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# RICE HUSK ASH APPLICATION IN PETROLEUM INDUSTRY

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## ABSTRACT

The producing performance of a petroleum well depends in great part on a good primary cementing job. In a high-quality cement job, mud and gas channels have been permanently prevented, and there is a complete hydraulic seal between the casing and formation throughout the zone of interest. To properly use the available cements, additives were used to control the major cement properties, including thickening time, fluid-loss rate, free water and compressive strength. Currently, all additives were imported from oversea, therefore studies have been carried out to determine rice husk ash potential to be used as a petroleum well cement additive. The paper presents the results of laboratory experiments on G cement performance with respect to fluid loss, free water, compressive strength and thickening time when rice husk ash (RHA) was added to the cement slurry. Various burning time, RHA particles size and amounts had been used, and Halad 322s as a standard additive. All experiments have been conducted according to American Petroleum Institute (API) Specification 10. The results show that fluid loss volume, free water content and thickening time decreases, and compressive strength increases as the amount of RHA added increases, RHA particles size decreases and burning time increases. RHA performance generally better than Halad 322 in respect to fluid loss and free water, and lower than Halad 322s in term of compressive strength and thickening time, but still within API Spec. 10 requirements. Therefore, RHA is suitable for application in petroleum well cementing operation, particularly as fluid loss control agent for class G cement.

## INTRODUCTION

Primary cementing is the process of placing cement in the annulus between the casing and the formation exposed to the wellbore with the major objective is to provide zonal isolation in the wellbore. To achieve this objective, a hydraulic seal must be obtained between the casing and the cement, and between the cement and formations, while at the same time preventing fluid channels in the cement sheath. This requirement makes primary cementing the most important operation performed on a oil and gas well. Without complete zonal isolation in the wellbore, the well may never reach its full producing potential. In order to meet the individual well requirement, the additives must be used to control major cement properties, such as fluid loss, free water, compressive strength, and thickening time.

Fluid loss control additive is a material which control the loss of the aqueous phase of a cement system to the formation and maintains the proper water-to-cement ratio by tie up the excess water, and prevent it from being squeezed from the slurry (Shell and Wynne, 1958). If fluid loss is not controlled, several serious consequences may result which can lead to job failure. As the volume of the aqueous phase decreases, the cement slurry density increases; as a result, the performance of the slurry diverges from the original design. If sufficient fluid is lost to the formation, the slurry becomes unpumpable. The API fluid loss rate of a neat cement slurry generally exceeds 1,500 ml/30 min. An API fluid loss rate less than 50 ml/30 min. is often required to maintain adequate slurry performance. To accomplish such a reduction in the fluid loss rate, fluid loss control agent is included in the slurry design. Once fluid loss commences across a formation, a filter cake of cement solids is deposited on the formation surface. Fluid loss agent decreases the filtration rate by reducing the permeability of filter cake, and/or by increasing the viscosity of the aqueous phase. For most primary cementing operation, an API fluid loss rate between 50 to 100 ml/30 min. is generally considered to be adequate. (Nelson, 1990, API 1991).

When a cement slurry is allowed to stand for a period of time prior to the set, water may separate from the slurry, migrate upward, and accumulate either in pockets or at the top of the column. This separation can result in incomplete zonal isolation, particularly in a highly deviated wellbore. The free water is important because excessive free water can allow adverse conditions to develop in the down hole region, such as free water pockets in the cement sheath can cause accelerated corrosion, steeling of weighting material which in turn can cause bridging and gas migration. Therefore free water should be held to a minimum. API specification requirement is not exceed 3.5 ml (1.4 %) of free water (API, 1991).

Thickening time is a length of time which a cement slurry remains in a pumpable fluid state under stimulated wellbore conditions of temperature and pressure. Thickening time can be defined as the elapsed time from initial mixing of the cement with water to achievement of a final consistency of 100 Bearden Units (Bc), that is the unit used to designate the consistency of a cement slurry. The API Spec. 10 requirement is in the range of 90 to 176 minutes (API, 1991).

