# Testing Reactivity Of Lime For Better Slaker Operation

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ABSTRACT

*The utility of lime reactivity test available in literature has been adopted for testing reactivity of lime as a routine test for lime.*

*Using this procedure, lime from different sources has been assessed for reactivity (in addition to Available lime index and causticized mixture settling property). From this study, it has been possible to asses the quality of lime more completely. The studies indicate, that lime of good reactivity is required to ensure proper slaking in the slaker and to ensure good causticizing efficiency. With Lime of low reactivity, causticizing efficiency is likely to get adversely affected (in addition to the necessity for over liming) because of losses in the classifier grits or slaker stones.*

## INTRODUCTION

Lime is a very important input for converting green liquor to white liquor. The performance of slaking and causticizing plants depends on the quality of lime used. The three important characteristics of lime are (i) Available lime Index (ii) Reactivity (iii) Settling property after causticizing reaction.

Available Cao content is regularly tested in the mills and settling properties are also assessed both in the plant and in the laboratory. However, reactivity test is not carried out, as there is no standard procedure.

The purpose of this work is to test Reactivity of lime by using the procedure available in literature (1) and to adopt that method for Reactivity testing, for routine testing of lime.

## REACTIVITY OF QUICK LIME

Scope: This methods helps to asses the quality of quick lime used for causticizing with respect to slaking property.

Principle: A standard and mass of lime is slaked with water in an insulated vessel, the ratio of lime to water being 1:4 under well defined conditions. The rate of temperature rise and the maximum temperature reached are used to assess the reactivity of lime.

**Apparatus:**

Thermometer with range 0-110°C

Casserol with suitable lid with a hole for insersion of thermometer (An insulated ss vessel of 600-800 mL volume).

Balance to weigh correct to ± 1 g.

**Reagent:** Distilled water.

**Procedure:** Collect around 5 kg of representative lime sample and crush this through a Jaw crusher (or manually if Jaw crusher is not available) such that the size of the lumps are around 20-25 mm insize. By coning and quartering prepare a test sample of around 500 g (without any further size reduction) and keep it in an air tight container (polythene bag can be used). From this weigh out 100 g of the lime (please ensure that the material represents lumps and powder of the prepared sample). Pour this weighed sample into the casserol containing 400 mL of distilled water

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**TABLE-I**

**SLUDGE SETTLING RATE**

**(Values given, are the sludge volume)**

| Time | Source of Lime 1 | Source of Lime 2 | Source of Lime 3 | Source of Lime 4 | Source of Lime 5 |
|---|---|---|---|---|---|
| After 1 minute | 870 ml | 850 ml | 850 ml | 850 ml | 850 ml |
| After 2 minutes | 750 | 560 | 680 | 700 | 600 |
| After 3 minutes | 620 | 300 | 500 | 560 | 380 |
| After 4 minutes | 500 | 150 | 320 | 410 | 210 |
| After 5 minutes | 370 | 140 | 230 | 300 | 190 |
| After 6 minutes | 230 | 140 | 210 | 190 | 170 |
| After 7 minutes | 170 | 140 | 200 | 180 | 170 |
| After 8 minutes | 160 | 140 | 190 | 180 | 170 |
| After 9 minutes | 160 | 140 | 180 | 180 | 170 |
| After 10 minutes | 160 | 140 | 180 | 180 | 170 |
| After 20 minutes | 160 | 140 | 180 | 180 | 170 |
| After 30 minutes | 160 | 140 | 180 | 180 | 170 |
| After 40 minutes | 160 | 140 | 180 | 180 | 170 |
| After 50 minutes | 160 | 140 | 180 | 180 | 170 |
| After one hour | 160 | 140 | 180 | 180 | 170 |

and immediately close the lid. Mix the contents by giving a swirling motion to the vessel and record temperature every 30 seconds until maximum temperature is reached.

The results can be interpreted as

**High reactivity:** If temperature increases to 40°C and above in three minutes and maximum is reached in less than 10 minutes.

**Moderate reactivity:** If temperature increase is 40°C and above between 3 to 6 minutes and maximum is reached in less than 20 minutes.

**Low reactivity:** If the temperature increase is 40°C and above in more than 6 minutes and maximum is reached in more than 20 minutes.

## WORK CARRIED OUT IN OUR LABORATORY

Using the procedure given above, we have evaluated lime being procured by us for its reactivity and causticizing and settling properties.

The reactivity was tested as per procedure given above. The Available lime index was tested as per TAPPI standard. T 617 Cm-84.

The causticizing experiments were carried out by carrying out causticizing reactions using one litre of green liquor from plant and using stoichiometric + 10 % excess lime based on $Na_2CO_3$ content of green liquor. Reaction was carried out at boiling temperature for one hour.

