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## The Attainment of Ultrahigh-Solid Coating Colors

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THE ATTAINMENT OF  
ULTRAHIGH-SOLID  
COATING COLORS

by  
Robert C. Ziolkowski

A Thesis submitted to the  
Faculty of the Department of Paper Technology  
in partial fulfillment  
of the  
Degree of Bachelor of Science

Western Michigan University  
Kalamazoo, Michigan  
December 1975

## ABSTRACT

Ultrahigh-solid coating colors were mixed containing (#1) clay, three different ground calcium carbonates of varying particle size, and a styrene-butadiene latex as a sole binder. The resulting colors demonstrated proper coating rheology and were applied to a base paper by means of a blade coater. The coated paper was then evaluated for the physical properties produced.

An effective control of binder migration and water retention without the aid of a hydrocolloid was indicated by tests made on the coated paper. The paper coated with the ultrahigh-solid coating colors also depicted desirable finished properties of brightness, opacity, pick strength, ink receptivity, and smoothness, but lacked high gloss.

## TABLE OF CONTENTS

INTRODUCTION.....	1
HISTORICAL BACKGROUND.....	2
EXPERIMENTAL DESIGN.....	7
Laboratory Search.....	7
Coater Demonstration.....	9
Coating Evaluation.....	11
RESULTS.....	12
Brightness.....	13
Opacity.....	13
Pick.....	20
K&N Ink.....	20
Smoothness.....	27
Gloss.....	27
CONCLUSIONS.....	34
SUGGESTIONS FOR FURTHER WORK.....	35
LITERATURE CITATIONS.....	36
ADDITIONAL REFERENCES.....	37
APPENDIX.....	38



## INTRODUCTION

The percent of solid matter present in a coating color has become an item of extreme importance since the introduction of machine coating. Conventional coating terminology, classifies coating colors as being either a high-solids mixture or low-solids mixture. The generally assigned ranges are 30%-50% solids for low-solid coating colors and 50%-70% solids for high-solid coating colors. A new term is finding its way into the coating industry, that being the advent of ultrahigh-solid coating colors. Ultrahigh-solid coating colors have a solids content in excess of 70%.

Until recently, the solids limitation from a rheological standpoint is probably in the neighborhood of 67% solids (1). It is the purpose of this investigation to pursue the possibility of obtaining runnable ultrahigh-solid coating colors with desired finished proper-

## HISTORICAL BACKGROUND

Paper coating has been a part of the paper industry since 1875 (2). Most pigmented coated papers are used in printing due to the demand for better printing surfaces. Mineral coatings are generally applied to paper for one or a combination of the following reasons: (1) to impart a smooth and receptive surface for printing, (2) to mask or change the color of the raw stock, and (3) to impart opacity (3). Coated paper has also aided in the control of such properties of the paper surface as ink absorbency, ink receptivity, smoothness, gloss, and brightness.

The two major ingredients of any coating formula are the adhesive and the pigment. Commercial coating formulas also contain a number of minor materials such as: antifoaming agents, dispersants, viscosity modifiers, and dyestuffs to achieve favorable coating properties.

The dry pigment, adhesive, and other desired constituents are added to water and an aqueous coating suspension is formed. The water-adhesive fluid acts as a lubricant between pigment particles, and enables them to slide over each other much more easily than would be possible if they were dry (4). The amount of water added to the coating mixture obviously controls the particular percent solids of that mixture. Increasing the solids content of a coating color by means of decreasing the available water will definitely alter the color's flow properties. The major drawback of formulating ultrahigh-solid coating colors is obtaining suitable flow properties or rheology necessary for application of the coating to the base stock. Unless the coating mixture has the proper rheology, improper transfer will result making

the mixture undesirable for application.

The use of coatings containing greater than 70% solids by weight has been considered impractical because they could not be pumped or uniformly spread due to the dilatant characteristics of such high solids composition (5). The term dilatancy (as defined by Reynolds) describes the increase in void volume which results when a closely packed assemblage of particles is subjected to shear (6). In a dilatant system, the dispersed particles and the liquid are in such close balance that there is barely enough liquid to fill the voids. When flow is initiated, the void volume is slightly increased, thereby creating a partial dryness which increases the resistance to flow (7). It is the resistance to flow which makes a dilatant coating color unacceptable for use in the coating application process.

In terms of the previous discussion the practicality of an ultra-high-solids coating color is dependent on avoiding a rheological dilatant condition. How is this done? A careful selection of pigments and adhesive is important since the flow properties of high-solid coatings are governed by the viscosity and rheological properties of the adhesive and pigment system. When making a pigment selection for rheological purposes, several pigment characteristics are considered. These factors are: (1) particle size and shape, (2) particle water demand, (3) particle adhesive demand, (4) pigment viscosity characteristics. It is the belief of this investigator that a pigment system consisting of a combination of a small (#1) clay particle and a larger, substantially spherical, ground Calcium Carbonate particle meet the necessary pigment specifications. Theoretically, the small clay particle together with the (hard) larger, spherical Calcium Car-

bonate particle should provide an additional particle lubrication effect to lower the inherent coating mixture viscosity and reduce the possibility of dilatancy.

The small particle size clay was also chosen because of its low hydration capacity which will produce a more fluid dispersion than clays of larger particle size. It also has a moderate adhesive demand and the ability to impart gloss on the finished paper. The ground Calcium Carbonate was chosen because of its comparatively low water and adhesive demand and its ability to increase ink receptivity.

The adhesive of a coating mixture exerts a profound influence on the properties of the final coated paper. The functions of the adhesive in pigment coatings are as follows: (1) to serve as a carrier for the pigment, (2) to impart the required rheological behavior and water (and adhesive) retention to the coating mixture, (3) to bond the pigment particles together in the dried coating and to bond the pigment to the base stock, (4) to control the absorption of printing ink during printing of the paper (8). The selection of a styrene-butadiene latex as a sole binder was made because of its appropriate viscosity and low water demand.

When formulating an ultrahigh-solids coating color or any coating mixture, two other important factors must also be given ample consideration. These factors being the coating's ability to retain water and the minimization of binder migration. Since the binder level and thusly water content of an ultrahigh-solids mixture is low, the ability of the coating to retain water is critical as well as to achieve the maximum adhesion of the binder by reducing its migration.

Water retention is the ability of the coating color to bind the

aqueous component within the mixture and not release it too rapidly to the base paper. "With the increase of the proportion of latex in a paper coating, the water holding power of a coating is decreased. The reason being the synthetic latex particle is hydrophobic and rather than 'holding' the water in the coating color, allows it to drain away into the paper substrate (9)." This condition of rapidly releasing water into the base stock must be avoided because of the quick increase in solids of the coating color at the point of application. Since the solids portion of an ultrahigh-solids coating color is already near the critical point, any sudden increase in solids can induce dilatancy. Often the addition of a synthetic thickener (hydrocolloid) such as sodium alginate, carboxymethyl cellulose, or methyl cellulose is employed to increase the water retention of a coating mixture (10). These hydrocolloids being hydrophilic attract water molecules thus containing them within the coating color.

Adhesive retention is another desired coating color property related to water retention. The lack of adhesive retention within the coating color induces a phenomenon known as binder migration. "Binder migration is essentially the selective movement of an adhesive through a pigmented coating. The small adhesive particles in relation to the larger pigment particles tend to be redistributed during the application and drying of the paper coating. There is a commonly accepted theory that binder migration follows the same pattern as water flow within the pigmented coating before the coating loses enough water to solidify (11)." The significance of migration is well established. With insufficient

whereas excessive binder migration weakens the finished coating layer (12).

A few "cures" for binder migration are: (1) type of binder used, (2) multiple coats, (3) proper control of drying variables, and (4) higher coating solids.

The ability to obtain ultrahigh-solids in a coating mixture could afford many desirable operability and finished coating qualities.

These desired properties are:

- (1) A decrease in the amount of drying required due to the lower quantity of water present in the coating mixture.
  - a) A savings in energy is cited.
  - b) There is also a possible reduction in drying equipment and resulting conservation of floor space.
- (2) A potential increase in machine speed can be utilized and therefore an increase in production.
- (3) An improvement in water retention and a restraint on binder migration due to the minimization of the liquid phase within the coating color.
  - a) A decrease in the amount of adhesive necessary to develop appropriate pick strength.
  - b) An increase in picking resistance.
  - c) An improvement in ink receptivity.
- (4) An increase in the quantity of coating that can be stored in a given area and conversely, a decrease in the amount of space required to store a given mass of coating.

Along with the many advantages of ultrahigh-solid coating colors a few disadvantages are seen:

- (1) Possibility of a "poor" rheology and the associated pumping and metering problems.
- (2) There might also be a loss of the ability to obtain low coat weights.

## EXPERIMENTAL DESIGN

This investigation was subdivided into three main areas of approaching the problem of obtaining a runnable ultrahigh-solids coating color. First, a laboratory search for the proper pigment system, dispersant, and adhesive was made. Experimentation with the weight percentage of pigment blends and the development of viscosity curves was sought with intention of finding optimum rheological properties. Second, the design and execution of a pilot coater trial with emphasis on developing a procedure for the proper "make down" of an ultrahigh-solids coating color. Finally, testing of the coated paper to evaluate the finished properties found.

### Laboratory Search

Previous work done by Smith disclosed an aqueous paper coating composition having a solids content of at least 70% by weight with said solids being comprised of a coarse ground substantially spherical pigment, a finely divided pigment and coating binder; said coarse ground pigment comprising from 25 to 90 per cent of the total pigment content with the finely divided pigment comprising the remainder of the pigment composition (13). Selection of three different ground Calcium Carbonates of various particle sizes was made along with a small particle (#1) clay. The (#1) clay was of high G.E. brightness (90) with 92% of the particles having a size less than  $2\mu$  with an average particle size of  $0.5\mu$ . The finest carbonate had particles with 36% less than  $2\mu$  and an average particle size of  $3.0\mu$ . The intermediate carbonate had particles with 26% less than  $2\mu$  and an average particle size of  $4.5\mu$ . The coarsest carbonate had particles with

22% less than  $2\mu$  and an average particle size of  $7.0\mu$ . All carbonates are sold by Harry T. Campbell Sons' Co. as Camel-White (finest), Camel-Tex (intermediate), and Camel-Carb (coarsest). A styrene-butadiene latex (Dow 640) was chosen because of its viscosity characteristics and particular particle size. Initially it was assumed that the dispersion of the clay fraction of the coating color would dictate whether or not dilatancy would result. For this reason, Tetrasodium pyrophosphate (TSPP) was chosen as a pigment dispersant.

