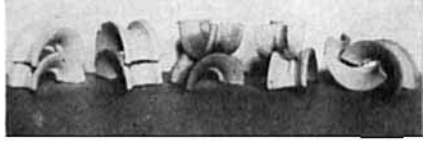

Fig. 3. A Few Mutual Combinations of Intalox Saddles.

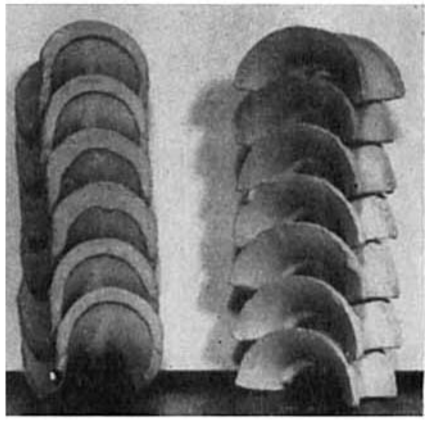

Fig. 4. Stacked Berl and Intalox Saddles.

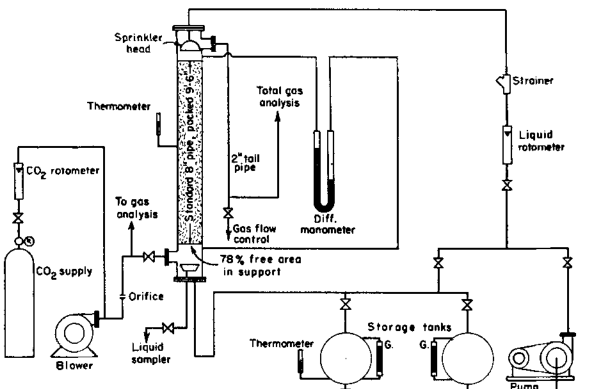

Fig. 1. Experimental Unit.

The carbon dioxide content of the gas was usually about 1.5%. In some instances (when gas mass velocities were low and carbon dioxide removal was sometimes 95% or more complete), 4 to 6% carbon dioxide was required in the inlet gas, so that the exit carbon dioxide concentration would still be measurable with the chosen analytical procedure. The sodium hydroxide concentration was always close to 1.0 *N* (4% sodium hydroxide). The solution was frequently renewed to prevent high carbonate build-up, the only exception being one series of runs where with 1-in. Intalox saddles the same solution was used virtually to complete carbonation. The object was to ascertain the effect of carbonate build-up on the coefficients. Solution temperatures ranged from 75 to 81°F. During absorption no appreciable temperature rise was noted.

The liquor sampler was a shallow trough communicating with the outside by way of a 1/4-in. pipe and valve. The trough extended virtually over the entire column diameter and thus representative liquid samples were collected. The carbon dioxide gas, preliminarily metered by a small rotameter, was conducted into the air on the up-stream side of the metering orifice. Gas rate through the column was controlled by manipulation of a 2-in. slide valve at the end of the 2-in. tail pipe. Solution storage was sufficient to permit operation for at least 30 min. before collection of gas and liquid samples was begun. This was more than ample time to establish steady state conditions.

The gas samples were analyzed with a Haldane gas burette (*1*). Analytical results could easily be duplicated within ±3%, which was better than the reproducibility of the tower operation. Check runs, made frequently, were always better than ±10%. Material balances ranged between 93 and 111%. The liquor was analyzed for total alkalinity by use of methyl orange as indicator. Carbonate was determined by precipitation with an excess $BaCl_2$ and titration of the free sodium hydroxide, with phenolphthalein as indicator.

