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The Effect of a Weight Agent on the Process of Waste Activated Sludge

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ABSTRACT

The effect of clay as a weighting agent on waste activated sludges generated from the activated sludge process was measured with respect to the gravity thickening rate. In addition, final thickened sludge consistency, centrifuge and pressurized cake dryness, and filterability were measured.

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INTRODUCTION

STATEMENT OF PROBLEM

Disposal of secondary sludges generated by the activated sludge process is a major problem which to date has no satisfactory solution. Solids are generated by absorption and adsorption of dissolved and colloidal matter on a biological growth and the reproduction of cells. Rate of generation ranges from 0.5 to as high as 1.1 pounds of dry solids per pound of 5-day B.O.D. removed. Consistency of the slurry to be wasted ranges from 1 to 2 percent (4).

It has been established daily per capita B.O.D. contribution averages 0.16 pounds. From the manufacture of one ton of paper, 20 to 40 pounds of B.O.D. are generated dependent on the grade. The Kraft pulping process, dependent on a number of variables, contributes anywhere from 30 to 80 pounds of B.O.D. per ton produced (4).

Per 10,000 populous served, the activated sludge process generates from 10,000 to 12,000 gallons of residual slurry to be wasted. In the industry, the treatment of effluent by the activated sludge process can be expected to generate from 78 to 156 gallons of waste slime per ton of paper produced, and from 117 to 312 gallons of biological solids per ton of Kraft pulp manufactured.

Any means by which the initial gravity thickening volume of sludge produced could be reduced would lessen present handling problem. This could probably be accomplished by increasing the specific gravity of the waste sludge. There is also a possibility that the mechanical dewatering properties of the weighed slurry might also lend themselves to centrifugation.

OBJECT AND SCOPE

The purpose of this research was to investigate the use of clay as an agent to weight the waste activated sludge and measure the effects of this modification on gravity thickening rate, final thickened sludge consistency, centrifuge cake dryness, and filterability.

HISTORICAL BACKGROUND

The most effective and efficient method to reduce B.O.D. from industrial effluents and domestic sewage in many instances is the activated sludge process. Its application has become increasingly common as requirements for secondary treatment due to public pressure have developed. While the process itself has been researched extensively and improvements devised, little has been done with the sludge disposal aspect of the problem.

Waste activated sludge from present day operations, Sludge Volume Index 100, has a consistency of about one percent (7). Reductions in S.V.I. would reduce costs of handling and disposal of the voluminous quantities of waste activated sludge.

Recent research at the Chicago Metropolitan Sanitary District has shown the gravity thickened consistency of waste activated sludge could be increased by the addition of long chain organic coagulants. The increase was greater with waste slurries of low S.V.I. (5). It was also stated increasing the thickened slurry consistency from 3.4 percent to 4.4 percent would reduce 1970 construction and operating costs of sludge treatment by 39 and 42 percent respectively (1).

A review of literature has shown very limited research has been done on the weighing of waste activated sludges. At the British Water Pollution Research Laboratory, settleability of activated sludge was improved by the addition of clay (10).

During a project undertaken by the Ohio Pulp and Paper Industry jointly with the National Council for Stream Improvement, it was observed waste activated sludge obtained from a mill using the deinking pulping process and producing fine, highly filled papers, could consistently be gravity thickened in the laboratory to 7.5% solids. The ash content of this sludge averaged 40 percent. This waste slurry could also be thickened to 7.5 percent upon standing in a 55 gallon drum for 12 hours.

Limited availability of land suitable for the drying of waste activated sludge on sandbeds and the potential odor problem associated with this method of disposal has in some instances necessitated mechanical dewatering prior to disposal. Present methods feature chemical conditioning and vacuum filtration at costs of \$20 to \$40 per ton of dry solids. To date, centrifugation has not been used as a means of thickening and dewatering these sludges. The potential of the process is just being realized. Prior to discussion of the application of centrifugation to the dewatering of waste activated sludge, it is felt a brief resumé of the theory and operation of the horizontal conveyor type centrifuge would be in order.

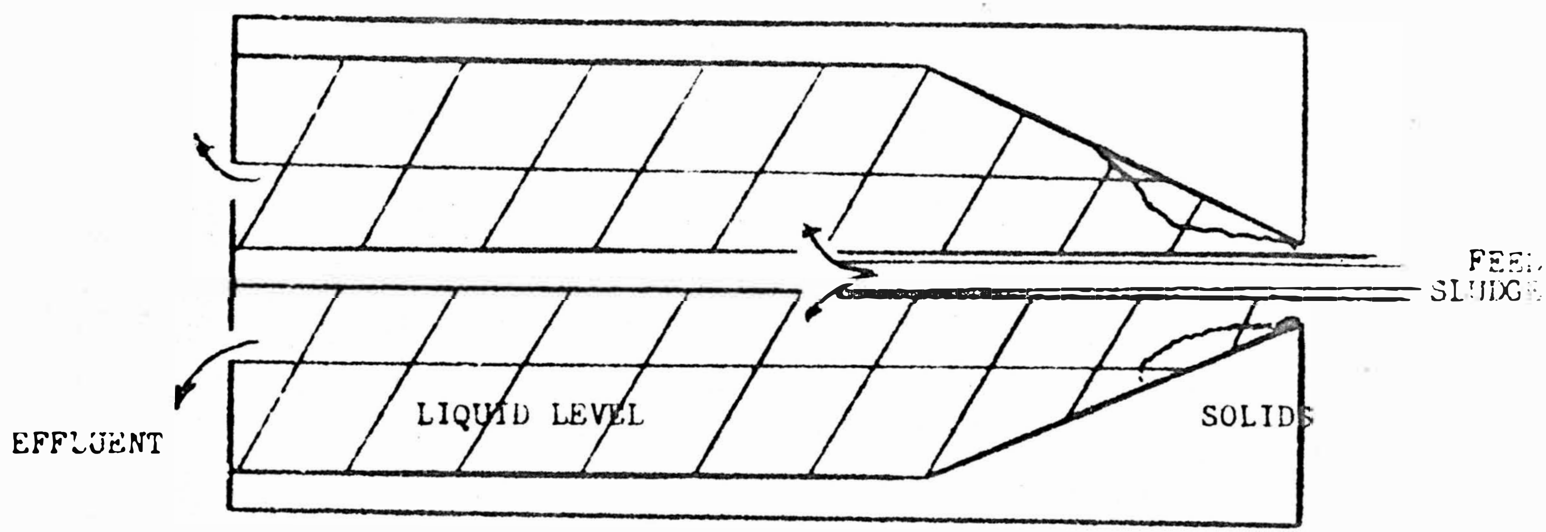
A centrifuge is essentially a device by which sedimentation is accelerated. Separation is dependent on specific gravity differential and by the gravitational force applied. In Fig. 1 a simplified diagram of a horizontal conveyor type centrifuge is presented. Slurry to be dewatered enters through the center of the revolving bowl. The magnified gravitational force created by rotation induces suspended solids to accumulate on the bowl wall.