The following coating formulation was then applied:

Water	(Amount needed to achieve desired solids level.)
Clay	100 parts
$\text{CaCO}_3$	
TSPP	0.3%
Latex (.48%)	12 parts

the only variations imposed were that of using the three different carbonates, changing the percent ratio of clay to carbonate, and the amount of any additional water needed as dictated by the solids level desired.

Coating colors with solid levels of 70%, 75%, 80%, and 82% were prepared with the use of a laboratory dispersator (high speed cowles type mixer). Viscosity curves for the different carbonate particles were developed by holding the specific solids level constant and varying the clay to carbonate ratio. Viscosity was measured with the aid of a Brookfield viscometer (@ 100 rpm) and a Hercules high shear rheogram was made of each individual coating. (The viscosity curves de-

At this time, a weight percent combination of TSPP and Calgon-T



(Sodium Hexametaphosphate) as a dispersant was developed in hope of achieving optimum chemical dispersion. It was found that by combining TSPP and Calgon-T in the same proportion of the pigment composition, a reduction in color viscosity resulted. This system thereby indicating better chemical dispersion by a combination of dispersants than with TSPP alone.

The result of the laboratory investigation indicated that the pigment composition of 25 parts (#1) clay and 75 parts carbonate exhibited the necessary Brookfield viscosity and rheology for purposes of running a blade coater trial.

#### Coater Demonstration

The pilot coater trial was designed in order to compare the ultra-high-solid coating colors with coating mixtures of typical commercial solids. For this reason, the solid levels of 64%, 70% and 82% were fixed for each different carbonate. Control of color viscosity was also sought. Since the viscosity of the 82% colors dictated the viscosity levels to be matched, a synthetic thickener (Kelgin Q) was necessary in the formulation of the 64% and 70% solid coatings. At this point an anti-foaming agent was introduced (Beck 144-C) into the coating formulation to control foam. It was also decided at this time to use a (#1) clay with normal brightness (Hydrafine). Table II in the Appendix shows the formulations and Brookfield viscosities for the nine coatings tried on the pilot blade coater.

Since the pigment dispersion is of critical importance in obtaining the proper rheology of an ultrahigh-solids coating color, the right choice of mixing equipment is necessary. An interesting phenomenon is that mechanical kneading of a dispersion at high solids and

then diluting, results in a lower adhesive demand than diluting to final solids before kneading (14). For this reason, "make down" of the trial coatings employed the use of a pilot Z-bar mixer (kneader) and the following mixing procedures:

- (1) Coatings having solids greater than 80%.
  - a) Mix free water fraction, total clay portion, and the appropriate amount of carbonate so as to having a composition of 75% solids until adequate dispersion develops.
  - b) Add dispersant.
  - c) Add one-half the amount of pre-weighed latex and the remainder of carbonate portion until adequate dispersion is observed.
  - d) Add defoamer and the rest of the latex and mix until dispersion is complete.
- (2) Coatings having solids less than 80%.
  - a) Pre-mix a calculated gross amount of 2.5% Kelgin Q solution in a high speed mixer.
  - b) Mix free water fraction, total clay portion, and the appropriate amount of carbonate so as to having a composition of 75% solids until adequate dispersion develops.
  - c) Add dispersant.
  - d) Add remainder of  $\text{CaCO}_3$  portion (if necessary).
  - e) Add the calculated amount of 2.5% Kelgin Q solution. (It's important to account for the water fraction introduced here into overall coating solids calculations.)
  - f) Add defoamer and necessary latex.

After coatings were mixed, they were processed through coating screens and applied to a 45# (3300 ft<sup>2</sup>) base paper by means of a blade coater. Coater speed was limited to 500 fpm to insure adequate drying of the

igation to hold coat weight constant for all nine coatings at 10# (3300 ft<sup>2</sup>). To accomplish this, blade pressure was varried for each coating. Initial indications revealed that a minimum coat weight of 12# (3300 ft<sup>2</sup>) could be accomplished at 24psi blade pressure for the highest solid coatings. For fear of provokin excessive blade scratching, a coat weight of 12# (3300 ft<sup>2</sup>) was sought for as a constant. Secondly, it was determined that a maximum coat weight of 10# (3300 ft<sup>2</sup>) could be

achieved by the lower solid coatings at a blade pressure of 1 psi. Finally it was decided to run blade pressures of 1, 2, and 3 psi for the lower-solid coatings (64% and 70%) and blade pressures of 20, 22, and 24 psi for the higher-solid coatings (80%+). At least coat weight could be held constant within the distinct solid levels this way. (See Table III in Appendix for coat weight-blade pressure data.)

#### Coating Evaluation

One sheet sample having an average coat weight of 9.5# (3300 ft<sup>2</sup>) for each coating of lower solids (64% and 70%) and sheet samples having an average coat weight of 14.8# (3300 ft<sup>2</sup>) for the higher solid coatings, were prepared for testing. Ten 12"X12" sheets were cut for each coating sample at each solids level and subjected to four nips through a laboratory calender at 30 psi. Each sample sheet was then tested for brightness, opacity, K&N ink (receptivity), IGT pick, gloss, and smoothness to depict the observed coating properties.

## RESULTS

The following table of results is arrived at by the calculation of an average value for the particular property being tested.

TABLE I  
TESTING RESULTS

	% Solids	Coat Weight	Ave. Part. Size	Bright.	Opac.	IGT Pick	K&N Ink	Smooth.	Gloss
C.W.**	64.4	9.05	3.0(M)	84.0	82.7	170	32.5	34	16.4
C.W.	70.2	9.89	3.0	83.9	82.9	167	30.3	28	20.4
C.W.	80.8	14.04	3.0	83.9	84.6	174	19.2	18	44.6
C.T.	64.3	8.91	4.5	82.4	82.4	191	32.7	40	13.5
C.T.	70.9	9.71	4.5	82.5	82.5	185	30.1	34	17.6
C.T.	82.1	15.77	4.5	81.9	83.9	318	17.9	23	38.5
C.C.	64.4	9.91	7.0	81.9	82.0	236	32.1	47	10.7
C.C.	69.9	9.33	7.0	82.1	81.8	240	28.9	39	14.5
C.C.	82.3	14.72	7.0	80.9	83.7	323	15.7	27	33.5
Base Paper				83.4	77.8			210	6.9

\* (% reduction = original bright. — K&N bright. / original bright. X 100)

\*\* Camel-White (C.W.)  
Camel-Tex (C.T.)  
Camel-Carb (C.C.)

When trying to characterize the testing results, three predicting parameters are indicative of the coating being tested. These parameters are the percent solids, coat weight, and average particle size (of the carbonate) of an individual coating color. An effort to graphically represent the data, tries to predict the general effects the

independent parameters have on the coating properties. Statistical support of the results was hindered however, due to the generation of the small number of sample points. Since only three possible sample points for each coating property were obtained, the application of statistical methods for regression were nearly ineffective and therefore won't be mentioned.

### Brightness

From Figures 1-3 it can be seen that neither percent solids, coat weight, or average particle size has a significant effect on brightness. A stratification between the curves for Camel-Wite, Camel-Tex, and Camel-Carb is noticed because of the difference in brightness of the individual carbonates with Camel-Wite having the highest brightness. The slightly negative slope of all lines (especially in Figure 2) shows the fact that the base sheet is brighter than the coating being placed on it.

### Opacity

Figures 4-6 characterize the dependance of opacity on the solids fraction, coat weight, and particle size of the pigmented coating colors with the following effects being observed: (1) The change in the solids of a color has little effect on opacity. (2) A positive linear relationship is depicted between opacity and coat weight signifying an increase in coat weight produces a direct increase in opacity. (3) By holding solids constant, a negative linear correlation is observed between particle size and opacity showing that an increase in particle size produces a decrease in opacity. This can be attributed to the decrease in overall pigment surface area as the particle size increases, which reduces the "hiding power" of the pigment.