Compressive strength data are required to furnish some indication of the ability of a set cement to provide zonal isolation, and to protect and support the pipe. Generally, the cement must have sufficient strength to support and secure the casing in the wellbore, achieve zonal isolation in the wellbore, prevent communication of fluids behind the casing, and withstand the shock of drilling, perforating, and fracturing. The most widely used minimum strength required for any operation is 500 psi in 24 hours at down-hole static temperature. API specification requirement is a minimum of 500 psi for 8 hours curing and 1000 psi for 24 hours curing period. Strength can also become a critical consideration when cementing across some intervals, such as plastic salt, or pay zone which will require subsequent stimulation (Goodwin and Phipps, 1984; Rae and Brown, 1988).

## EXPERIMENTAL WORKS

### Rice Husk Ash Preparation

After rice husk had been dried and cleaned from impureties, they were burn in special burner under control burning time and temperature. After cooling, the ash undergo the seiving process in order to get the various particle size before added to the cement slurry.

### Cement Slurry Preparation

The equipment specification and operational procedures for the preparation of well cement slurries in the laboratory are contained in Section 5 and Appendix A of API Spec. 10 (API, 1991). The mixing device is a two-speed, propeller type mixer, and normally 600 ml of slurry are prepared. The mixer is operated at 4,000 RPM for 15 seconds (during which all of the cement solids and rice husk ash or H322s should be added to the mix water), followed by 35 seconds at 12,000 RPM.

### Fluid Loss Test

Fluid loss test is to measure the slurry dehydration during and immediately following the completion of the placement phase of a cementing operation. Operational test procedure for determination of the fluid loss tests are contained in Appendix F of API Spec. 10 (API, 1991). After being subjected to stimulated wellbore conditions in a consistometer, the test slurry is placed in a heated filter press cell and the filtrate loss at 100 psi differential pressure is measured across a standard filtration medium (325 mesh screen supported on a 60 mesh screen). The duration of the test is 30 minutes, and the filtrate volume is noted.

### Free Water Test

The free water test is designed to measure the separation tendency in the laboratory, using a 250 ml graduated cylinder as a simulated wellbore. The duration of the test is two hours. The specification and operational test procedures are contained in API Spec 10, Section 6, and Appendix M (API, 1991).

### Compressive Strength Test

The API specifications and procedures for the determination of compressive strength are described in Section 7 and Appendix D of API Spec 10 (API, 1991). Test cement slurries are prepared according to the API mixing procedure, poured into two inch cube molds, and cured for various time periods at specific temperature and pressure. The set cement cubes are removed from the molds, and placed in a hydraulic press where increasing uniaxial pressure is exerted on each until failure. The compressive strength is then calculated by dividing the pressure at which failure occurred by the cross-sectional area of the specimen.

### Thickening Time Determination

The test slurry is evaluated in a high temperature and pressurized consistometer which measures the consistency of slurry contained in a rotating cup while under stimulated wellbore conditions. The pumpability or consistency of the slurry is measured in Bearden units (Bc). The end of thickening time is defined when the cement slurry reaches a consistency of 100 Bc; however, 70 Bc is generally considered to be the maximum pumpable consistency. The specification and operational procedures for determining slurry thickening time are contained in Section 8 and Appendix E of Spec. 10 (API, 1991).