A helical screw rotating in the same direction, but at a slightly different speed than the bowl conveys solids along the bowl and up an inclined beach for discharge through suitably located ports. Clarified liquid is discharged through adjustable weirs located at the opposite end of the device.

In pilot scale studies involving centrifugation, both disc and solid bowl units were evaluated separately as well as jointly in a two stage operation. Stevens (8) stated that with a solid bowl centrifuge operated on waste activated sludge, effective recoveries were obtained at half to two-thirds the flow rates used on primary digested sludge. Lower sludge volume indexes resulted in better solids recovery due to better cake conveying of scrolling characteristics. Activated sludge cake consistencies ranged from 7 to 20%, commonly in the 7 to 15% range. The disc centrifuge was also evaluated for dewatering waste activated sludge. Recycling of nozzle discharge to the centrifuge resulted in cake consistencies of 10 to 12%.

FIGURE 1

CROSS SECTION
HORIZONTAL CONVEYOR CENTRIFUGE



Keith (6) reported that the conveyor type centrifuge, which was capable of treating abrasive materials, dewatered activated sludge to 5 to 13% solids. Throughput rates were low and effluent clarity poor unless floc aids were used. Recoveries of 75 to 95% were experienced at polyelectrolyte addition rates of 1% or less on a dry weight basis. A disc centrifuge, a unit more compatible to the thickening of fine particles, produced a dewatered activated sludge cake of 5 to 12% consistency from gravity thickened activated sludge feed without recycling. Solids recovery efficiencies of 95% or better were feasible without polyelectrolyte addition. It was shown, also, that at addition levels of 1% or less, organic flocculents increased capacity by 3 to 4 fold.

Woodruff (4) conducted pilot scale studies on the dewatering of waste activated sludge by a disc centrifuge, horizontal conveyor type centrifuge, and a two stage operation featuring the disc unit as prethickener for the horizontal conveyor type centrifuge. In the disc type unit, recycling dewatered solids resulted in a discharge of 1 to 7% suspended solids. Operational problems however were encountered due to plugging of the recirculation system. Without recycling, sludge concentrations of 4% suspended solids were obtained and plugging problems eliminated. Polyelectrolyte addition increased solids recovery efficiency. It was surmized larger units would operate at solids recovery efficiencies of 90% and higher producing a nozzle discharge of 5 to 6% solids. It is essential these units be preceded by grit and fiber removal facilities. The solid bowl centrifuge was evaluated on pre-thickened waste activated sludge. Optimum operating conditions were at the deeper pond depths, a bowl speed of 3250 rpm, and high scroll to bowl differential speed of

19 rpm. Benefits obtained from flocculent aids were two-fold; one, production of sludge cake with sufficient body to facilitate scrolling from the bowl; two, enhancement of the settling characteristics of the suspended solids in the bowl. Polyelectrolyte addition improved performance by increasing solids recovery efficiency at all dosage levels. With this sludge, the data indicated a cake consistency of 13 to 19%, and dosage rates of 10 pounds per ton of dry solids.

Pressurized filtration is a fairly new process when considering its application to the mechanical dewatering of waste activated sludge. Fig. 9 is a simplified diagram of such a system reportedly used in Europe (13).

Pre-thickened sludge is pumped to a mixing chamber where proper proportions of sludge and a porosity aid are automatically mixed. This aid can take the form of fly ash, saw dust, repulped newsprint or Solka-Floc, a wood fiber product marketed as a filtering aid. The purpose of the aid it two-fold; one, it pre-coats the filtering medium as a means of protection and two, it increases the sludge bulk and filterability. After proper conditioning, the sludge is pumped to the pressure press from the mixing chamber. The filtrate is collected and returned to the treatment plant. After the pressure is withdrawn, the mechanically dewatered cake is automatically discharged to a conveyor belt.

Disposal of sludge is either by incineration or land fill. Cake consistencies range from 40 to 50% solids, O.D. Basis, with a filtrate containing less than 10 ppm suspended solids and 200 ppm five-day B.O.D.,