FIGURE 1-DEPENDANCE OF BRIGHTNESS ON SOLIDS LEVEL

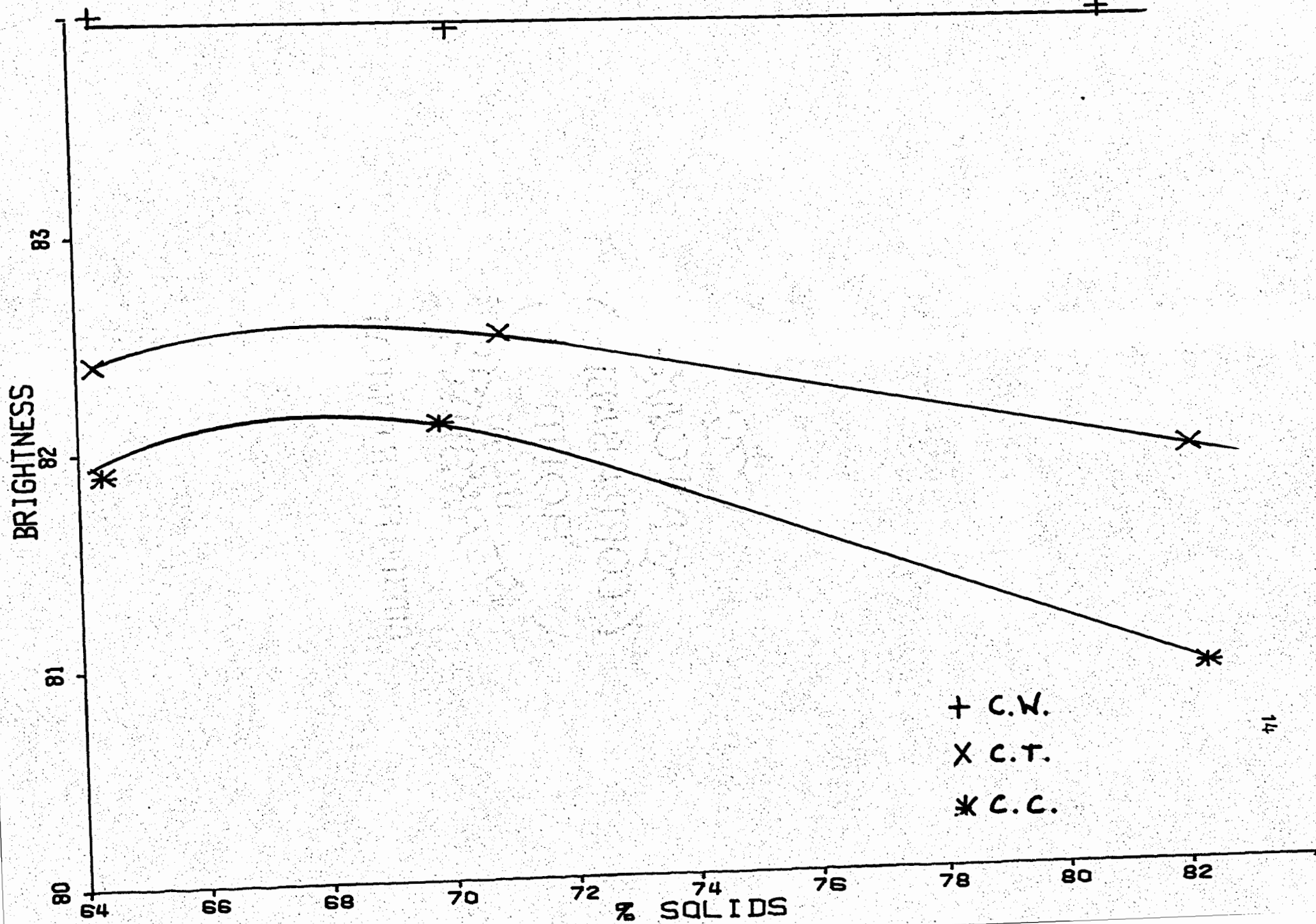


FIGURE 2-DEPENDANCE OF BRIGHTNESS ON COAT WEIGHT

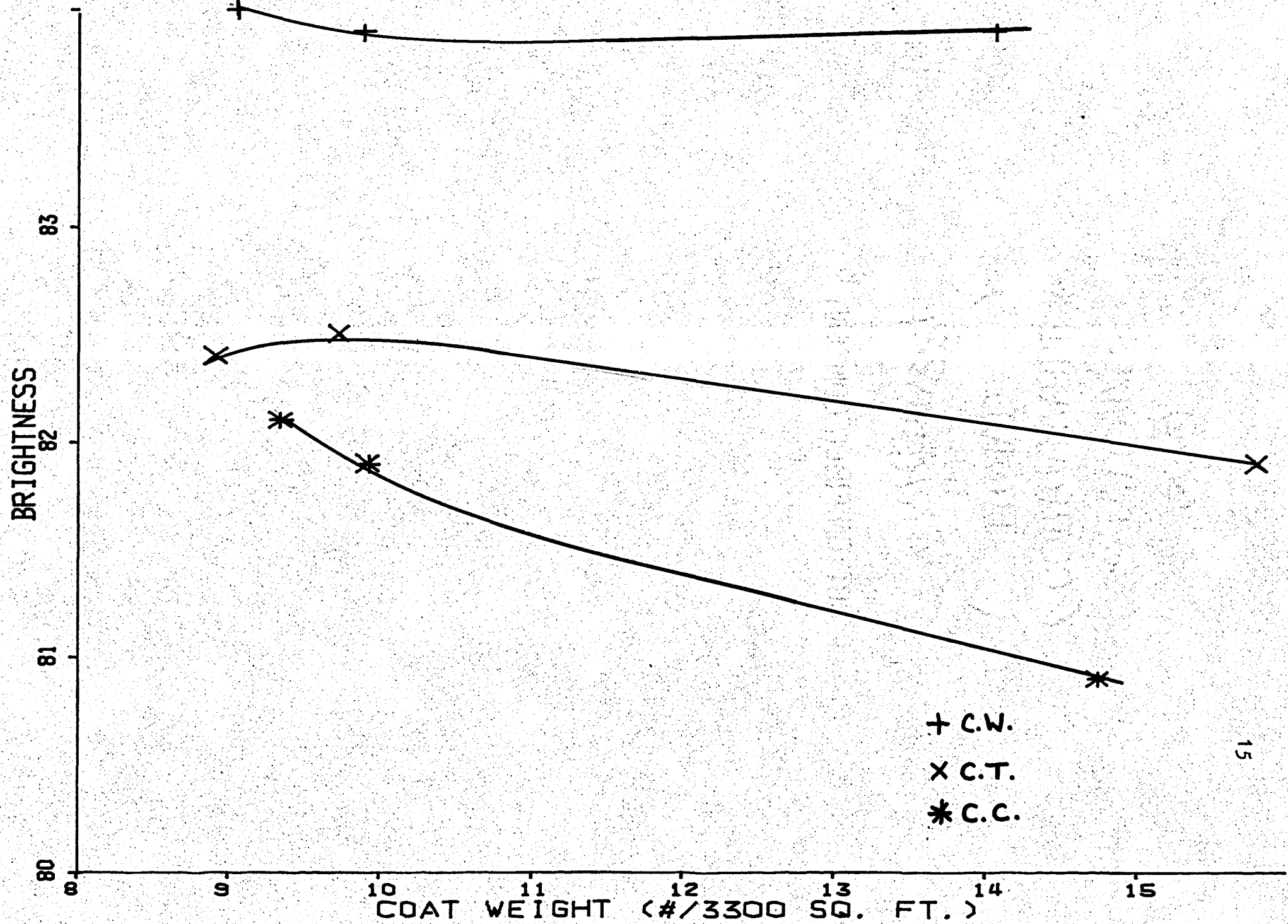


FIGURE 3-DEPENDANCE OF BRIGHTNESS ON AVE. PARTICLE SIZE

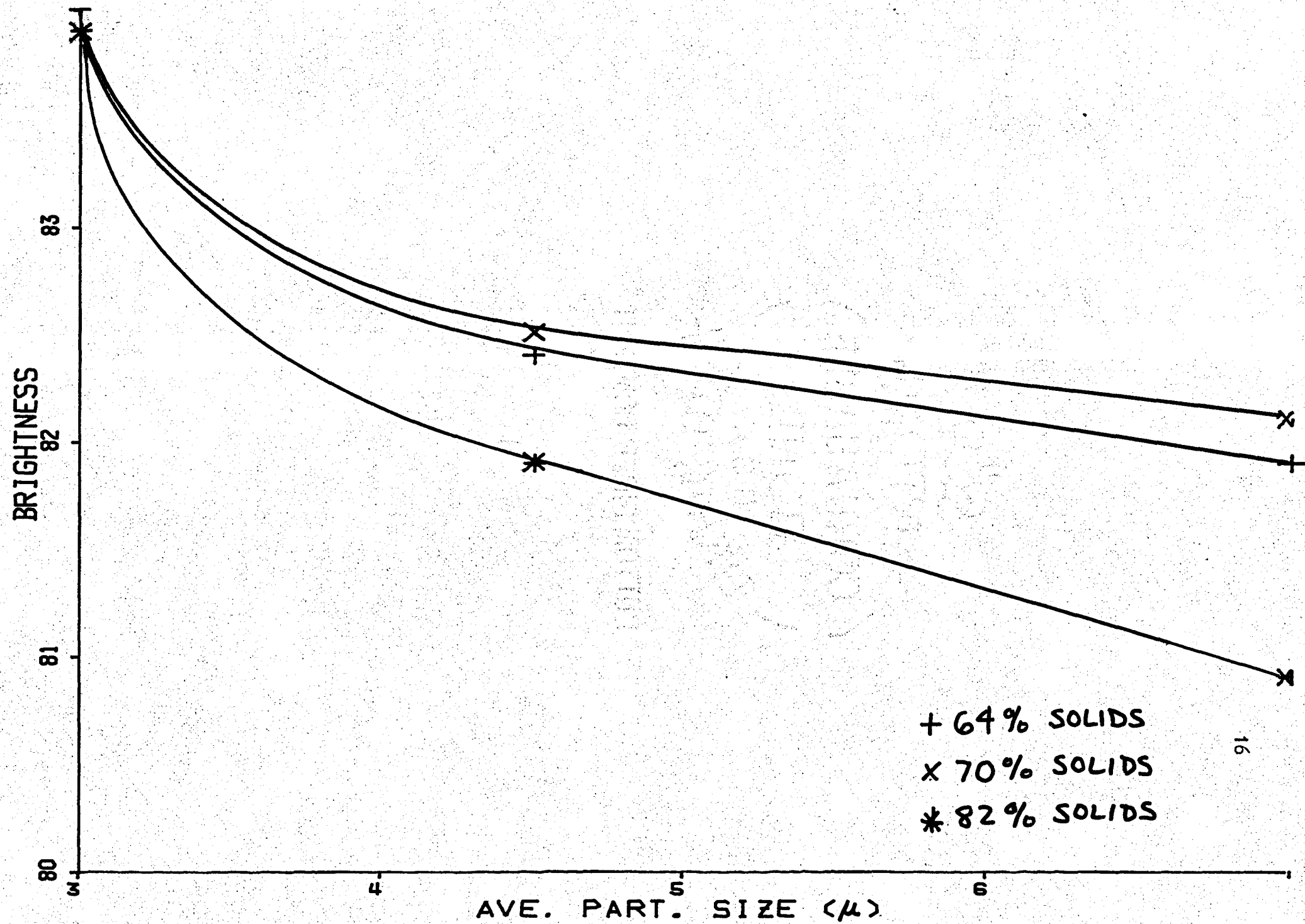




FIGURE 4-DEPENDANCE OF OPACITY ON SOLIDS LEVEL

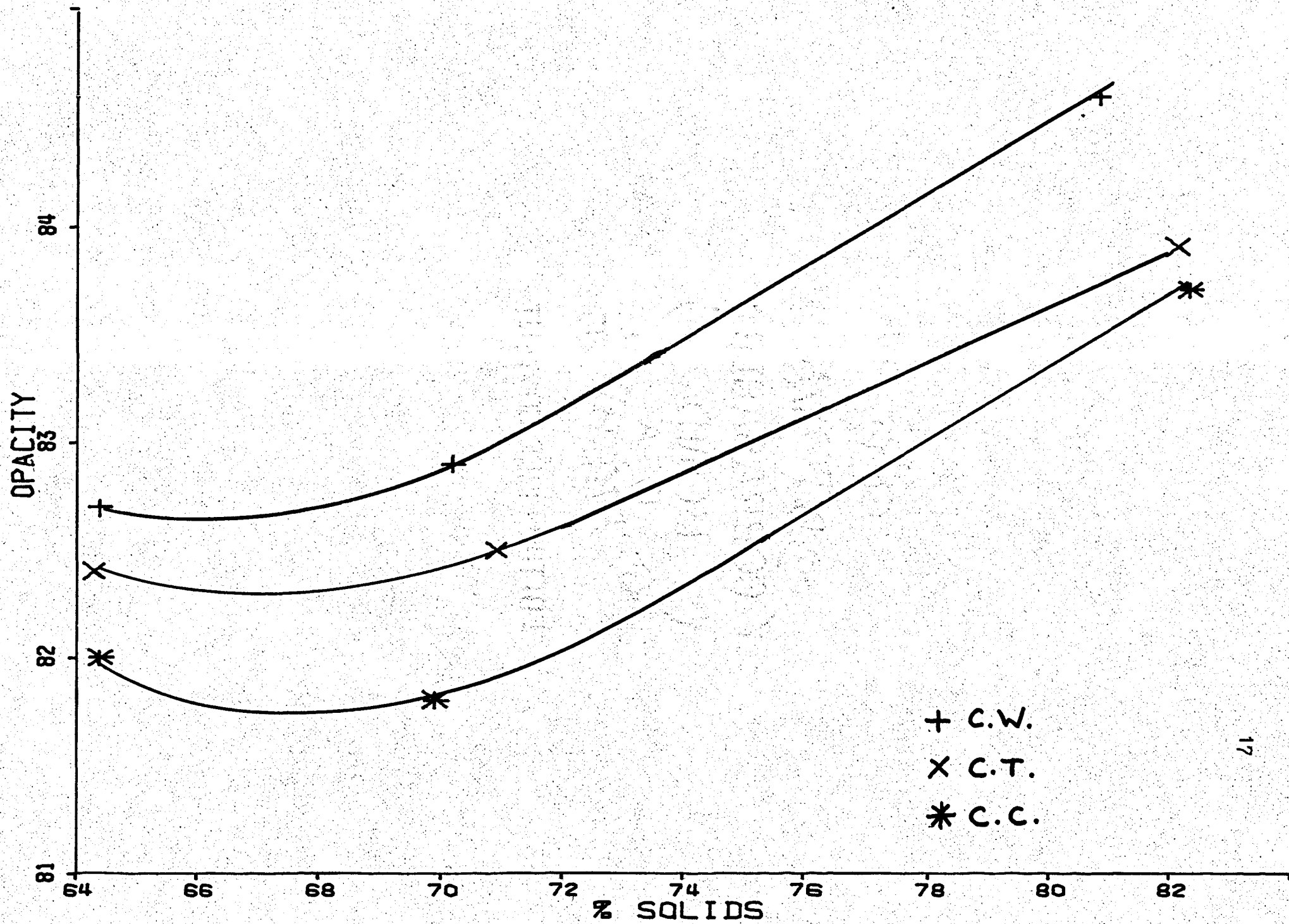


FIGURE 5-DEPENDANCE OF OPACITY ON COAT WEIGHT

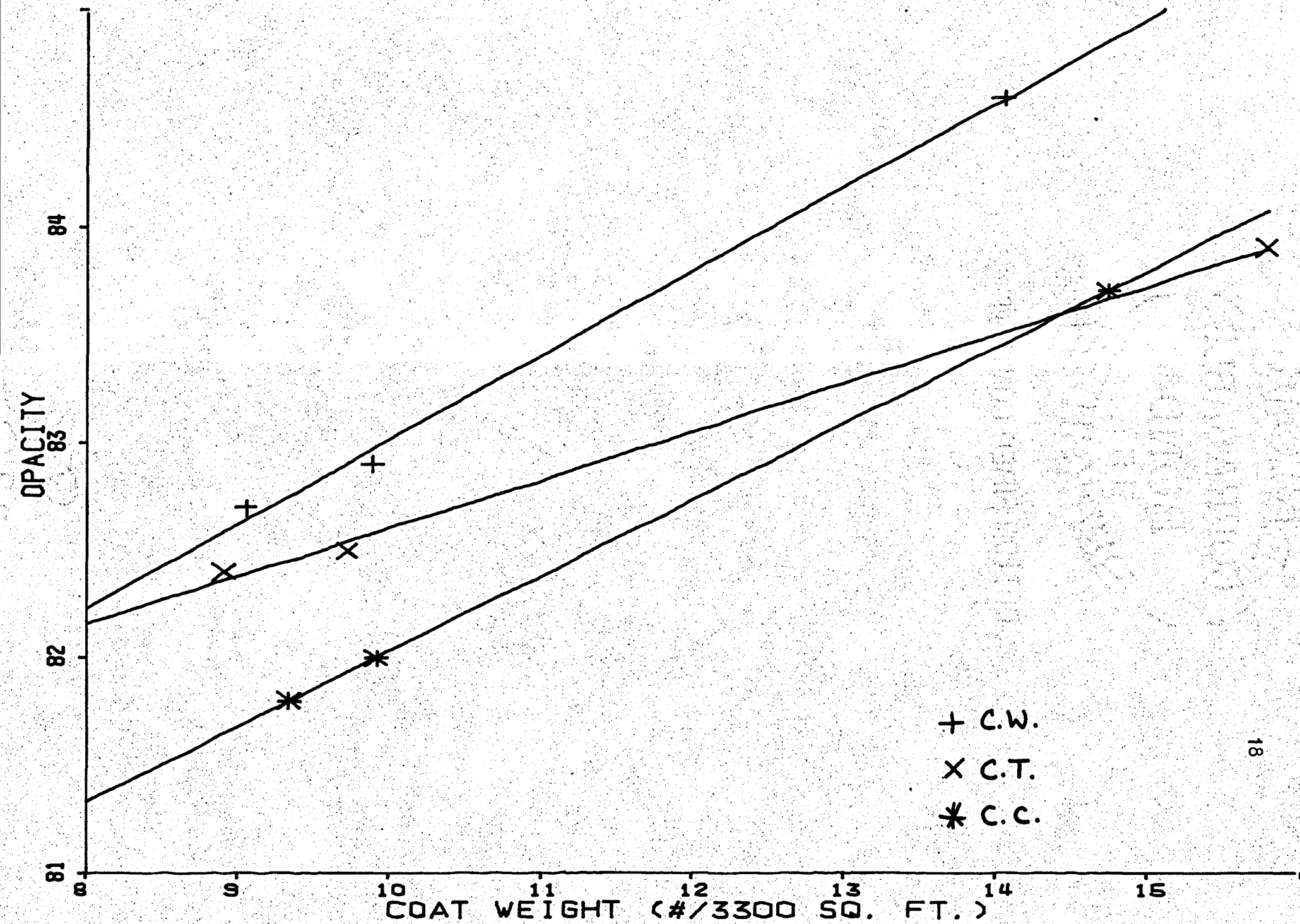
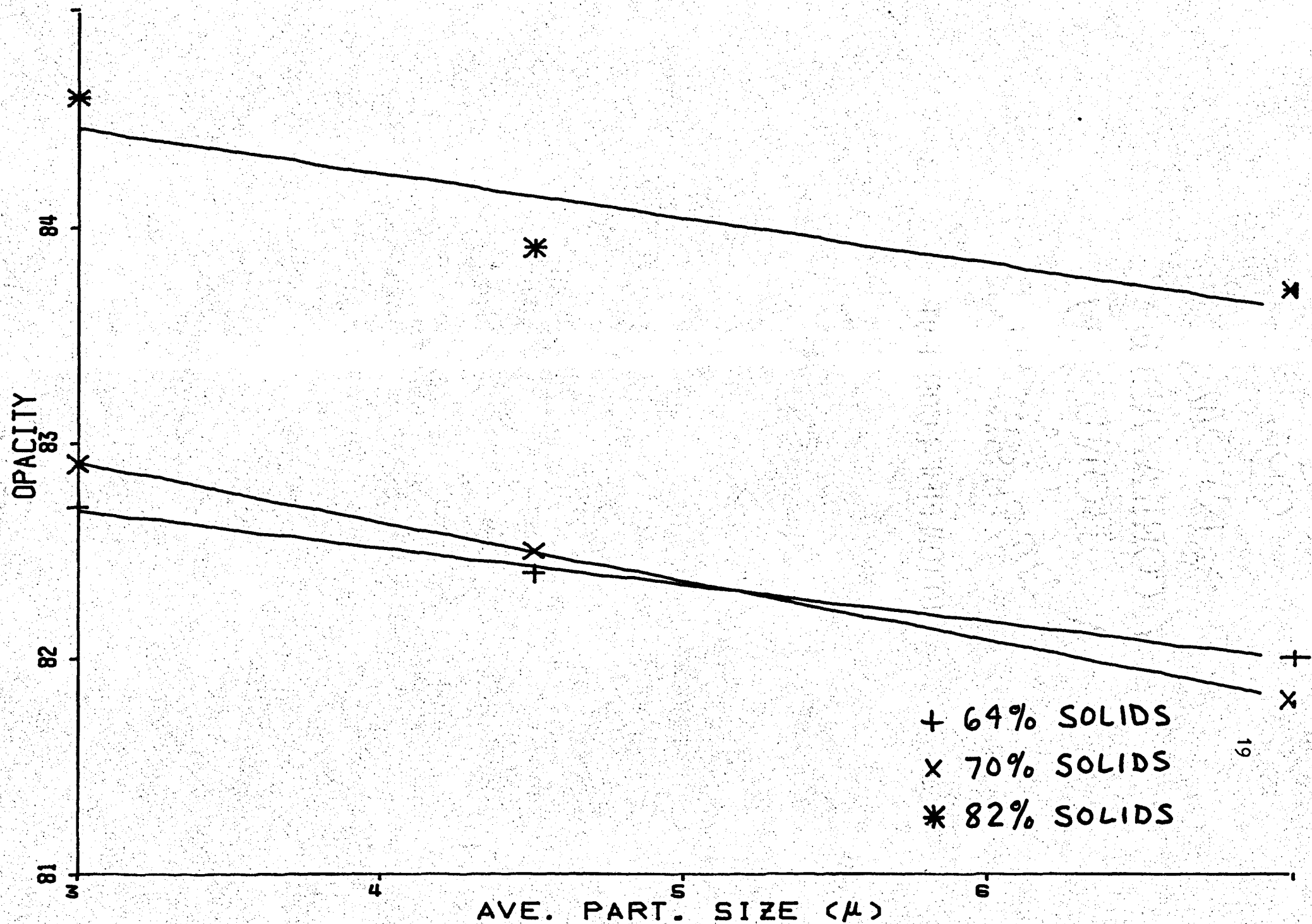


FIGURE 6-DEPENDANCE OF OPACITY ON AVE. PARTICLE SIZE



### Pick

Figures 7-9 demonstrate the dependence of pick strength on percent solids, coat weight, and the particle size of a coating. By comparing Figure 7 with Figure 8, it can be seen that both coat weight and percent solids have nearly equal positive effects on pick. Figure 9 shows a definite positive correlation between particle size and pick signifying that an increase in particle size yields a greater pick value. By increasing the solids content, coat weight, and pigment particle size of a coating, greater pick strength develops due to the minimization of binder migration and therefore lowering adhesive demand.