PACKINGS

Packing characteristics pertaining to the 8-in. pilot plant unit are

TABLE 1.—SUMMARY OF LITERATURE—CARBON DIOXIDE—SODIUM HYDROXIDE

Authors	Tower diameter, in.	Packed height, ft.	Packings investigated	Working pressure, atm.	Liquor normalities	Liquid rates, lb./(sq. ft.)(hr.)	Gas rates, lb./(sq. ft.)(hr.)	Approx. CO_2 inlet conc.
(2)	2.8–4.0	2.8–4.33	1/4 to 1/2-in. rings (ceramic)	1	....	....	....	3–28%
(6)	8	up to 4	3/4-in. metal Lessing rings, 1/2 and 1-in. Raschig rings	5.4	2–2.5	600–22,000	150–700	300 p.p.m.
(10)	12	10–16	3/4-in. Raschig rings and 1-in. Berl saddles	1–6	2.5	800–14,000	270–950	300 p.p.m.
(11)	18	10–15	1- , 1 1/2-in. ceramic Berl saddles, 2-in. metal rings	1				
(12)	6	3	1/2-in. carbon rings	1	0.75–4.0	700–9,600	100–440	1–5%
This work	8	9.5	1-in. metal rings, 1, 3/4, 1/2-in. Raschig rings, Berl saddles, Intalox saddles	1	1.0	380–3,200	215–1,000	1–6%

given in Table 2. The data are as expected and in satisfactory accord with large-scale commercial-tower observations. Probably of most immediate interest is the considerably higher packing population that prevails in a bed of saddles as compared with a bed of rings of equivalent size. It is believed that this property, yielding to the generally larger specific packing surface of the saddles, is responsible for the fundamentally different behavior of the saddle packings as compared with the ring packings. The difference in packing arrangement between rings and saddles is apparent from Figure 2, which shows sections of a 12-in.-diam. glass column, packed with 1-in. nominal-size Intalox saddles (top), Berl saddles (bottom), and Raschig rings (center). The rings show predominant pattern packing, both "in parallel" as well as "in series." The Berl saddles show practically no in-parallel pattern packings, though stacking and series packing is observed. The Intalox saddles exhibit no pattern packing of any kind. An essential packing difference between saddles and the rings is achieved because saddles represent an open shape, whereas

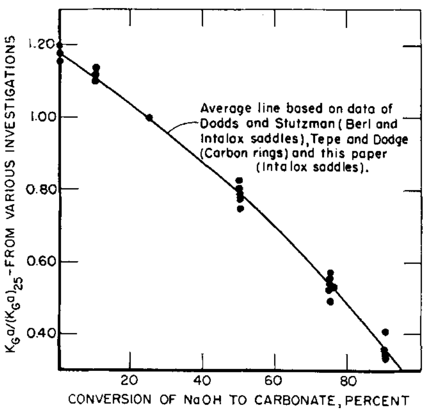

FIG. 5. EFFECT OF CARBONATE BUILD-UP ON K_Ga.

rings, being closed packings, do not have mutual interlocking features. As far as saddle characteristics are concerned, the packing population in Intalox saddle beds is substantially higher than in Berl saddle beds of comparable nominal size, as reported in Table 2, because of the difference in the two saddle shapes. Intalox saddles, being of a more irregular shape (7), will permit a large number of mutual combinations with each other. A few such combinations, shown in Figure 3, represent the basic arrangements in the Intalox saddle bed. Since Berl saddles are of a more regular shape, their combinations are fewer and the tendency to pack in patterns is encouraged. This is the more true since the prevalent packing pattern that Berl saddles tend to assume possesses a high degree of mechanical stability. Stacked saddles, both Berl as well as Intalox, are shown in Figure 4. The more labile arrangement of the Intalox saddles and the ready area accessibility between pieces are apparent.

VARIABLES AND DATA EVALUATION

Packings investigated were 1/2-, 3/4-, and 1-in. ceramic Raschig rings and Berl and Intalox saddles. A few results, observed with 1-in. steel Raschig rings, were also reported. Since mass transfer rates will decrease as the carbonate ion concentration in the liquor increases, and because with the relatively high tower a substantial carbonate build-up in the descending liquor can result, a series of tests was desirable that would permit recognition of this fact and

TABLE 2.—PACKING CHARACTERISTICS

Packings	Number of pieces/cu. ft.	Percentage voids	Weight/cu. ft., lbs.	Specific surface area, sq. ft./ft.³
1-in. metal rings	1,290	93	36	56
1-in. Raschig rings	1,440	73	39	62
1-in. Berl saddles	1,770	72	43	61
1-in. Intalox saddles	2,270 (2,160)	78 (79)	32 (30.5)	74 (71)
3/4-in. Raschig rings	3,300 (3,450)	72 (71)	47 (49)	84 (88)
3/4-in. Berl saddles	4,410	70	46	73
3/4-in. Intalox saddles	6,930	75	37	109
1/2-in. Raschig rings	10,800	64	55	125
1/2-in. Berl saddles	13,300	67	50	117
1/2-in. Intalox saddles	17,100	76	33	157

possible adjustment of the capacity coefficients to a standard state. The carbonate concentration build-up in the liquor could of course be minimized by resorting to shorter packed heights, which would, however, lead to questionable results because of the then pronounced end effects and also because of possible insufficient opportunity for the liquid flow pattern to develop. Thus the data may not embody one of the characteristic packing features (namely the establishment of the internal liquid distribution pattern). Another objection to