## RESULTS AND DISCUSSION

### FLUID LOSS PERFORMANCE

Results of fluid loss tested at 52 °C circulating temperature and 100 psi differential pressure with different percentage of RHA added to the cement slurry is shown in Fig. 1. It can be seen that fluid loss volume decreases as the amount of RHA added to the cement slurry increases, depending on the RHA particle size and burning time. As the size decreases, the fluid loss volume also decreases. As clearly seen from Fig.1, RHA produced less fluid loss than Halad 322s. This is due to the additive presents in the cement slurry and also due to the part played by the fine RHA particles in occupying the micro pores and it's pozzolanic reactivity in reducing the permeability of the cement, therefore reduced the amount of fluid loss. It proves that, during the cement reaction and with the existing of water, fine ash particles will react with the excess calcium oxide and calcium hydroxide produced during the early reaction stage to form an additional cementitious material of tricalcium silicate hydrates which will filled the existing pores within the cement and thus will reduce the number of pores, and consequently will reduce the permeability of the cement. When the smaller RHA is added to the cement slurry, the formation of calcium silicate hydrate gel is faster, therefore faster permeability reduction and less fluid loss is produced. In addition, smaller particles had the better sorting, therefore bigger surface area for the chemical reaction to take place, which resulting in higher chemical reaction. As shown in Fig. 2, the fluid loss volume produced by the RHA will be decreased as the burning time increasing, depending on the particles size. This is due to the better burning process with longer burning time which in turn will produced better quality of RHA. In general, RHA performed better than Halad 322s in controlling fluid loss of the cement slurry. The performance improved with longer burning time and smaller RHA particles size.

### FREE WATER PERFORMANCE

Fig. 3 shows the capability of RHA and Halad 322s to control free water content in the cement slurry. It can be seen that the RHA produces less free water content in the cement slurry than Halad 322s. The volume of free water decreases with increasing the amount of RHA or Halads 322s added to the cement slurry, depending on the particles size and burning time. The amount of free water decreases with particle size decreases and burning time increases, as shown in Fig. 4. Fig. 3 & 4 also show that the volume of free water produced by RHA is less than that produced by Halad 322s.

The different in tricalcium aluminate content in each cement slurry will results in different rate of reaction and consumption of water, and will effect the amount of free water produced by the slurry, respectively. First, the ash content will delayed the reaction of cement with water by filling the pores between the cement grains and calcium silicate hydrate, and thus traps some of the water. In addition, some of the water is consumed by the ash to disintergrade and react with the calcium hydroxide to produced cementitious material, therefore the cement set with less free water. API specification requirement for free water is less than 3.5 ml, therefore both RHA and Halad 322s fulfilled the API Spec. requirement with RHA is much better in controlling free water of cement slurry.

### COMPRESSIVE STRENGTH PERFORMANCE

It can be seen from Fig. 5, both 8 and 24 hours compressive strength increases as the amount of RHA added to the cement slurry increases, depending on the RHA particles size and burning time. The cement compressive strength increases as the RHA particles size decreases and burning time increases. Fig. 6 shows the effect of burning time on the compressive strength performance for various partciles size. In general, RHA produced less compressive strength than that by Halad 322s but still in the API Specification ranges, that is minimum of 500 psi.

Reaction between calcium hydroxide and calcium oxide in the cement with RHA will produced more tricalcium silicate hydrate which will hold the grain within the cement molecule structure, resulting in increasing compressive strength. In addition, fine particles of RHA will react with the excess calcium oxide and calcium hydroxide to produce an additional cementitious material of tricalcium silicate hydrates which will filled the existing pores within the cement and thus will increased the cement compressive strength.

## THICKENING TIME PERFORMANCE

Fig. 7 shows the results of the thickening time of the cement slurry with various concentration of RHA and Halad 322s. It was found that the cement slurry with RHA will set faster than the cement with Halad 322s. This is due to the fact that Halad 322s is a synthetic polymer which can hold the cement particles and preventing them from react with water, therefore more time is needed by the water to break the polymer bonding and react with the cement particles. Even though RHA will gives the shorter thickening time but still within the API Specification, that is in the range of 90 to 176 minutes (API Spec. 10, 1991).

It also clear that the thickening time decreases with increasing amount of RHA and Halad 322s were added into the slurry, depending on the particle size and burning time. When smaller RHA particles and/or more RHA was added to the cement slurry, faster chemical reaction will take place, therefore the cement slurry will set faster. More silica will be produced with longer burning time. Since silica has very high pozzolanic reactivity, therefore very faster pozzolanic reaction will take place, which in turn will also cause the cement slurry to set faster. Fig. 8 shows the effect of burning time on the RHA performance in respect with the thickening time.