### K&N Ink

The ink receptivity of a coating is generally sensitive to the following factors: (1) The amount of adhesive present in the coating. (Excessive penetration of adhesive into the base stock during coating shows an increase in ink receptivity.) (2) The particle size and type of pigment. (The finer sized grades (carbonates) usually have better ink receptivity.)

Figures 10-12 show the effect of increasing the solids content, coat weight, and average particle size of the pigmented coatings, on ink receptivity. Figures 10 and 11 both exhibit negative relationships between solids content and coat weight with ink receptivity. The reason being that by increasing the solids fraction of a coating, less water is available for penetration into the substrate thereby leaving more adhesive in the coating layer which decreases the ink receptivity. Also, an increase in coat weight will prevent adhesive migration merely by increasing the physical distance in which the adhesive particles have to travel to reach the base stock. Figure 12

FIGURE 7-DEPENDANCE OF IGT PICK ON SOLIDS LEVEL

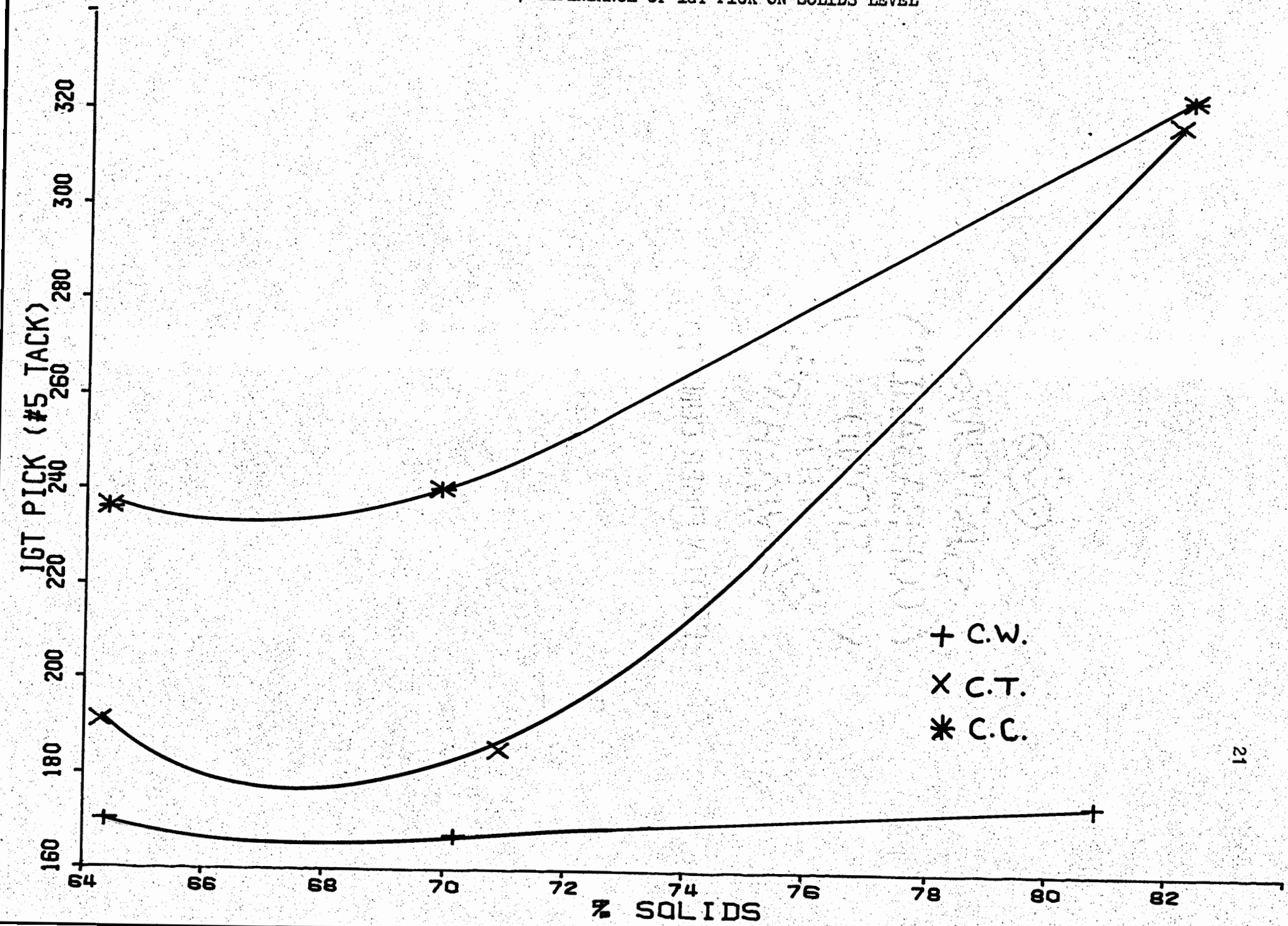


FIGURE 8-DEPENDANCE OF IGT PICK ON COAT WEIGHT

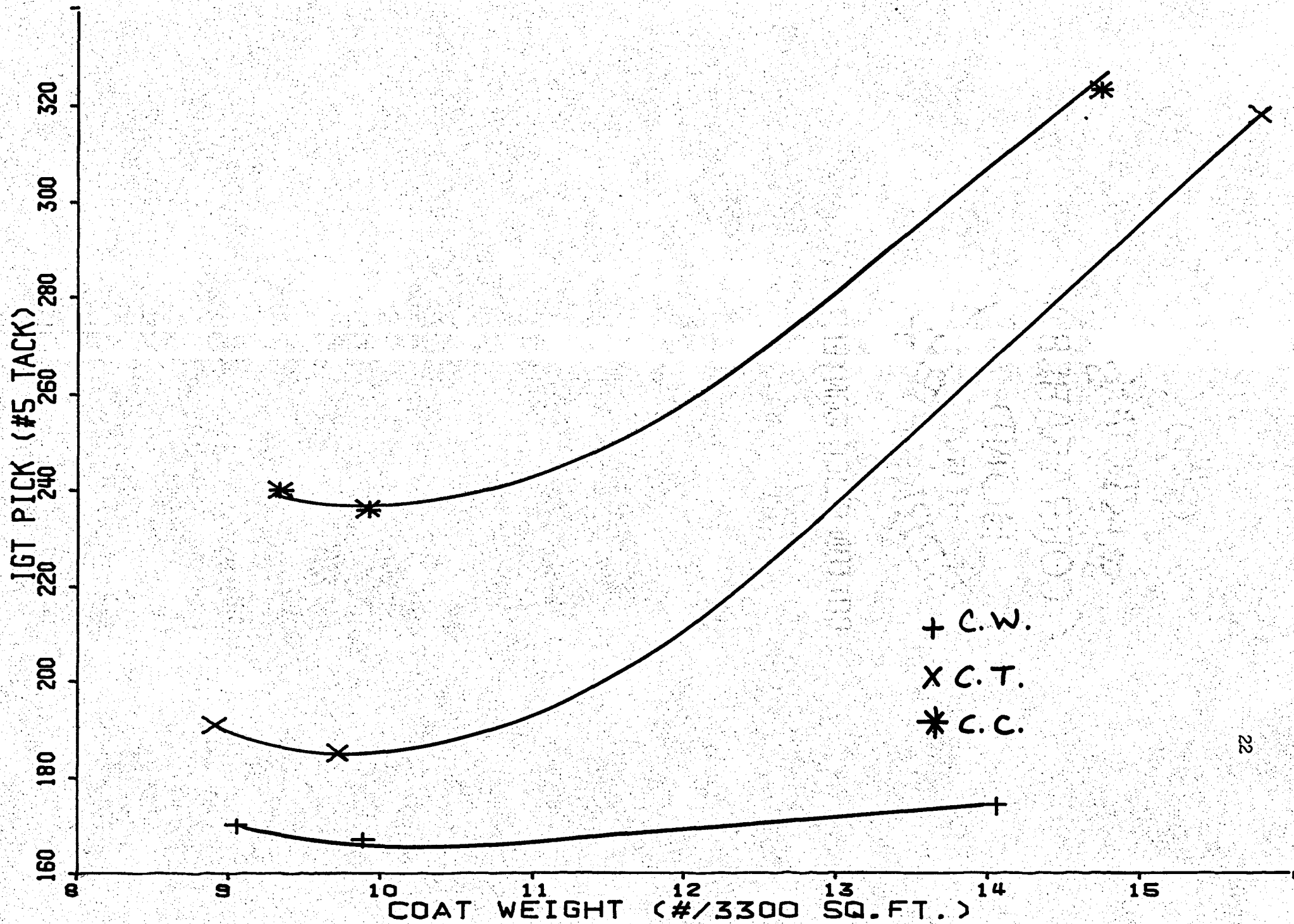


FIGURE 9-DEPENDANCE OF IGT PICK ON AVE. PARTICLE SIZE

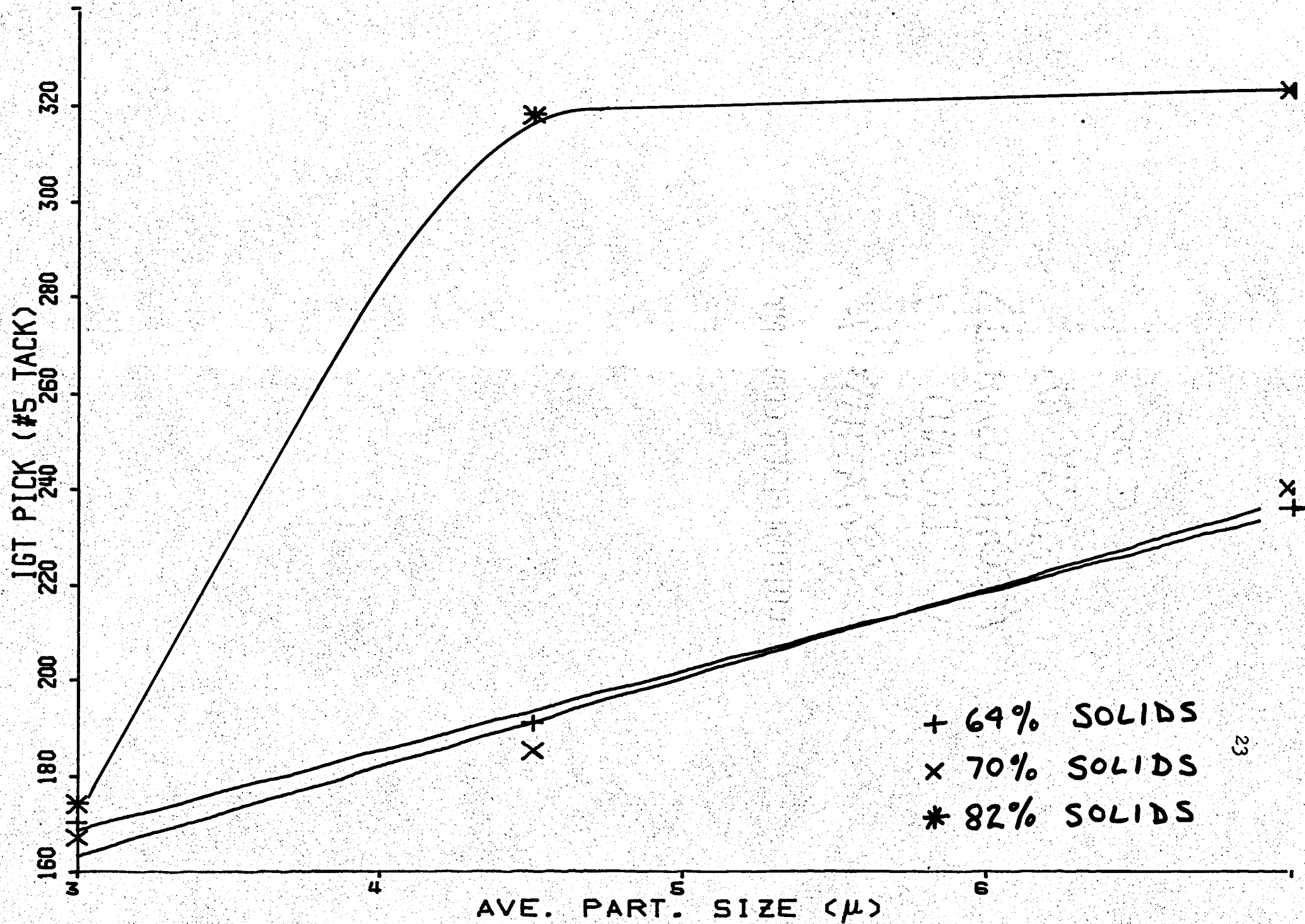


FIGURE 10-DEPENDANCE OF K&N INK ON SOLIDS LEVEL

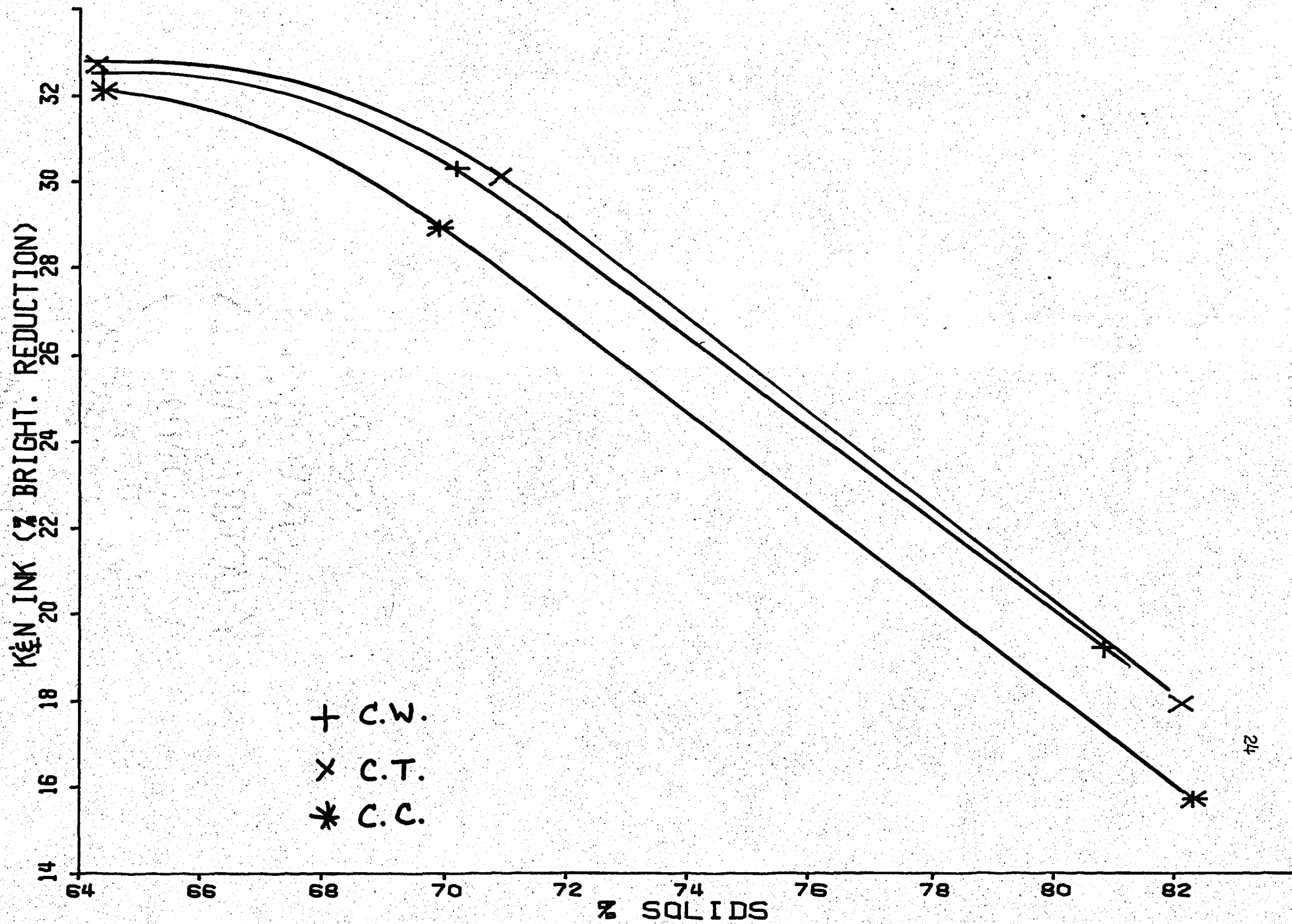




FIGURE 11-DEPENDANCE OF K&N INK ON COAT WEIGHT

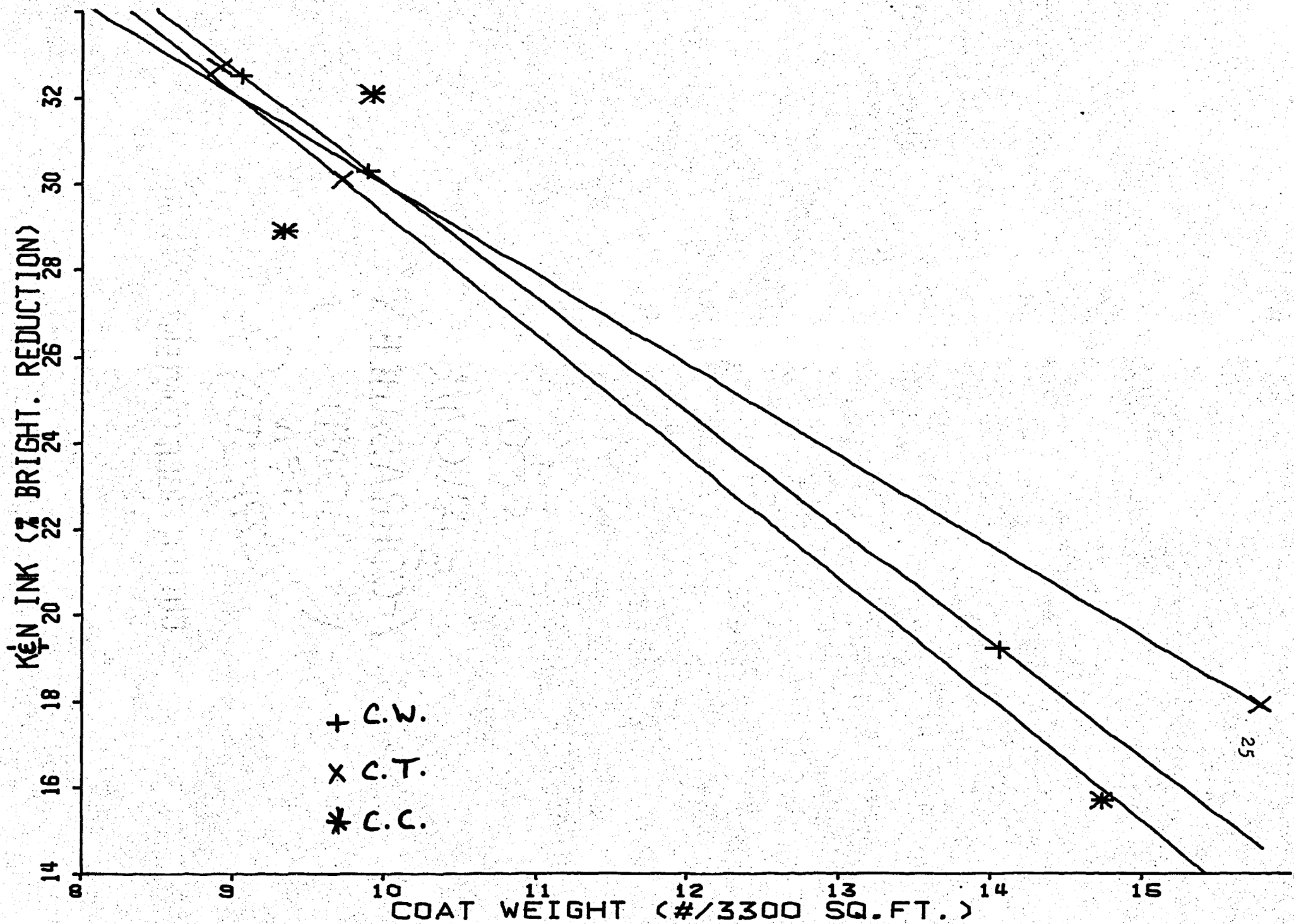