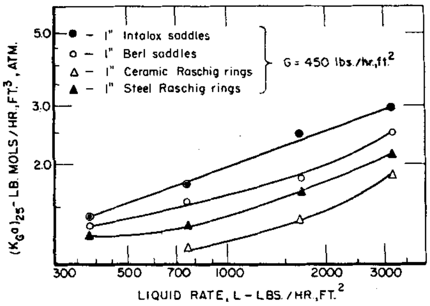

FIG. 6. CORRECTED 1-IN. PACKING DATA FOR SYSTEM CARBON DIOXIDE–SODIUM HYDROXIDE; GAS RATE CONSTANT.

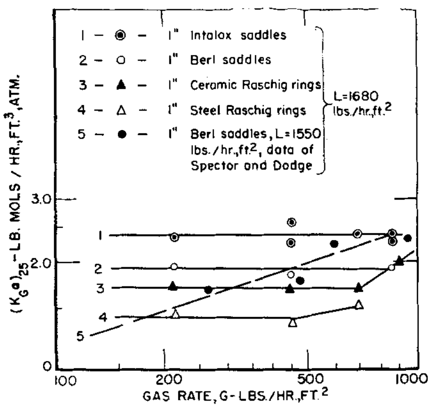

FIG. 7. CORRECTED 1-IN. PACKING DATA FOR SYSTEM CARBON DIOXIDE–SODIUM HYDROXIDE. LIQUID RATE CONSTANT.

smaller heights would be the reduced accuracy of the data, caused by small concentration differences of carbon dioxide in the gas streams; on the other hand, the more concentrated the liquor the smaller will be the rate of carbonate build-up. But here too difficulties will arise, caused primarily by the higher liquor viscosity, which has a bearing on initial liquor distribution to the top of the packing. In consideration of these factors it was decided to work with a normal sodium hydroxide solution (4%) and an inlet gas stream that contained ordinarily about 1 to 2% carbon dioxide.

The effect of carbonate build-up upon the coefficients was noted first.* Since the liquor, carrying CO_3 ions exerts no appreciable CO_2 partial pressure(*3*), over-all coefficients were calculated from the equation

$$K_G a = \frac{N}{h \times A \times \Delta p_{lm}}.$$

In this equation the symbols are as follows:

N = lb.-moles of solute gas transferred/hr

h = packed height, ft.

A = tower cross-sectional area, sq. ft.

Δp_{lm} = logarithmic mean partial pressure of solute in gas stream

$K_G a$ = over-all capacity coefficient, lb.-moles/(hr.)(cu.ft.)(atm.)

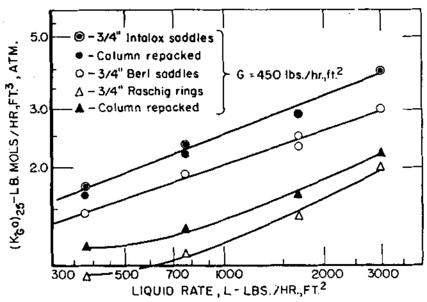

FIG. 8. CORRECTED ¾-IN. PACKING DATA FOR SYSTEM CARBON DIOXIDE–SODIUM HYDROXIDE; GAS RATE CONSTANT.

For the purpose of ascertaining the carbonate ion effect, liquor and gas rates were kept constant and the arithmetic-average carbonate concentration was calculated between top and bottom. The resulting graph served as basis for preparation of Figure 5. $K_G a$ at 25% conversion to carbonate, $(K_G a)_{25}$, was arbitrarily chosen as reference state. The course of the curve of Figure 5 is also supported by some data of Stutzman and Dodds(*11*), as well as of Tepe and Dodge(*12*). As expected, the effect of carbonate concentration build-up, being essentially a saturation-diffusion phenomenon in the liquor, is not dependent on packing. Hence the curve of Figure 5 was used to refer all the data to the 25% carbonate reference state.