## CONCLUSION

The results of the study had shown that the RHA can be used as an additive to the class G cement with better fluid loss control and free water content than standard additive of Halad 322s. Even though RHA gives lower compressive strength and shorter thickening time than Halad 322s, but their compressive strength and thickening time still within acceptable limit of API Specification 10. The results also proved that the RHA performance as an additive depend on the amount used, particle size and burning time. In general, longer burning time, smaller particle size and more RHA added will gives the better results.

In general, the rice husk ash is suitable for the application as an additive in the petroleum well cementing operations, particularly as fluid loss control agent for class G cement.

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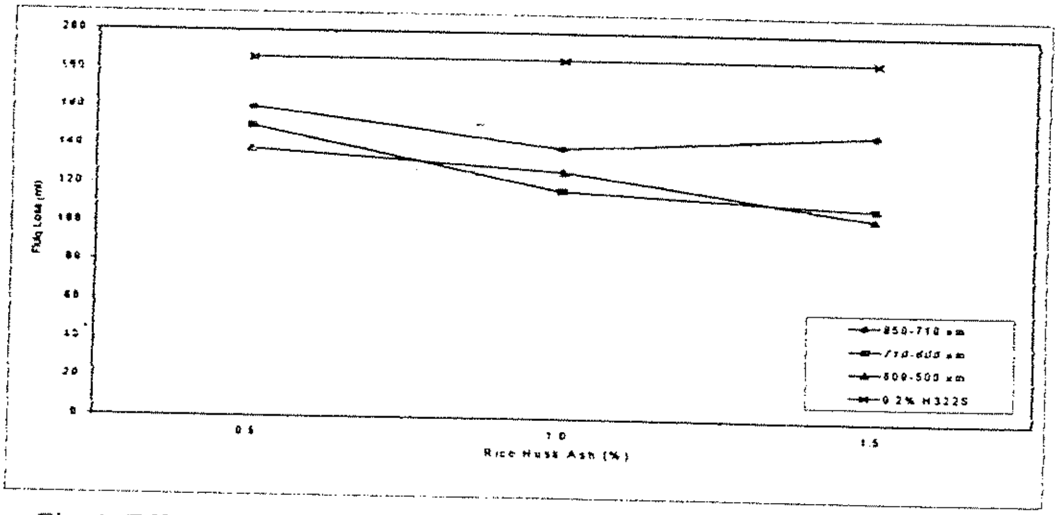


Fig. 1 Effect of RHA on Fluid Loss for Various Particles Size.

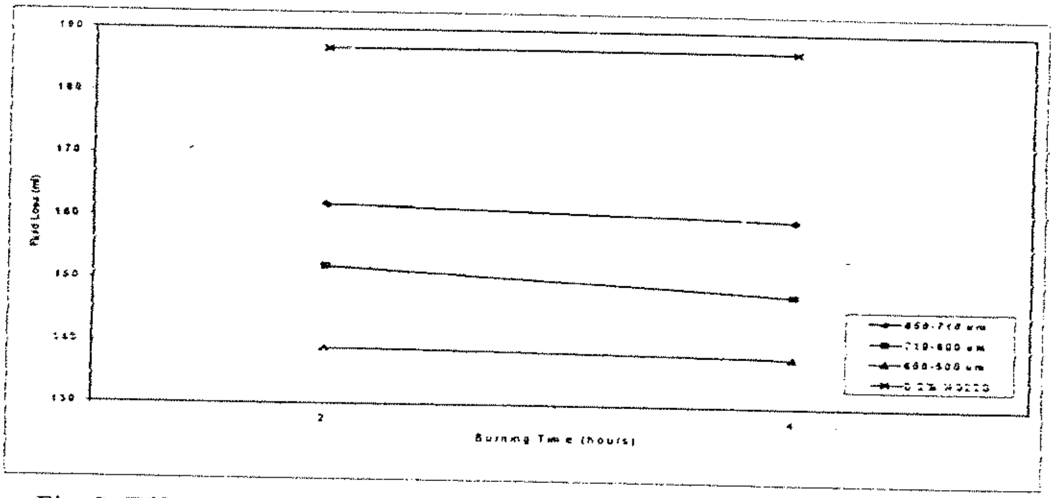


Fig. 2 Effect of Burning Time on RHA Fluid Loss Performance.