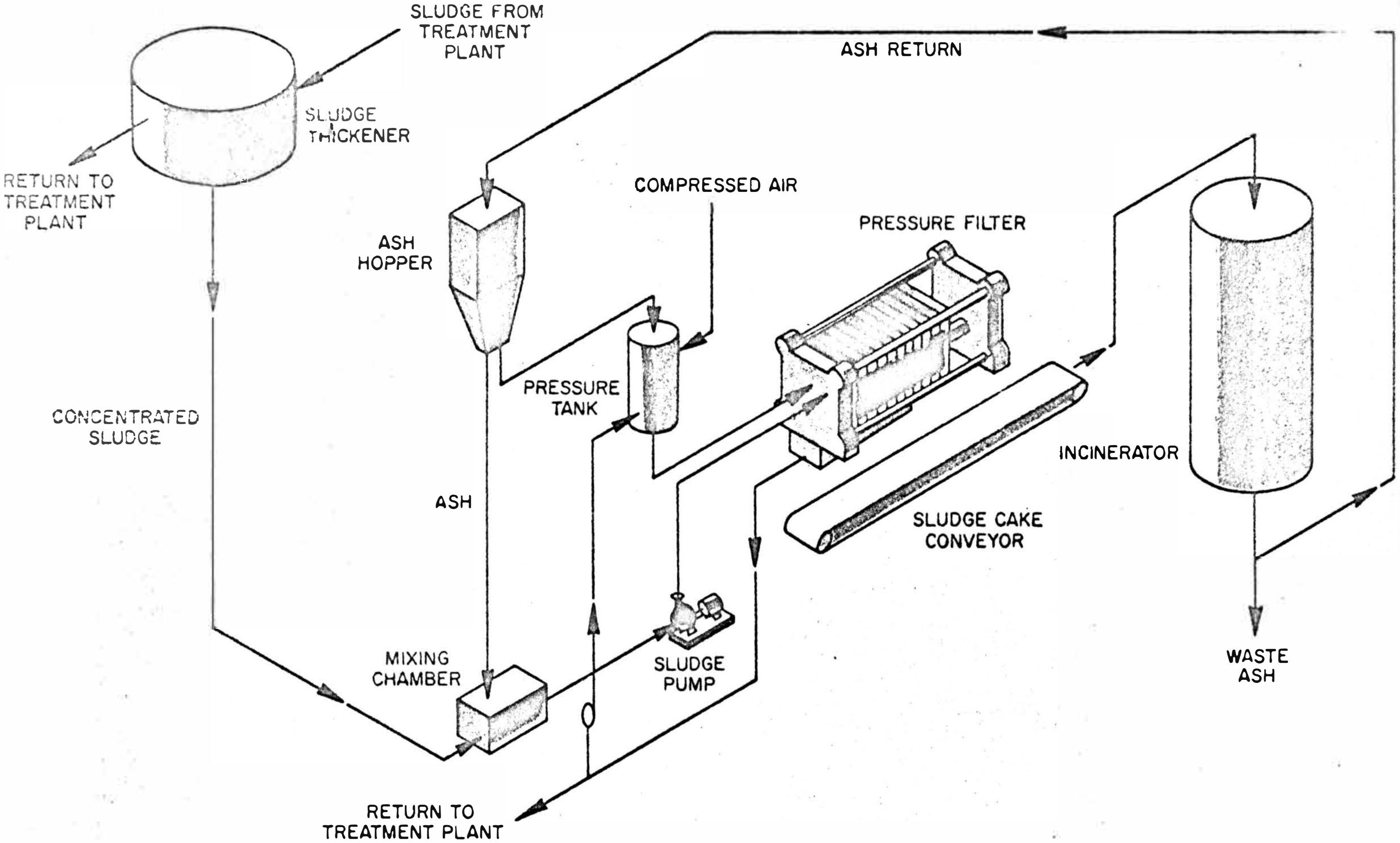


FIGURE IX

BELOIT-PASSAVANT one-stage sludge dewatering and incineration system

Total power requirements are 50 kwh per ton of dry solids

reportedly (13).

At an activated sludge plant treating boardmill effluent, this system was evaluated on a waste activated sludge of 0.5 to 1.5% consistency. Initial attempts to process the material were unsuccessful resulting in cake consistencies of 15 to 30% solids, and low loading rates. The experimental data indicated some form of pre-thickening to increase the consistency of the feed to the unit was necessary.

Work completed to date on centrifugal and pressure filtration on dewatering of waste activated sludge has indicated a pre-thickened slurry can increase the efficiency and effectiveness of the process.

EXPERIMENTAL PROCEDURE

MATERIALS USED:

1. Starch - Stacco M. Cooked at 180° for ten minutes at a consistency of 20 percent solids preserved with 10 percent Salicylic Acid, O.D. basis.
2. Clay slurry, Huber Beater Clay at 30 percent consistency, mechanically dispersed in a Waring blender for five minutes. The specific gravity of clay is 2.
3. Highly fibrillated fibers, obtained from newsprint aged by heating to 90°C for 150 minutes, then dispersed in a Waring blender for 25 minutes at 2 percent consistency.
4. Waste activated sludge from the Lexington Green Treatment Plant in Portage, Michigan.

EQUIPMENT USED:

1. Four 1 liter cylinders
2. Four standard laboratory gravity sludge thickeners operating at 0.1 rpm
3. Time clock
4. Conical centrifuge tubes, 50 milliliter capacity, calibrated in units of 0.1 ml
5. International Centrifuge. The centrifuge used was an International Size 2, Model V, explosion proof, equipped with calibrated retractable tachometer, rheostat, automatic timed transformer and electric brake. Use of the tachometer and rheostat insured duplication of

both time and gravitational force applied on various slurries.

MATERIAL PREPARATION:

The waste activated sludge was modified with highly fibrillated fibers, starch, and clay to simulate papermill effluent conditions. This was accomplished by reacting the activated sludge, at 0.5% consistency, with 10% highly fibrillated fibers, O.D. basis, and 10% starch, for a 24-hour period. To each cylinder was added the following percentages of clay prior to the 24-hour reaction time.

Cylinder A	-	Control
Cylinder B	-	20% on O.D. Basis
Cylinder C	-	40% on O.D. Basis
Cylinder D	-	60% on O.D. Basis

The total and fixed suspended solids content of each reactor was determined and all samples to be gravity thickened adjusted to 0.5% dry solid basis. The individual modified sludges were subjected to the standard laboratory gravity thickening test to obtain curves from which gravity thickening area requirements were determined (7).

All centrifuge tests were performed as follows:

1. Fifty ml of sludge slurry at 2% consistency was volumetrically added to each of six identified centrifuge test tubes of known weight.
2. The six tubes were subjected to a centrifuge force of 900 G's, equivalent to 2000 rpm, for a five minute period.
3. The supernatant was decanted and individual weights and cake

volumes recorded.

4. The tubes were oven dried for a 24-hour period, weighed and recorded. The cake consistency of the concentrated sludge was determined.

DISCUSSION OF RESULTS

The initial sludge was modified by reacting it with clay at addition rates of 20, 40 and 60% on a dry solids basis. As shown in Fig. 2, the ash content of the initial waste activated sludge was increased from 23.2 to 44.1% in proportion to the amount of clay the slurry was reacted with. Clay absorption efficiency increased to a maximum of 65% at the 43% clay addition rate. Thereafter, adsorption efficiency decreased as illustrated in Fig. 3. Typical curves obtained upon gravity thickening are shown in Fig. 4. The average area requirement for gravity thickening decreased from 122 to 72.7 square feet per ton of dry solids, and inversely proportional to the ash content of the slurry as plotted in Fig. 5. This resulted in a decrease of 21.9 to 40.4% in area requirements thus increasing the efficiency and capacity of existing units and reducing the sizing of future gravity thickeners.

The consistency of the waste activated sludge after gravity thickening increased in proportion to ash content from 1.25 to 2.22% or, by nearly 100% as shown in Fig. 6. This reduced the volume of biologically active slurry by about 50%; thus, lessening the problems involved with further processing and disposal. This is of vital importance when we consider Chicago estimated 1970 sludge handling costs could be reduced 40% by increasing the gravity thickened slurry consistency 30% (1).

The literature also indicated (6, 8, 11) that successful dewatering by centrifugation in horizontal conveyor type units is dependent upon a pre-thickened slurry.