*Complete original data may be ordered from the Photoduplication Service, American Institute of Documentation, Library of Congress, Washington 25, D.C., as document 4564 for $1.25 for microfilm or photoprints.

Effect of solution rates on the capacity coefficients is obtained from Figures 6, 8, and 10. In Figures 7, 9, and 11, capacity data are shown in relation to gas rate. The effect of repacking the column and the reproducibility of the performance both for Intalox saddles and rings may be observed from Figure 8. As the loading state of the packings is approached, capacity data will increase, as may be observed from Figure 12.

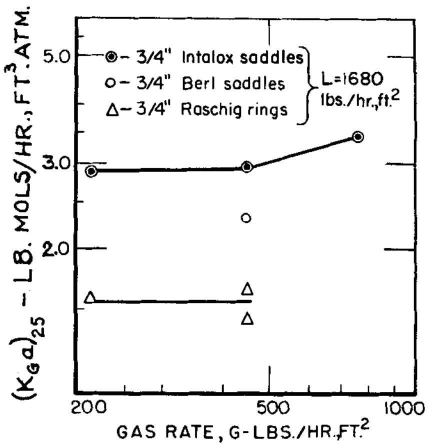

FIG. 9. CORRECTED ¾-IN. PACKING DATA FOR SYSTEM CARBON DIOXIDE–SODIUM HYDROXIDE; LIQUID RATE CONSTANT.

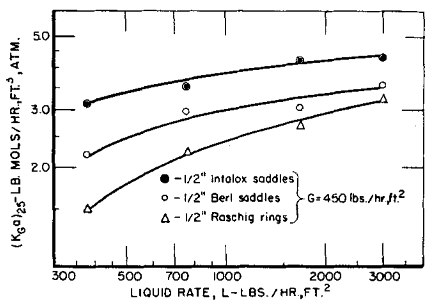

FIG. 10. CORRECTED ½-IN. PACKING DATA FOR SYSTEM CARBON DIOXIDE–SODIUM HYDROXIDE; GAS RATE CONSTANT.

DISCUSSION

Irrigation Rate Dependence. Consideration of the effect of liquid rate on the coefficients indicates that for all packing and sizes, $K_G a$ increases as the irrigation rate increases. The relationship may be approximated by $(K_G a) \propto L^n$, where n is the slope of the individual data. It is found to vary from approximately 0.35 for the large to 0.18

for the small packings. For the larger size rings K_Ga is almost independent of irrigation rate when the latter is low. These variations of the slope value are doubtlessly associated with area utilization in the packed bed. No definite conclusion may be formulated, though, because irrigation rate will influence not only area utilization but the K_G portion in the capacity data as well. Since it is doubtful whether the effect of liquid rate upon K_G can be accurately determined in a packed bed, the data of Figures 6, 8, and 10 are not helpful to give a definite indication as to surface-area utilization.

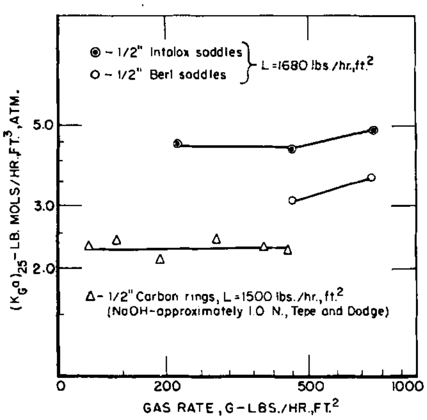

FIG. 11. CORRECTED ½-IN. PACKING DATA FOR SYSTEM CARBON DIOXIDE–SODIUM HYDROXIDE; LIQUID RATE CONSTANT.

In all instances it is found that Intalox saddles give the highest capacity data; Berl saddles are next; and Raschig rings are lowest. Except for the 3/4-in. packings, the difference between Intalox and Berl saddles is equivalent to the difference between the latter and Raschig rings. It is of interest to note that the order of magnitude of the coefficients does not conform with the surface area offered by the individual packings.