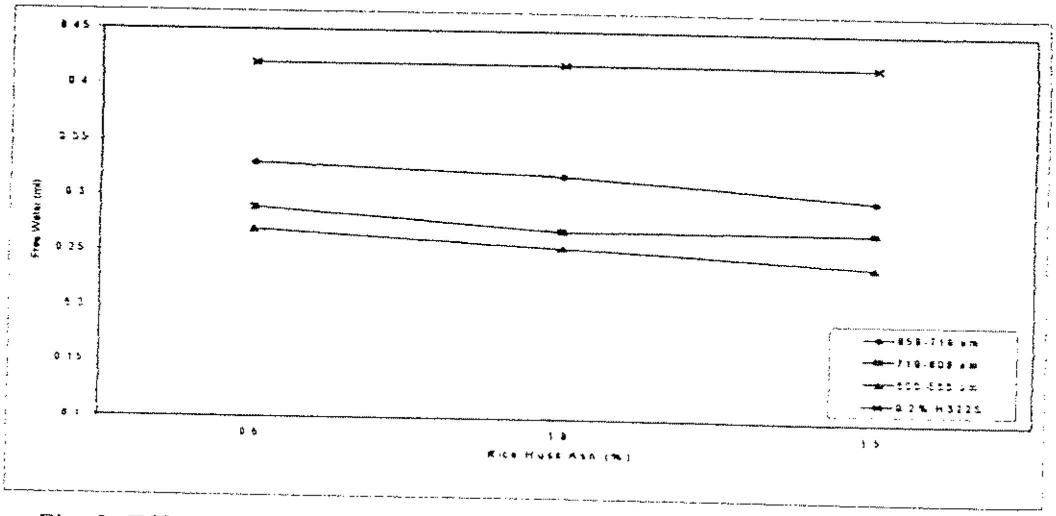


Fig. 3 Effect of RHA on Free Water Content for Various Particles Size.

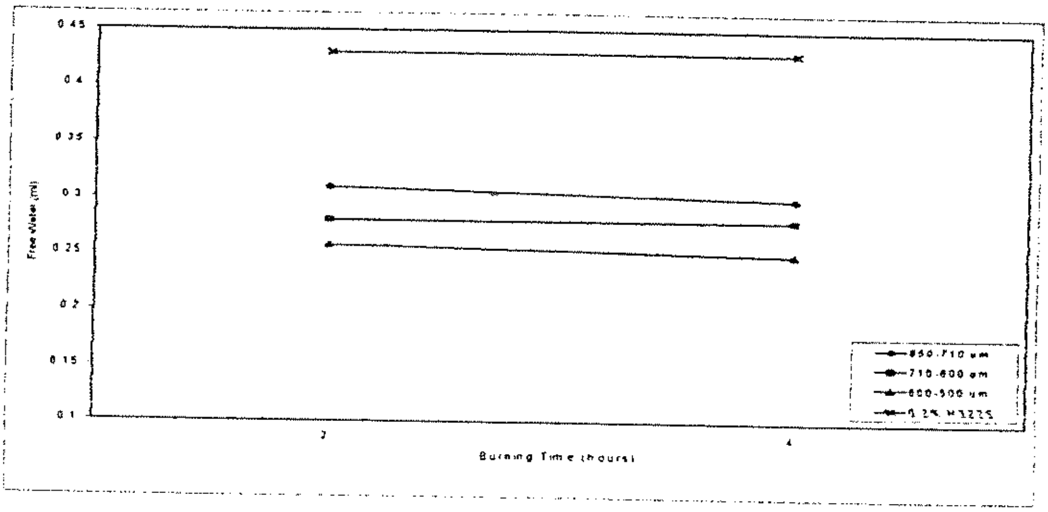


Fig. 4 Effect of Burning Time on RHA Free Water Performance.