After the reaction time, The total reacted mass was transferred to a 1 litre measuring cylinder and the settled sludge volume was recorded at fixed intervals of time.

The sludge settling rate data are given in **Table-I** and the analysis of resulting white liquor are given in **Table-II** for limes from different sources. The settling rate is also graphically represented in **Fig.1.**

**TABLE-II**

**White liquor Analysis obtained by Causticizing Reaction of Green liquor by using lime of different quality collected**

| | Source of Lime 1 | Source of Lime 2 | Source of Lime 3 | Source of Lime 4 | Source of Lime 5 |
|---|---|---|---|---|---|
| TTA as $Na_2O$ gpl | 82.15 | 79.05 | 77.81 | 83.08 | 79.98 |
| NaOH gpl as $Na_2O$ | 54.56 | 53.94 | 52.08 | 58.28 | 50.84 |
| $Na_2S$ gpl as $Na_2O$ | 14.88 | 14.88 | 13.64 | 14.88 | 16.12 |
| TAA as $Na_2O$ gpl | 69.44 | 68.82 | 65.72 | 73.16 | 66.96 |
| $Na_2CO_3$ gpl as $Na_2O$ | 12.71 | 10.23 | 12.09 | 9.92 | 13.02 |
| Causticizing Efficiency, % | 81.11 | 84.06 | 81.16 | 85.45 | 79.61 |
| Available lime Index (as CaO) % by Mass (used for settling rate) | 65.5 | 68.5 | 51.8 | 70.8 | 58.1 |

All the above limes samples were also tested for their reactivity by the method given earlier. Reactivity data are given in **Table-III** and graphical representation in **Fig. 2.** Summary of results are given in **Table-IV.**