The 1-in.-metal-ring data are significantly lower than the 1-in.-ceramic-ring data. The difference may be due to a number of reasons, of which the following may be the most likely. Since the metal rings have a considerably thinner wall than the ceramic rings, the free space in the metal-ring bed is much greater than in the ceramic-ring bed. Therefore, the metal rings will, for given liquid and gas rates, be in a lower state of loading than the ceramic rings. Aside from the state of loading, surface characteristics, as caused by material of construction, may be involved. Thus it is conceivable that the aqueous liquor will spread into films more readily over a ceramic than over a metal body.

The effect of repacking the column is observed from Figure 8. Table 2 shows the packing densities for the two Intalox charges and the two Raschig ring charges. The reproducibility observed with Intalox saddles is very satisfactory. Since Intalox saddles have virtually no tendency to pattern pack this is to be expected. The rings, on the other hand, show that the process of repacking (floating into water in both cases) causes a significant variation in the capacity data. This is obviously due to pattern-packing tendencies which are not controllable in ordinary packing operations. Severe differences in performance have been reported both in the field as well as in research(*4a*).

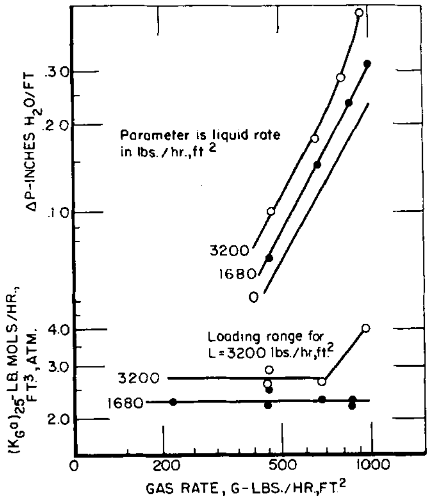

FIG. 12. ABSORPTION AND PRESSURE DROP DATA FOR 1-IN. INTALOX SADDLES.

Gas-Rate Dependence. From Figures 7, 9, and 11, it may be concluded that K_Ga data are independent of gas rates when the latter are low. At higher gas rates K_Ga will increase with G sooner as one progresses from Intalox saddles to Berl saddles and finally to Raschig rings. This trend is caused by the effect which gas rate exerts on the holdup in the packing. As the loading range is approached (through an increase in gas rate) the packing-surface area will be utilized to a greater extent. Approach to loading is indicated by the pressure-drop data of Figure 12. Thus for a gas rate of, say 900, and a water rate of 3,200, lb./(hr.)(sq.ft.) the coordinates for Figure 13(*8*) become 0.0404 and 0.123. Location of the point on the graph discloses that operation occurs in the loading range with a pressure drop of about 0.5 in. of water/ft., in agreement with the experimental value.

The gas-rate dependence of the Spector and Dodge(*10*) 1-in. Berl-saddle data, shown in Figure 7, is not due to approach to the loading range; it is a genuine gas-rate dependence, probably caused by the very dilute carbon dioxide concentration in the gas. At a solute concentration of only 300 p.p.m., absorption from the gas film may be rapid when compared with a possibly slower step of diffusion of carbon dioxide from the main body of the gas through the film. The carbon-ring data of Tepe and Dodge(*12*), shown in Figure 11, are not gas-rate dependent. For their highest gas rate of 430 and a liquid rate of 1,500 lb./(sq.ft)(hr.), the coordinates for Figure 13 become 0.0257 (packing factor 270) and 0.120, a location well below the loading range. The present study is not only in agreement with the Tepe and Dodge work on the matter of singular liquid film control, but the general data level of the two studies are also in satisfactory agreement. The present data may, therefore, be used for a further comparison of ring and saddle behavior.

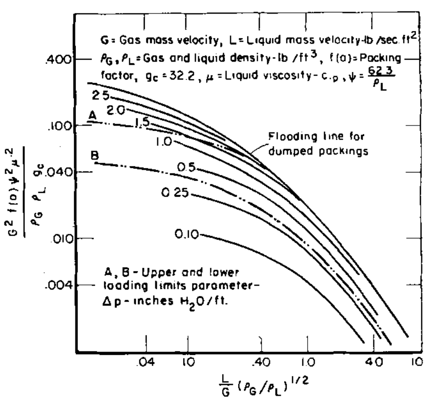

FIG. 13. GENERALIZED PRESSURE DROP FLOODING CORRELATION FOR DUMPED PACKINGS.