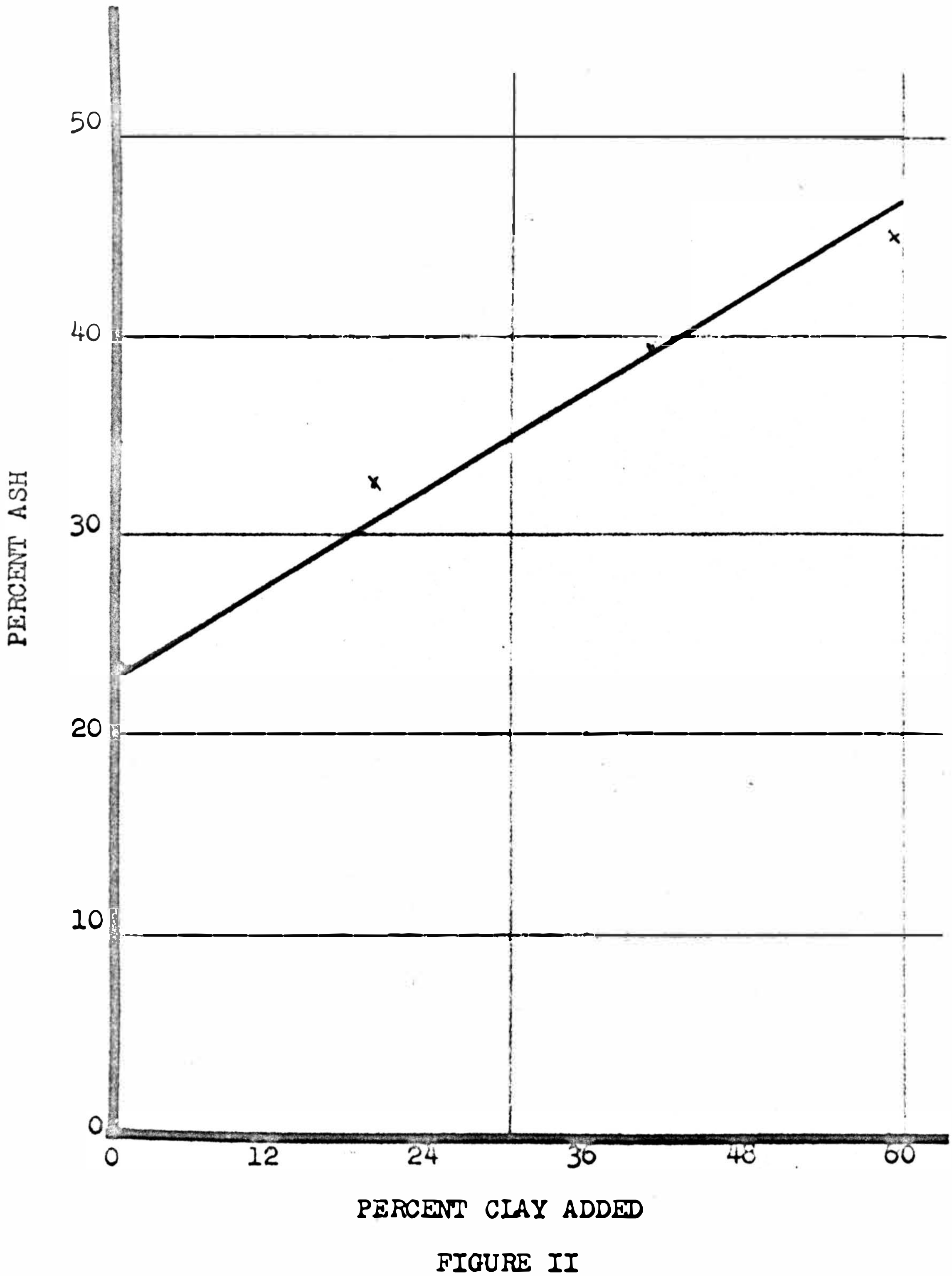


FIGURE II

ASH vs CLAY ADDED

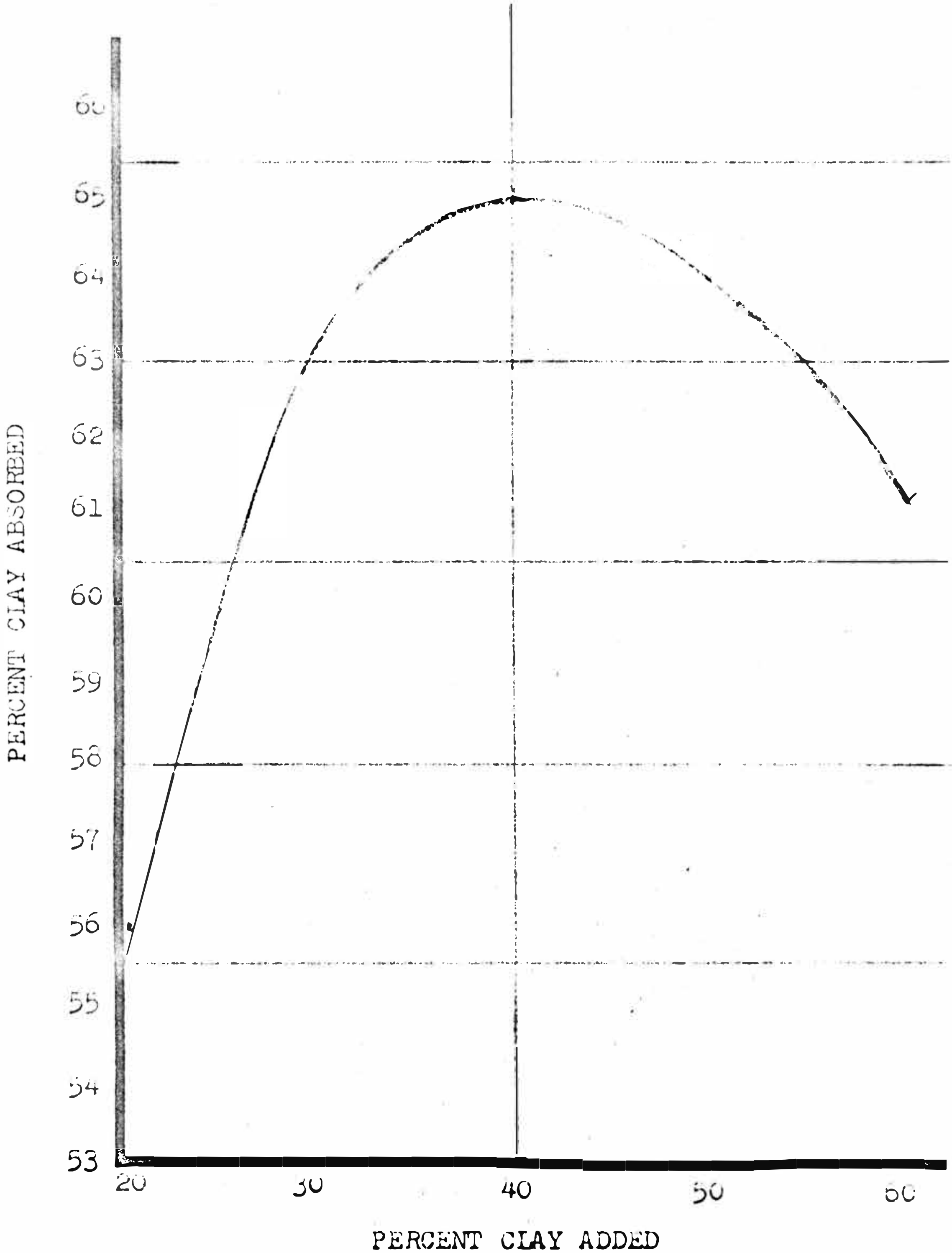


FIGURE III

CLAY ABSORBED vs CLAY ADDED

GRAVITY THICKENING RATE

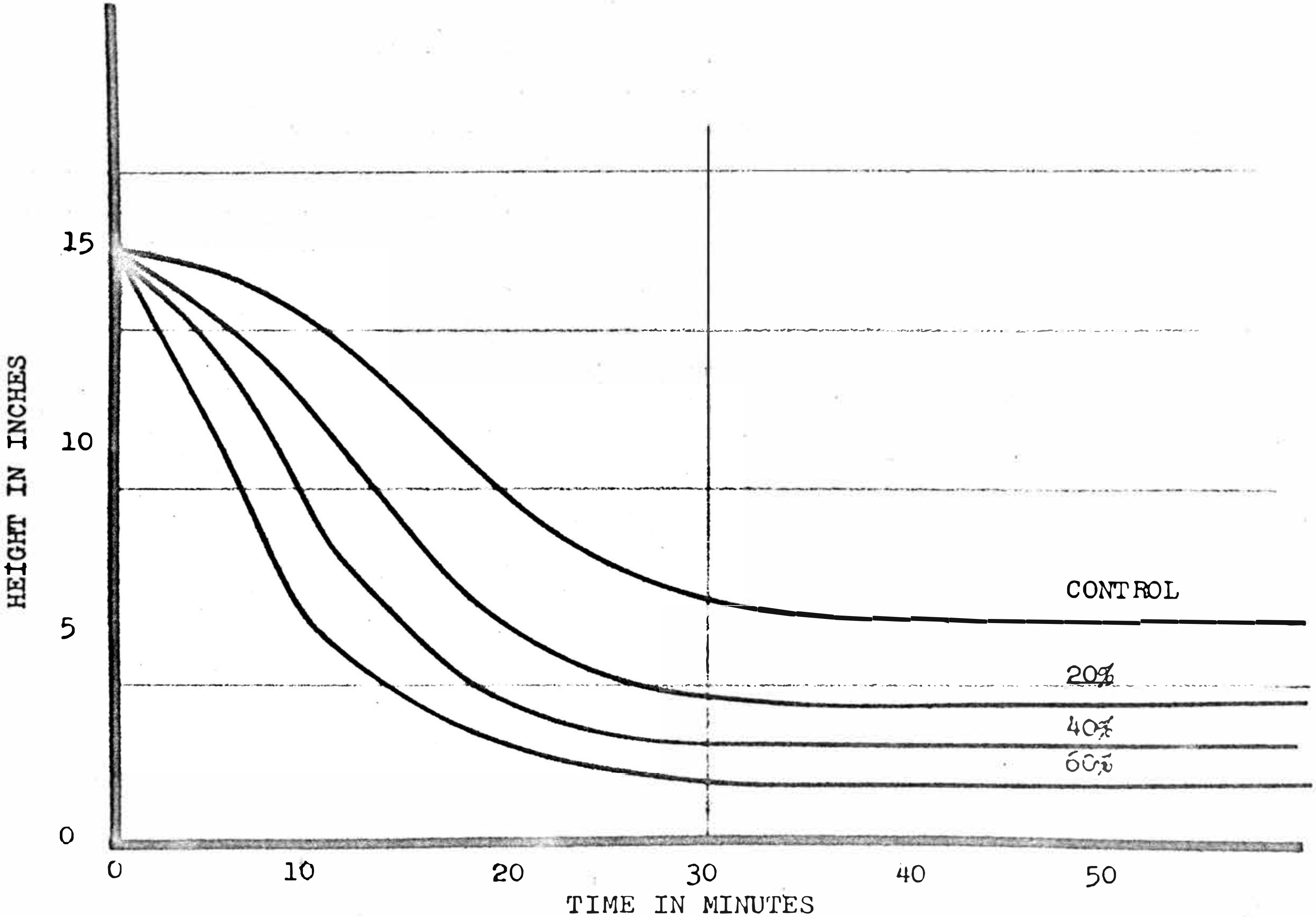


FIGURE IV

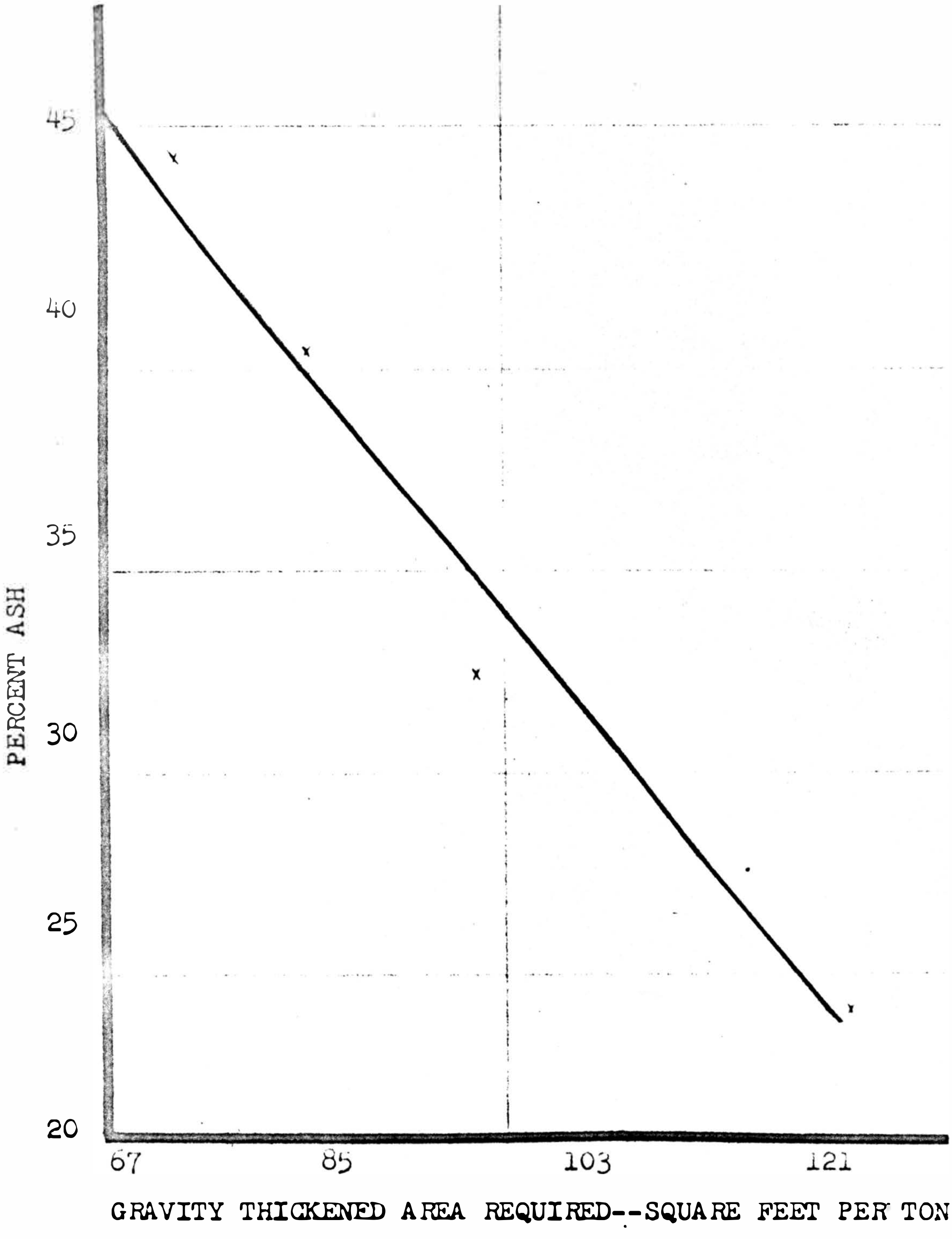


FIGURE V

PERCENT ASH vs GRAVITY THICKENED AREA REQUIRED

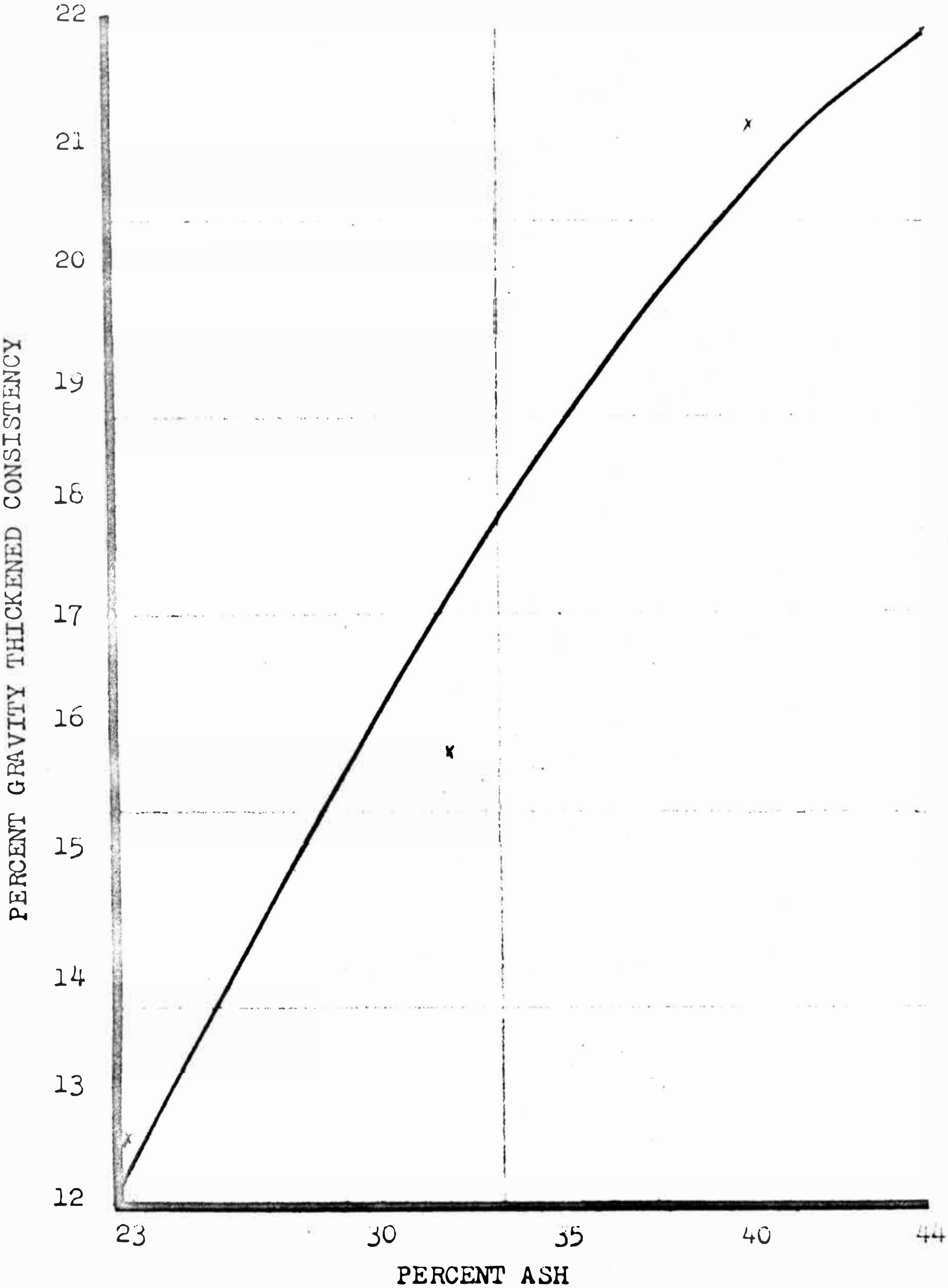


FIGURE VI

GRAVITY THICKENED CONSISTENCY vs ASH

The performance of gravity thickeners in the field is always superior to results obtained in the laboratory. This is mainly due to the high side wall area to volume ratio in laboratory units (7, 12).

After gravity thickening, the modified and non-modified sludges were subjected to centrifugation to determine their mechanical dewatering properties. Cake consistencies ranged from 5.5 to 9.54% solids, in proportion to ash content as illustrated in Fig. 7.

Water content of the cake and the weight of the cake was reduced by almost 50%. This is significant when considering disposal of concentrated sludge either by hauling to a land fill area or by incineration.