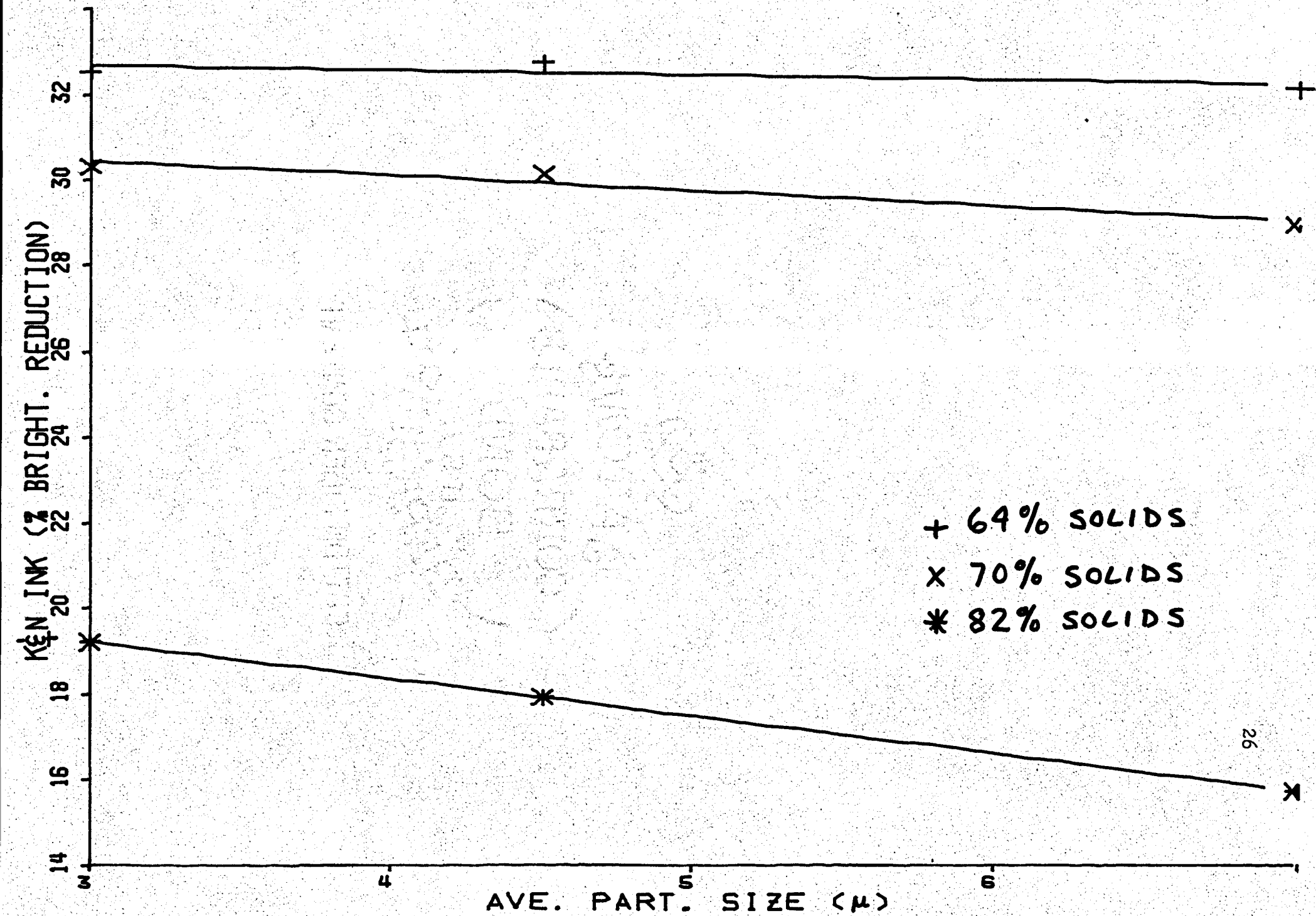


FIGURE 12-DEPENDANCE OF K&N INK ON AVE. PARTICLE SIZE



proves that there is little effect of the average particle size on the ink receptivity of the nine different coatings. There is also an excellent demonstration of the negative effect of increasing the solids content on ink receptivity, greatly signifying a reduction in binder migration.

#### Smoothness

Figures 13-15 depict the effects of increasing the percent solids, coat weight, and average particle size on smoothness. Figure 13 shows improvement in smoothness with increased solids content (better packing of particles) while Figure 14 reveals an increase in smoothness with an increase in coat weight (more pigment available for calendering action). Figure 15 demonstrates the expected reduction in smoothness by increasing the average particle size of the pigmented coatings.

#### Gloss

Figures 16-18 show the effects of increasing the solids content, coat weight, and average particle size on the developed gloss. Since gloss is a measure of optical smoothness, the diagramed gloss curves follow the same trends as smoothness. An increase in gloss is produced by an increase in the percent solids and coat weight, while an increase in the average particle size of carbonate, reduces gloss. It might also be noted here that gloss for all nine coatings was relatively low as expected, due to the high percentage of calcium carbonate present in the coatings.