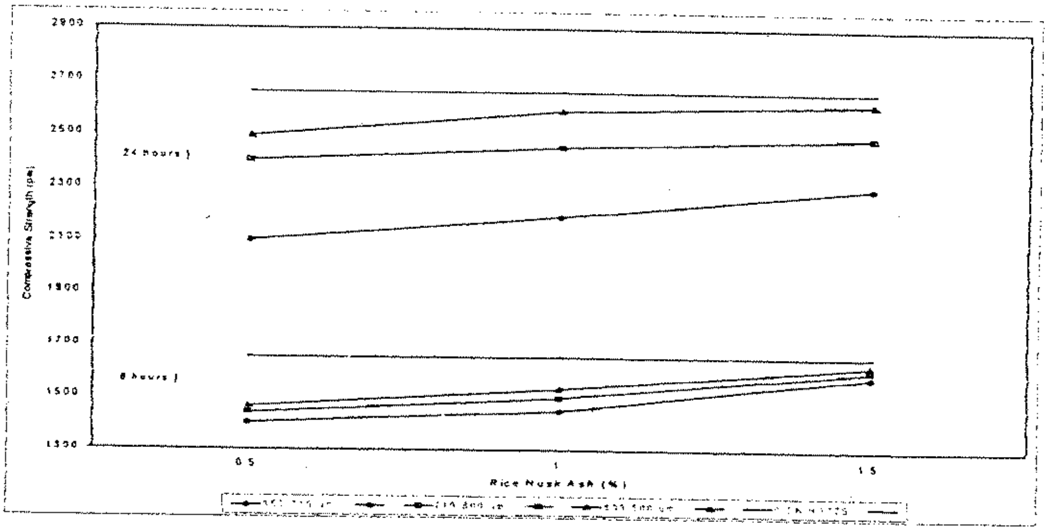


Fig. 5 Effect of RHA on Compressive Strength for Various Particles Size.

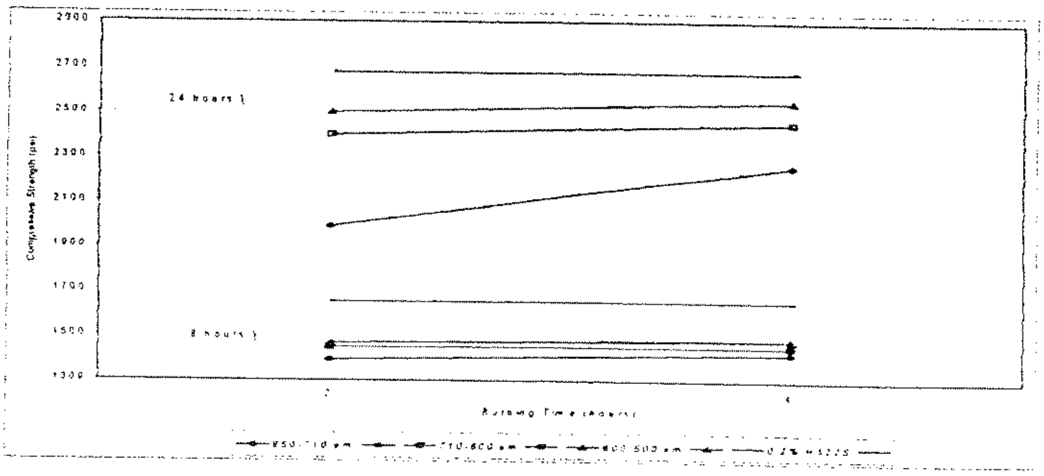


Fig. 6 Effect of Burning Time on RHA Compressive Strength Performance.