Filterability, one atmosphere of the modified sludge, remained essentially unchanged as shown in Fig. 8. Drainage rates obtained were within a 10% range.

Tests performed at the Kalamazoo City Sewage Treatment Plant indicated possible utilization of a pressurized filtration system. Initial sludge ranging from 0.5 to 1.0% concentration resulted in cake consistencies of 20 to 30% and allow surface loading rate. Gravity thickening this same slurry to consistencies of 3 to 5% increased pressed cake solids content to the 40 to 60% range.

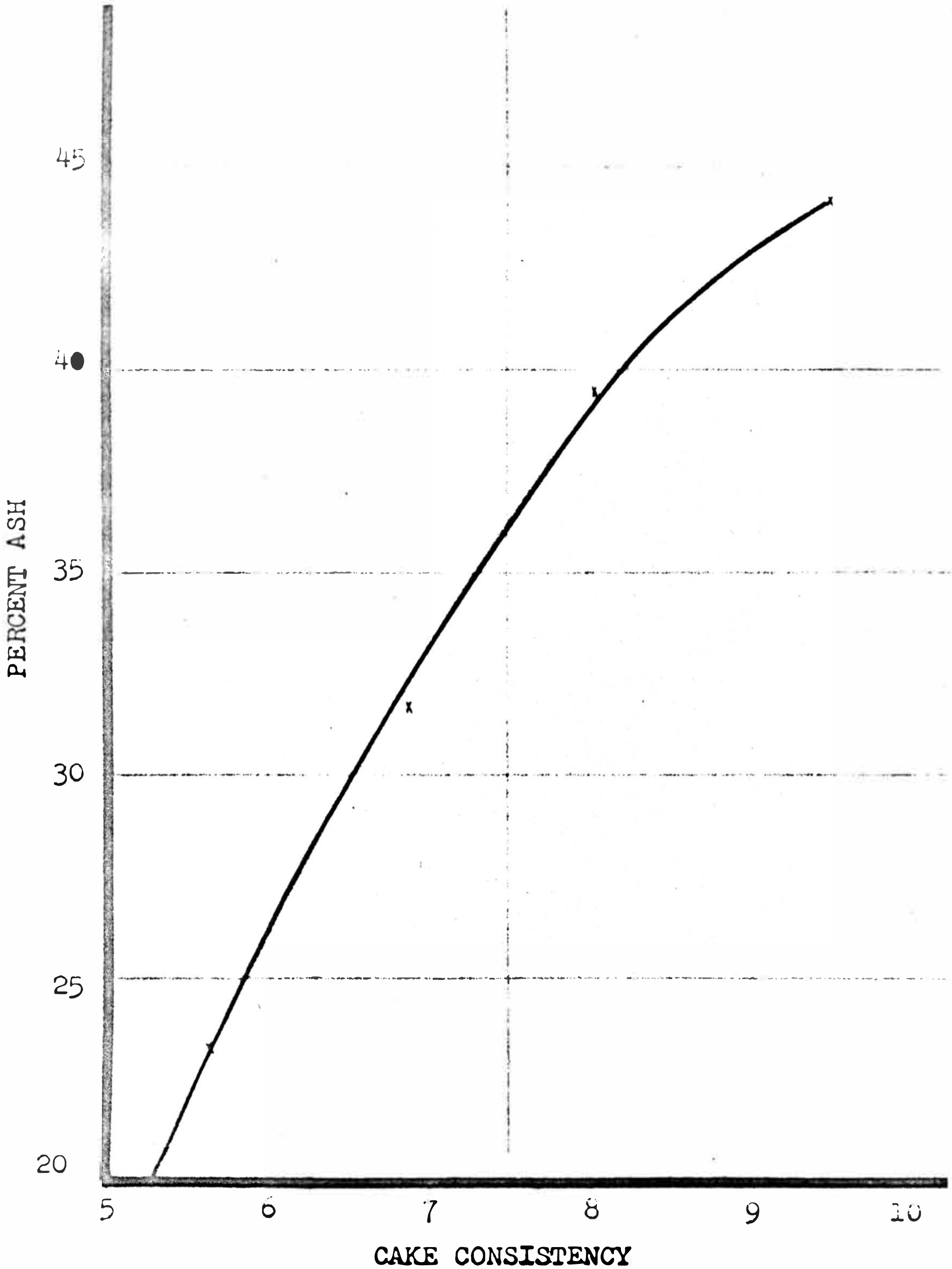


FIGURE VII

ASH vs CAKE CONSISTENCY

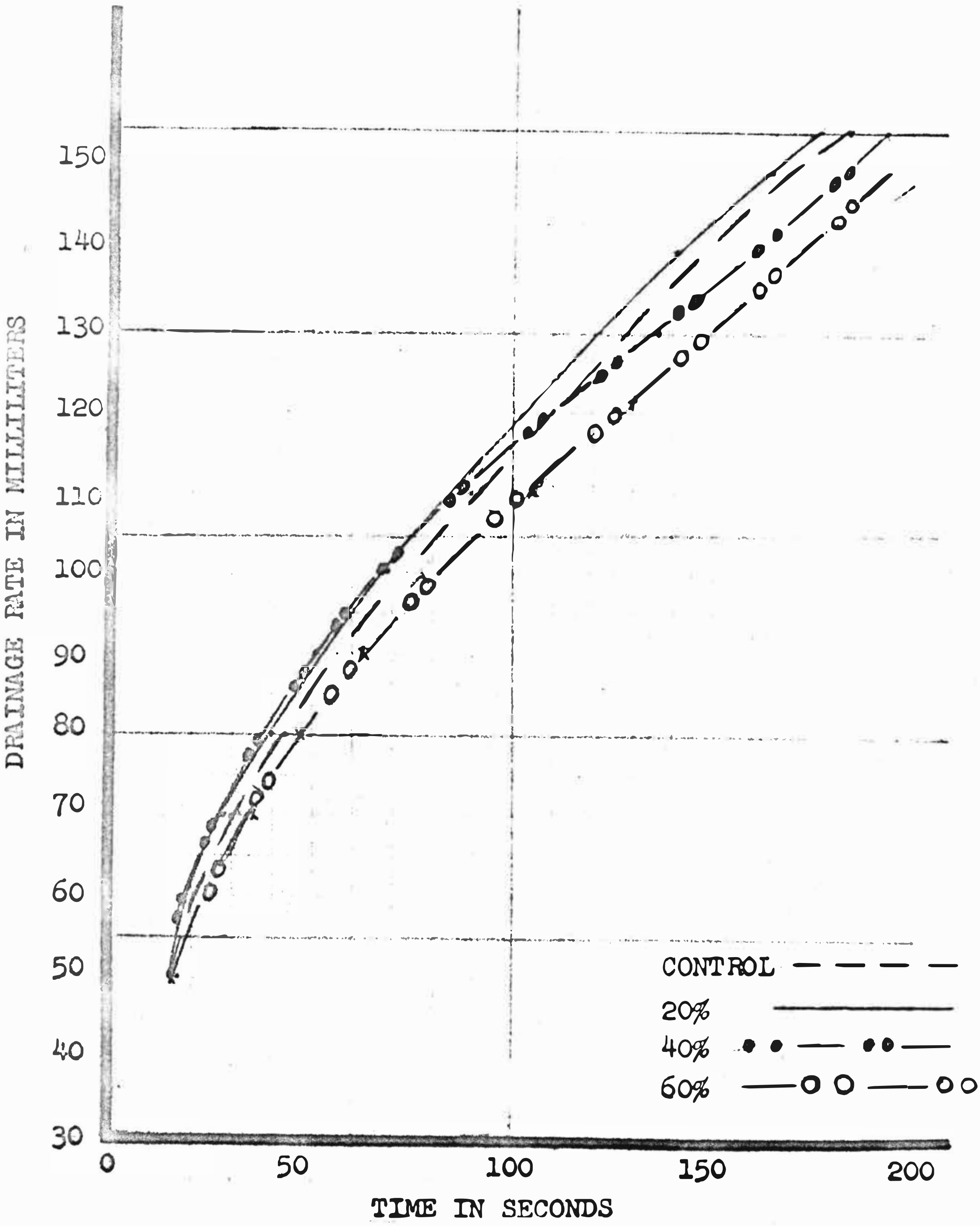


FIGURE VIII

FILTERABILITY

SUMMARY

Laboratory work showed clay could be absorbed on a biological growth. The absorption of this weighing agent on waste activated sludge reduced the area required for gravity thickening by as much as 40%, and also reduced the volume of the thickened slurry by 50%. Further laboratory work demonstrated centrifuge cake consistency of the thickened and weighted product was increased by about 100%. Trials with laboratory pressure filtrating equipment suggested an increase of at least 100% on cake solids. Filterability of the slurry remained essentially unchanged.

CONCLUSIONS

From this work it was concluded:

1. Clay, a weighting agent, was successfully absorbed on waste activated sludge.
2. The average area required for gravity thickening decreased considerably; thus, increasing the efficiency of existing and future units.
3. The consistency of the gravity thickened product was increased by about 100%; thus, reducing the slurry volume by 50%.
4. Centrifuged cake solids content increased in proportion to ash content of the slurry.
5. Cake consistency obtained upon pressure filtration were notably increased with pre-treatment of a high ash slurry by thickening to 3% solids.
6. Absorption of the clay onto the biological growth presents no adverse effects on filterability of sludge.

RECOMMENDATION

It is felt that this laboratory work has shown sufficient promise to warrant further investigation on a pilot plant scale.

DATA SHEET

Description of Test	Control			20%			40%			60%		
	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.
Final Solids After Gravity Thick	1.25	1.45	1.00	1.58	1.80	1.20	2.13	2.30	1.80	2.22	2.30	1.80
Percent Clay Absorbed				55.80	82.00	41.00	65.10	74.80	53.60	61.80	67.60	51.30
Area Required Sq'/ton	122.00	136.00	102.00	95.20	138.00	90.00	82.30	106.00	80.00	72.70	92.00	56.00
Percent Decrease In Area Required					21.90			32.50			40.40	
Cake Consistency After Centrifugation	5.52	7.24	4.05	6.85	8.43	5.47	9.26	12.20	6.95	9.54	11.60	7.45