FIGURE 14-DEPENDANCE OF SMOOTHNESS ON COAT WEIGHT

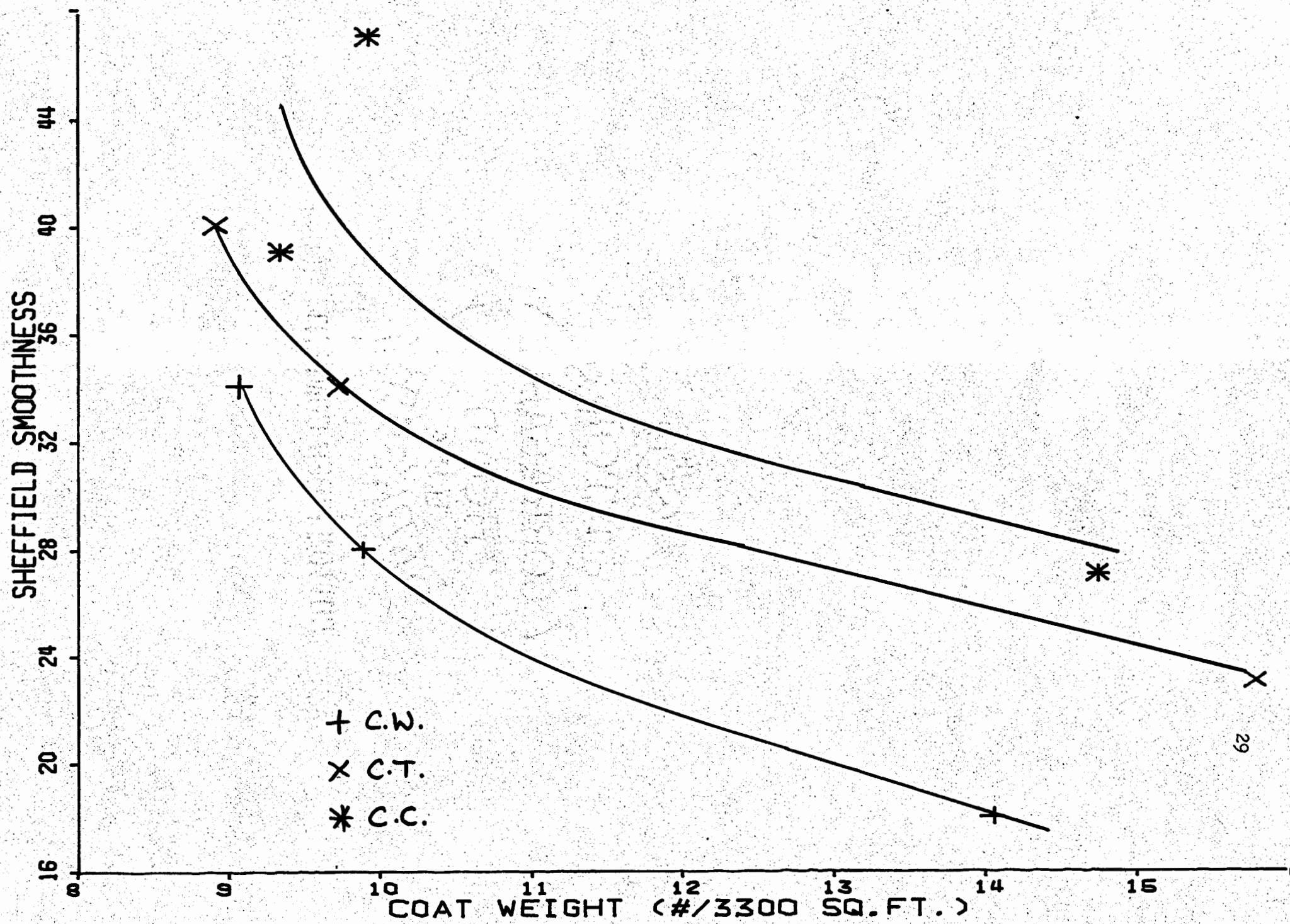


FIGURE 15-DEPENDANCE OF SMOOTHNESS ON AVE. PARTICLE SIZE