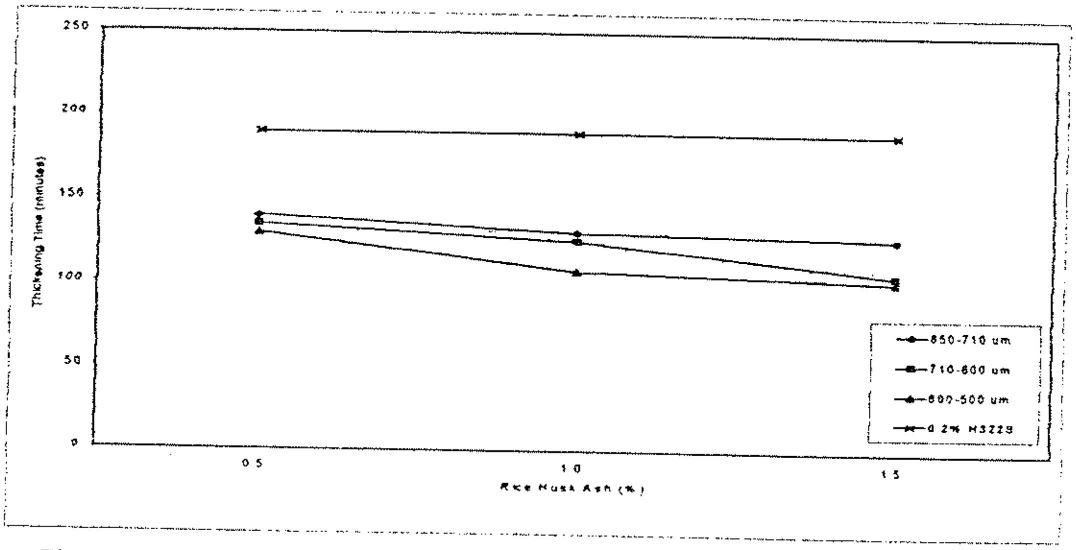


Fig. 7 Effect of RHA on Thickening Time for Various Particles Size.

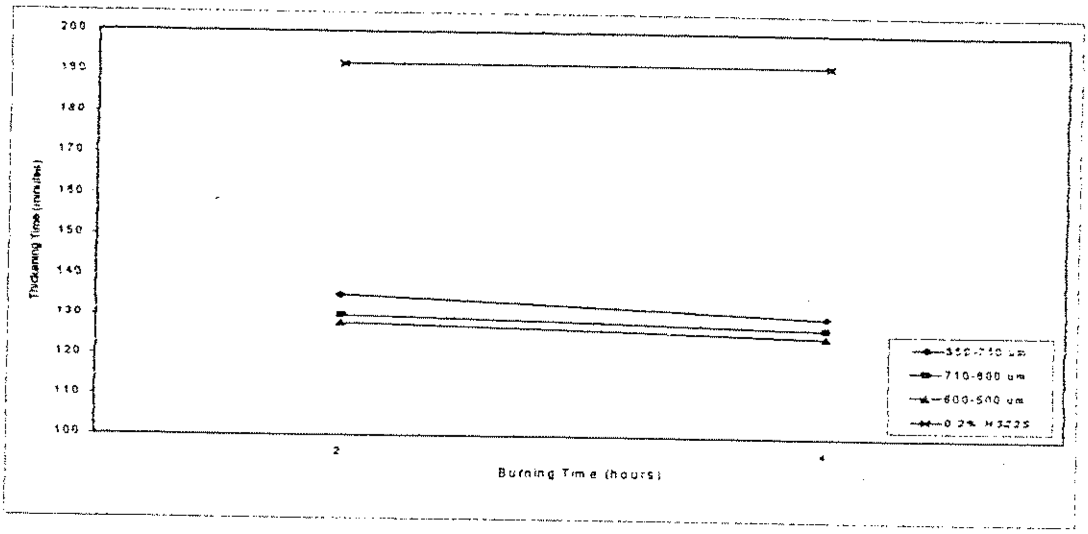


Fig. 8 Effect of Burning Time on RHA Thickening Time Performance.