K_Ga vs. Specific Surface Area. Specific surface-area evaluations of the packings tested are given in Table 2. In Figure 14 corrected coeffi-

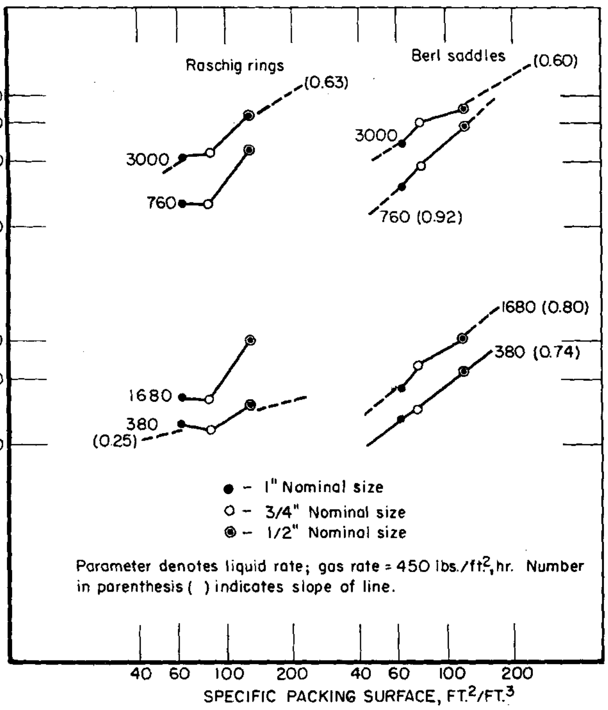

FIG. 14. RASCHIG AND BERL SADDLE DATA FOR SYSTEM CARBON DIOXIDE–SODIUM HYDROXIDE.

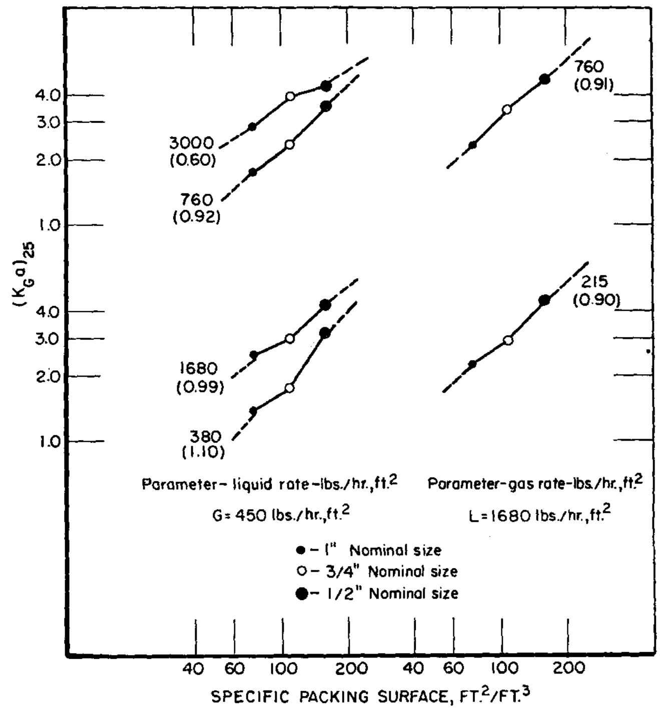

FIG. 15. INTALOX SADDLE DATA FOR THE SYSTEM CARBON DIOXIDE–SODIUM HYDROXIDE.

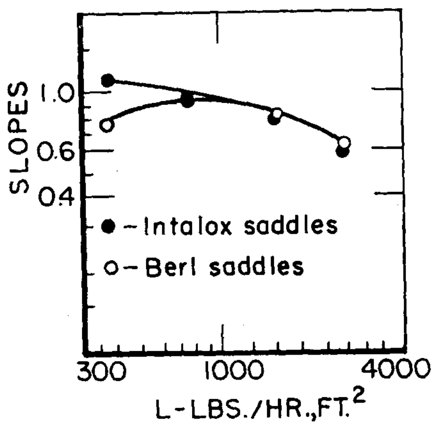

FIG. 16. SLOPE VALUES FROM FIGURES 14 AND 15.