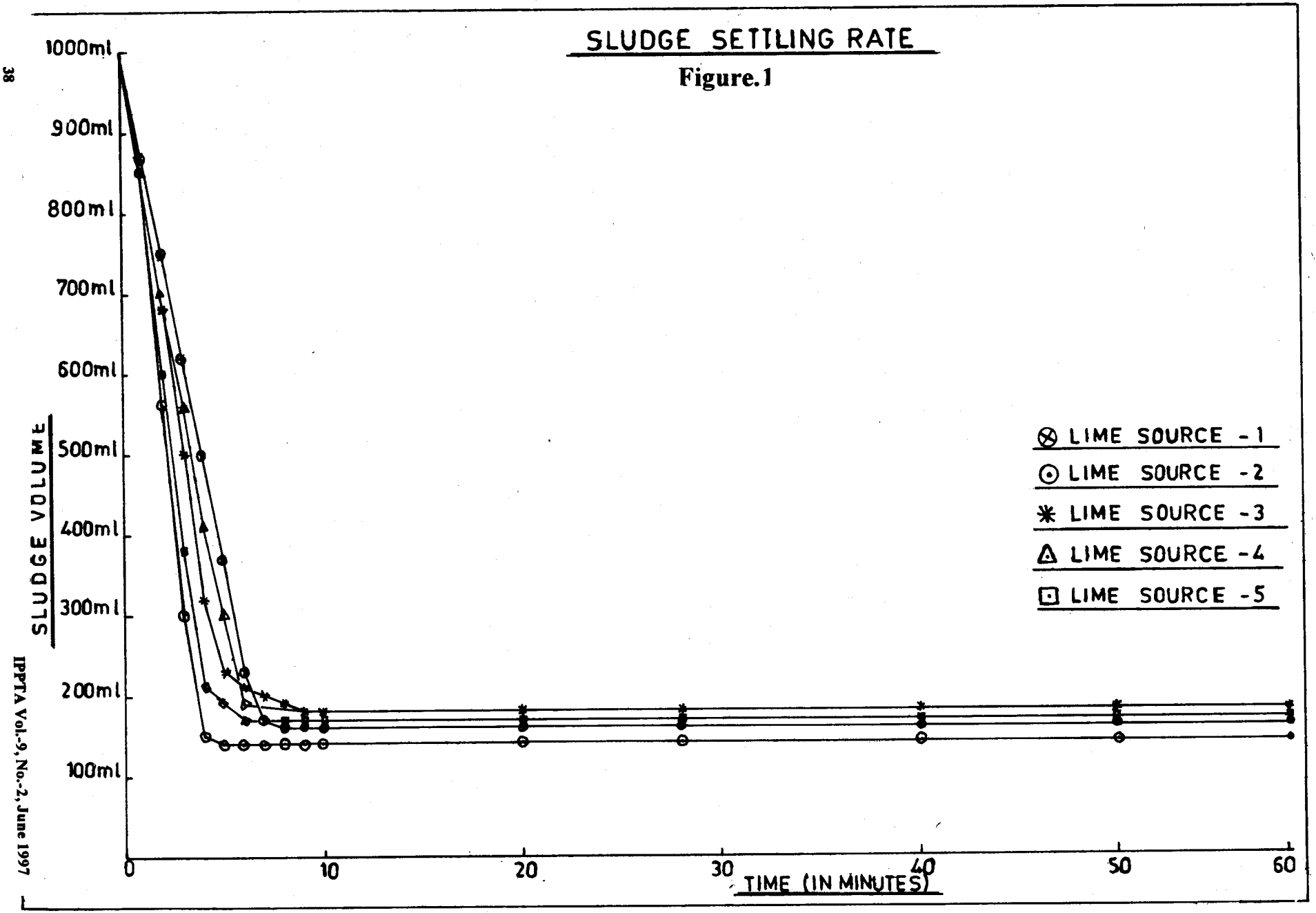
**TABLE-III**

**REACTIVITY OF LIME**

| Time (in minutes) | Source of Lime 1 | Source of Lime 2 | Source of Lime 3 | Source of Lime 4 | Source of Lime 5 |
|---|---|---|---|---|---|
| After 0.5 | 35 | 36 | 33 | 35 | 30 |
| After 1.0 | 37 | 46 | 52 | 40 | 32 |
| After 1.50 | 38 | 53 | 62 | 45 | 34 |
| After 2.0 | 40 | 58 | 72 | 48 | 36 |
| After 2.5 | 41 | 63 | 77 | 52 | 36 |
| After 3.0 | 43 | 66 | 80 | 54 | 37 |
| After 3.5 | 45 | 68 | 80 | 60 | 39 |
| After 4.0 | 47 | 70 | - | 65 | 40 |
| After 4.5 | 50 | 70 | - | 72 | 41 |
| After 5.0 | 53 | 71 | - | 83 | 42 |
| After 5.5 | 55 | 72 | - | 85 | 43 |
| After 6.0 | 57 | 73 | - | 88 | 45 |
| After 6.5 | 59 | 74 | - | 88 | 47 |
| After 7.0 | 61 | 75 | - | - | 50 |
| After 7.5 | 63 | 76 | - | - | 52 |
| After 8.0 | 65 | 77 | - | - | 55 |
| After 8.5 | 66 | 77 | - | - | 57 |
| After 9.0 | 68 | - | - | - | 58 |
| After 9.5 | 69 | - | - | - | 60 |
| After 10.0 | 70 | - | - | - | 61 |
| After 10.5 | 71 | - | - | - | 62 |
| After 11.0 | 71 | - | - | - | 63 |
| After 11.5 | 72 | - | - | - | 63 |
| After 12.0 | 72 | - | - | - | - |