Percent Ash	23.20	26.10	18.40	31.70	34.90	28.90	39.40	41.70	34.40	44.10	45.00	39.40

LITERATURE CITED

1. BACON, V. W., DALTON, F. E. "Chicago Metro Sanitary District Make No Little Plans." Public Works, 97, 11, 66 (1966)
2. CARON, A. L., BLOSSER, R. O. "Centrifugal Dewatering of Primary Paper Industrial Sludges." National Council for Stream Improvement, Kalamazoo, Michigan and Corvallis, Oregon, respectively.
3. CARON, A. L., FOLLETT, R. H. "Progress Report Pilot Biological Treatment of Settled Effluent from a Paper Mill Using the Deinking Pulping Process." National Council for Stream Improvement, July, 1964.
4. ECKENFELDER, W. W., Jr. "Industrial Water Pollution Control." McGraw Hill Book Co., New York (1966).
5. ELLETT, G. A., KENNEDY, T. J. "Research and Operational Experience in Sludge Dewatering at Chicago." Water Pollution Control Federation Journal, 38, 2, 248 (Feb. 1966).
6. KEITH, F. W., Jr. "The Use of Centrifuges in Disposal of Solids from Wastes." Paper given at the 33rd Annual Meeting of the Pacific Northwest Pollution Control Association. Portland, Oregon. October 19, 1966.
7. LESPERANCE, T. W. "Application of Fundamentals of Waste Treatment Sedimentation Design." Reprinted from "Biological Treatment of Sewage and Industrial Wastes." Vol. 2.
8. STEVENS, M. H. "Dewatering Sludges and Slurries by Centrifugation." Paper given at the Water Pollution Control Federation Conference. Kansas City, Missouri. September 1966.

9. "Manual of Practice for Sludge Handling in the Pulp and Paper Industry." Technical Bulletin #190, National Council for Stream Improvement.

10. Water Pollution Research Laboratory. "Water Pollution Research 1965." Her Majesty's Stationery Office (London 1966)

11. WOODRUFF, R. H., WESTON, R. F., WALTER, J. H. "Dewatering Activated Sludge by Two-Stage Centrifugation." June 1967 - unpublished.

12. CARON, A. L. Private Communication.

13. BELOIT PASSAVANT, Bulletin 6000.

VITA

The author was born on July 19, 1941, in Kalamazoo, Michigan. He graduated from Kalamazoo St. Augustine High School in June, 1959.

He had one year of college in the Accounting Curriculum prior to entering the service. The author spent four years in the U.S.A.F. as a non-morse operator and photographer. Three of those years were spent in Germany where he met his wife, Mary T. Heneghan, a native of Birmingham, England.

After discharge, he re-entered Western Michigan University in the Pulp and Paper Curriculum and held a scholarship supported by the Louis Calder Foundation for the four years.

The author is the father of three children: Michael Christian, Laura Therese, and Simon Anthony.