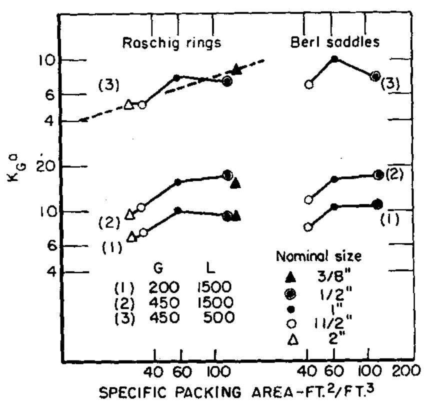

FIG. 17. DATA OF FELLINGER (NH_3-H_2O).

cients have been related to specific surface areas for Raschig rings and Berl saddles. The same type of data are given in Figure 15 for Intalox saddles. Gas rate is constant for all the data [450 lb./(sq. ft.) (hr.)]. For each set liquid rate is constant, as indicated; hence the data for the various nominal-size rings and saddles may now be compared with each other. The fundamentally different behavior of rings and saddles is immediately apparent. Proceeding from 1-in. saddles to the 1/2-in. size, there results a relatively steady increase in the coefficients. The rings, on the other hand, show no increase in coefficients between the 1-in. and 3/4-in. size. In fact, at the lowest liquid rate the coefficient for the 3/4-in. Raschig ring is actually lower than for the 1-in. ring. This retrograde result is surprising, especially because the total specific surface area of 3/4-in. Raschig rings is substantially higher than that of 1-in. rings. Even for the highest flow rate the coefficients do not recover sufficiently to rise convincingly above the 1-in.-size level. The conclusion which must be drawn from this observation is that, although with the 1-in. rings a certain modest fraction of the inside surface area of the packing may be effective contacting area, the value of the inside surface area of the 3/4-in. size is very small. This observation is supported by the fact that there is an approximate numerical equality between the total *outside surface* area of the 3/4-in. rings and the combined outside and inside surface areas of the 1-in. size. The foregoing retrograde phenomenon, observed at low liquid rates, points to the possibility that there may be preferential liquid flow through the inside of the packing and preferential gas flow on the outside or vice versa. The two streams would thereby be well separated from each other, a result that should lead to low coefficients. In view of such possibilities one may well wonder whether it is at all significant to measure surface-area utilization in rings (and perhaps in packings in general) by mechanical means alone, that is, in the absence of mass transfer. When the Raschig-ring data are considered further, the rapid increase in the coefficients as one proceeds to the 1/2-in. size is understandable from the very large accompanying surface-area increase. The outside 1/2-in. ring area is significantly in excess of the total 3/4-in. ring area. The inside-surface-area contribution of 1/2-in. rings is probably nil.

The saddles, being open packings, do not show a retrograde effect. The slopes of the data are an indication of the area utilization. Slopes have been evaluated for the four liquid rates and plotted in Figure 16. For flows beyond 1,000 lb./(sq.ft.) (hr.) area utilization in both Intalox and Berl saddles seems equally good. At low flows, such as are observed in distillation columns, Intalox slope values are higher, and the packing utilizes its surface area more effectively than do Berl saddles. At high liquid rates and in beds of small packings, surface-area utilization drops off for both packings. At the particular limiting rate (3,000 lb./(sq.ft.)(hr.) when water is used) individual small streams and rivulets form in the column and become sufficiently heavy that they may no longer be broken up by small packing elements. At this point cascading flow begins, causing a reduction in effective gas-liquid contact area.

From Figure 15 it is apparent that only liquid rate has an effect on area utilization. The two sets of data for gas rates, 760 and 215 lb./sq.ft.)(hr.) and the accompanying liquid rate of 1,680 are conditions sufficiently below loading that no effect on the coefficients is observed.