## SLUDGE SETTLING RATE

**Figure.1**



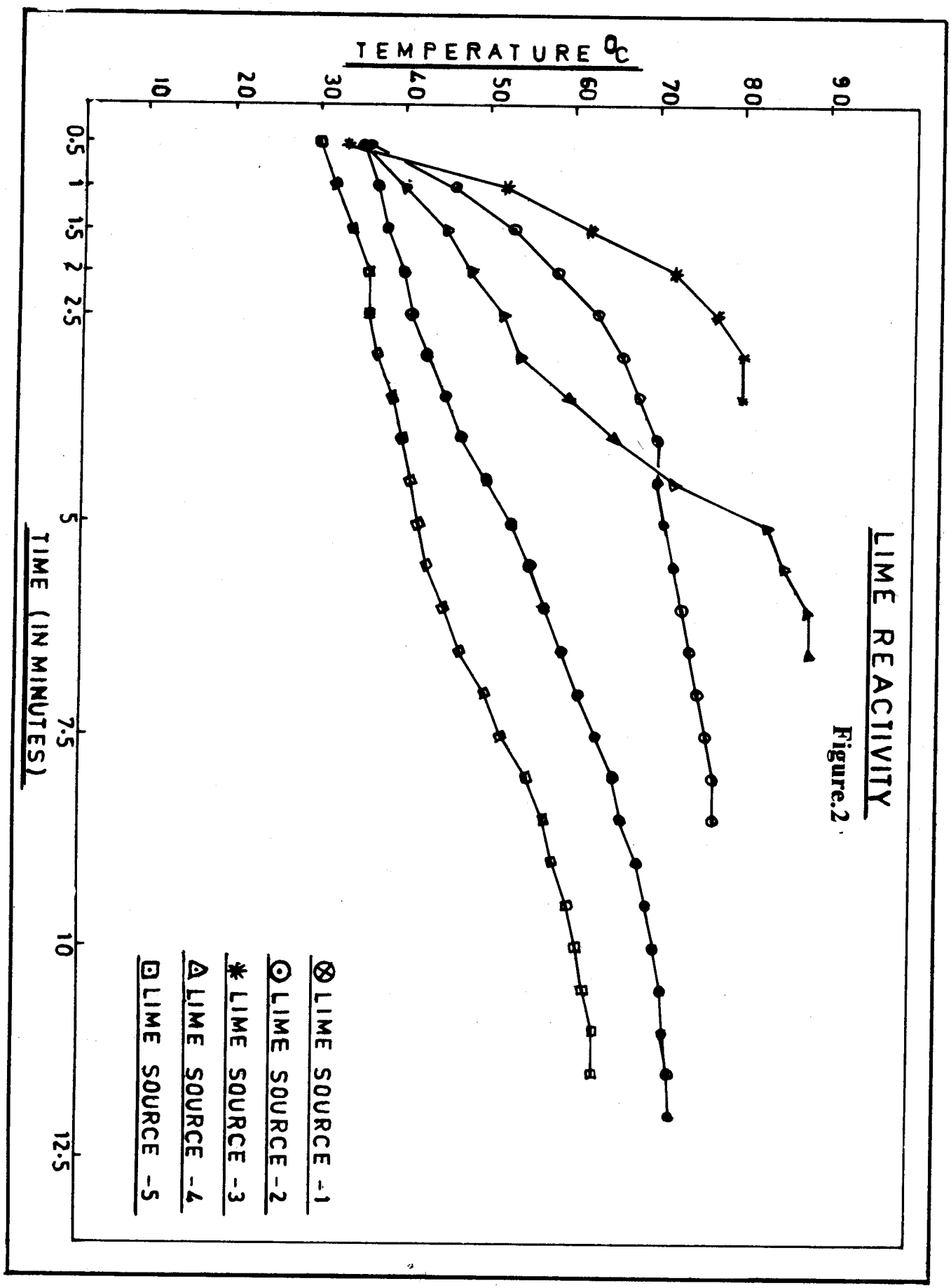

LIME REACTIVITY
TEMPERATURE °C
10
20
30
40
50
60
70
80
90
0.5
1
1.5
2
2.5
5
7.5
10
12.5
TIME (IN MINUTES)
⊗ LIME SOURCE -1
⊙ LIME SOURCE -2
* LIME SOURCE -3
Δ LIME SOURCE -4
⊡ LIME SOURCE -5

Figure.2

**TABLE-IV**

**Summary of Reactivity & settling Rate Results**

| Source of Lime | Available Lime index | Rate of Settling mL/min (In 1st 10 minutes) | Reactivity (as per 5.1 to 5.3) clause (given in Test procedure) | Temp.°C in 3 minutes | Time for maximum temperature min. | Maximum Temp.°C reached |
|---|---|---|---|---|---|---|
| 1 | 65.5 | 84 | Moderate | 41 | 12 | 72 |
| 2 | 68.5 | 86 | High | 66 | 7.5 | 77 |
| 3 | 51.8 | 82 | Very high | 80 | 3.5 | 80 |
| 4 | 70.8 | 82 | High | 54 | 6.5 | 88 |
| 5 | 58.1 | 83 | Low | 37 | 11 | 63 |

## RESULTS AND DISCUSSIONS

From Table-1 and Fig.1, it is observed that there is no significant difference in settling rates inspite of varying Available lime index and also reactivity. The clear volume perminute (in Ist 10 minutes) is ranging from 82 mL to 86 mL for all the limes (Table-IV).

Also from Table-III and Fig.2, it is observed that the reactivities are varying from one source to the other. The summary of reactivity data (Table-IV) clearly indicates that the limes are very high to low reactivity. This parameter will be very helpful in deciding the feed rate to the slaker. If the reactivity is poor, and retention in the slaker is low (by design or by over loading) the lime is likely to react incompletely and leading to subsequent losses in slaker stones and in classifiers and also resulting in poor causticizing efficiency. This may also lead to the necessity for over liming with attendent problems of over loaded settlers, mud washers and loss of excess free CaO in final filter cake.

## CONCLUSIONS

1. A simple procedure has been adopted and tested (based on information available in literature) to assess Reactivity of lime. This can be carried out in any laboratory as no special appartus is needed.
2. Using this method Reactivity has been tested for limes from different sources and the method is found to give a correct picture of reactivity.
3. No significant difference was observed in the settling rate of causticized reaction mixture for limes of different reactivity and with varying Available lime index.
4. In addition to the test carried out for available lime index, and settling rate of causticized mixture, the reactivity test if carried out helps to assess the lime quality more completely. This also helps in improving causticizer plant operation by helping to control proper slaking in slaker by controlling retention time in slaker or to buy suitable lime to suit the equipment.

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## REFERENCES

1. AWWA Test Method B-202-65.