Essentially all the observations made so far on surface-area utilization may be substantiated by the extensive data of Fellinger—NH_3-H_2O system—(*5*) and Mehta and Parekh — H_2O_l-H_2O_g — (*9*). Their data are reproduced in Figure 17 and 18. Fellinger observes retrograde effects with 1/2-in. and 3/8-in. Raschig rings. The retrograde effects disappear at elevated liquid rates. In general, surface-area utilization in rings improves as irrigation rate increases. Gas rate affects the over-all data level, but not significantly the extent of area utilization for the various sizes. The ring data are in reasonable agreement with the finding of Dodge and Dwyer(*4*), who report that in ammonia absorption K_Ga varies as the 0.45 power of the specific surface area. The behavior of the Berl saddles is similar, as already described. The Mehta and Parekh data lead essentially to the same observations. Retrograde effects are observed with rings. These effects are minimized and may wholly disappear as flows increase. The Berl-saddle behavior is strictly analogous to the present CO_2-NaOH results and the NH_3-H_2O data of Fellinger. The approach to cascading flow is apparent as the irrigation rate increases.

The difference between ring and saddle behavior is reflected in the character of the holdup data (Figure 19). As expected, holdup increases for all packing as irrigation rate increases. Slopes reveal that for the two kinds of saddles the rate of increase is the same, but is considerably higher for the Raschig rings. Significantly, at low irrigation rates the holdup is lower in rings than in saddles. The situation tends to reverse at higher liquid rates. One possible explanation is that at the low irrigation rate the liquid flows preferentially at the outside of the rings; whereas at higher rates, an ever increasing fraction of the inside-ring voidage becomes effective.

A comparison of the two types of saddles is shown in Figure 20. The observation that both Berl and Intalox-saddle data correlate (for the high irrigation rates) along one singular line indicates that at these rates area utilization in beds of both packings is about equal. The higher coefficients observed with Intalox saddles (as compared with the same nominal-size Berl saddles) are due chiefly to the higher surface area that is provided by the Intalox-saddle bed. At the low irrigation rate the higher slope of the Intalox data reveals improved area utilization. As far as order of magnitude is concerned, it is noted [in accord with Stutzman and Dodds(*11*)] that as a rule Berl saddles will give the same coefficients as the next larger nominal size of Intalox saddles.

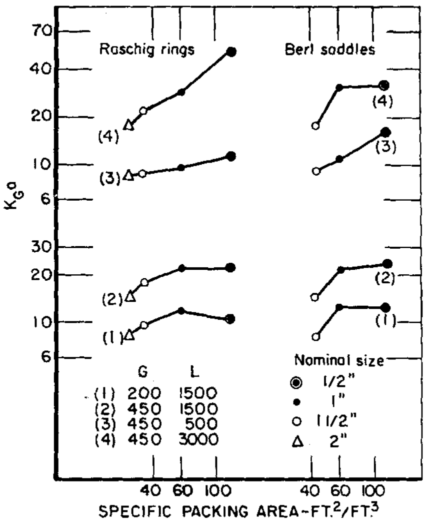

FIG. 18. DATA OF MEHTA AND PAREKH (H_2O GAS-H_2O LIQUID).

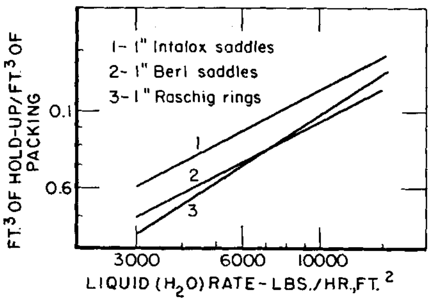

FIG. 19. HOLDUP DATA FOR RINGS AND SADDLES.

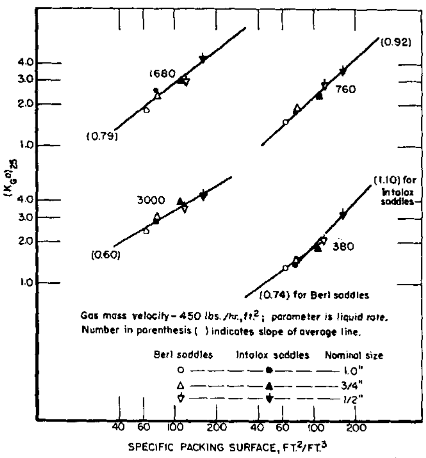

FIG. 20. COMPARISON OF SADDLE DATA FOR THE SYSTEM CARBON DIOXIDE–SODIUM HYDROXIDE.

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