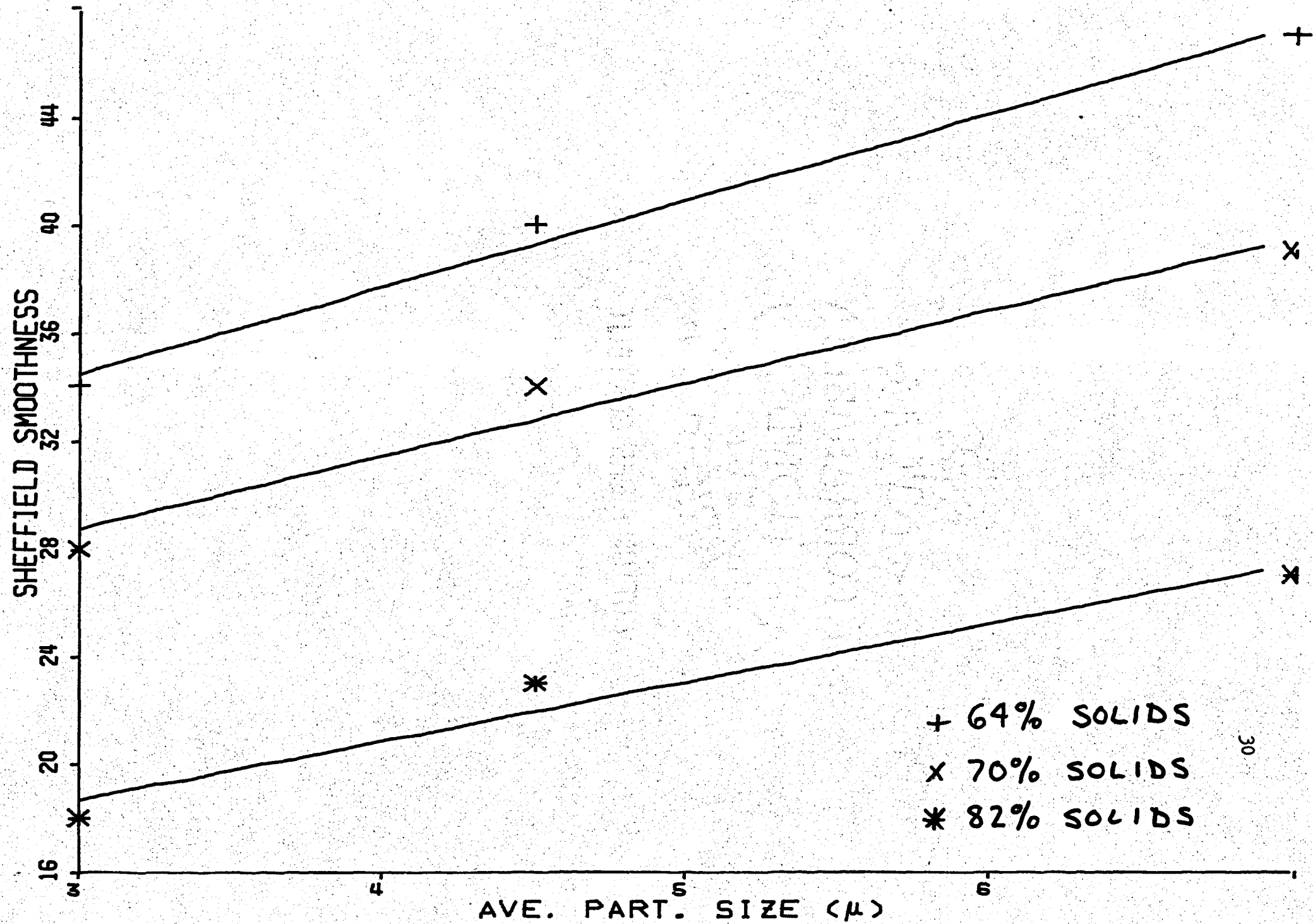
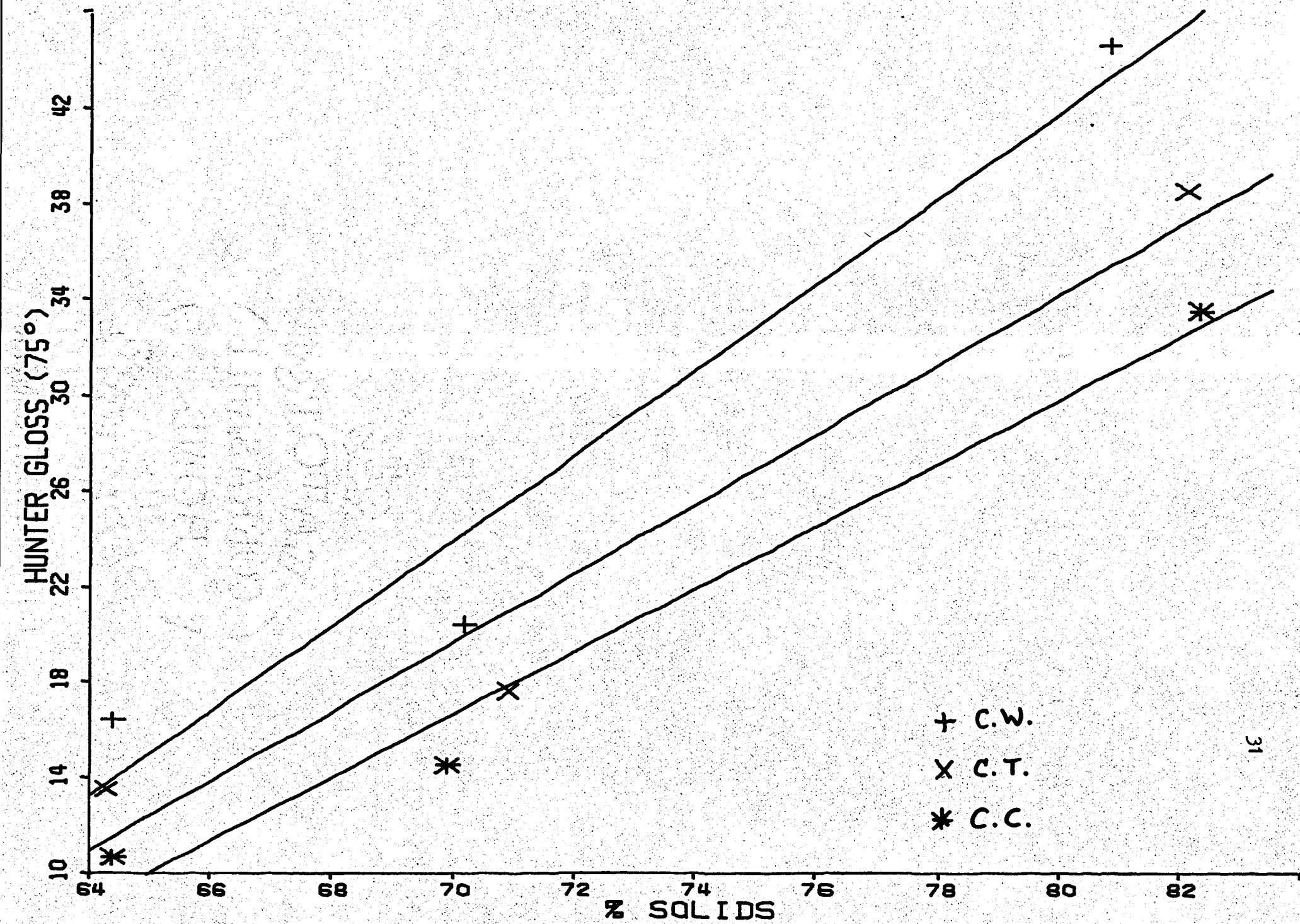
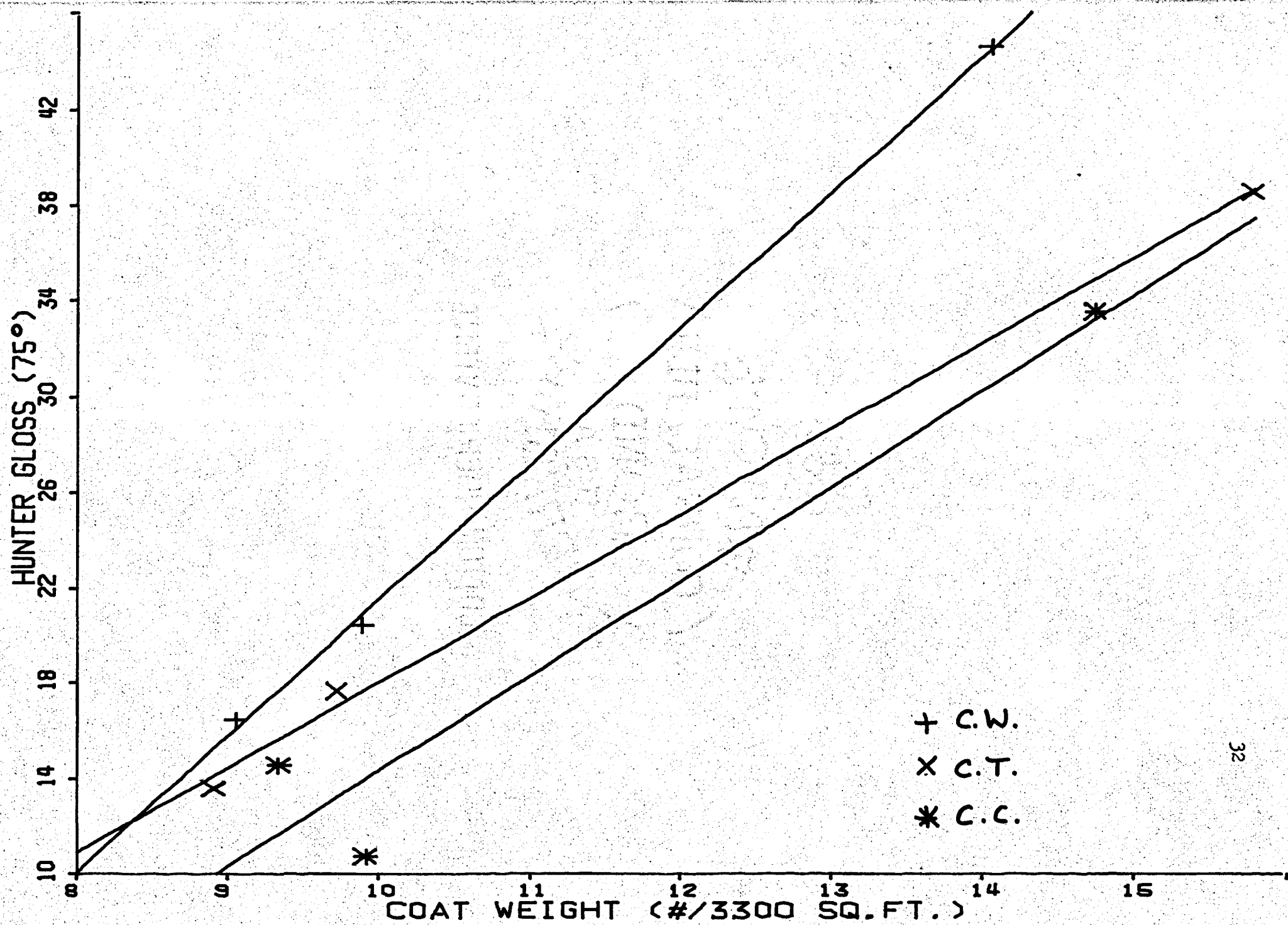
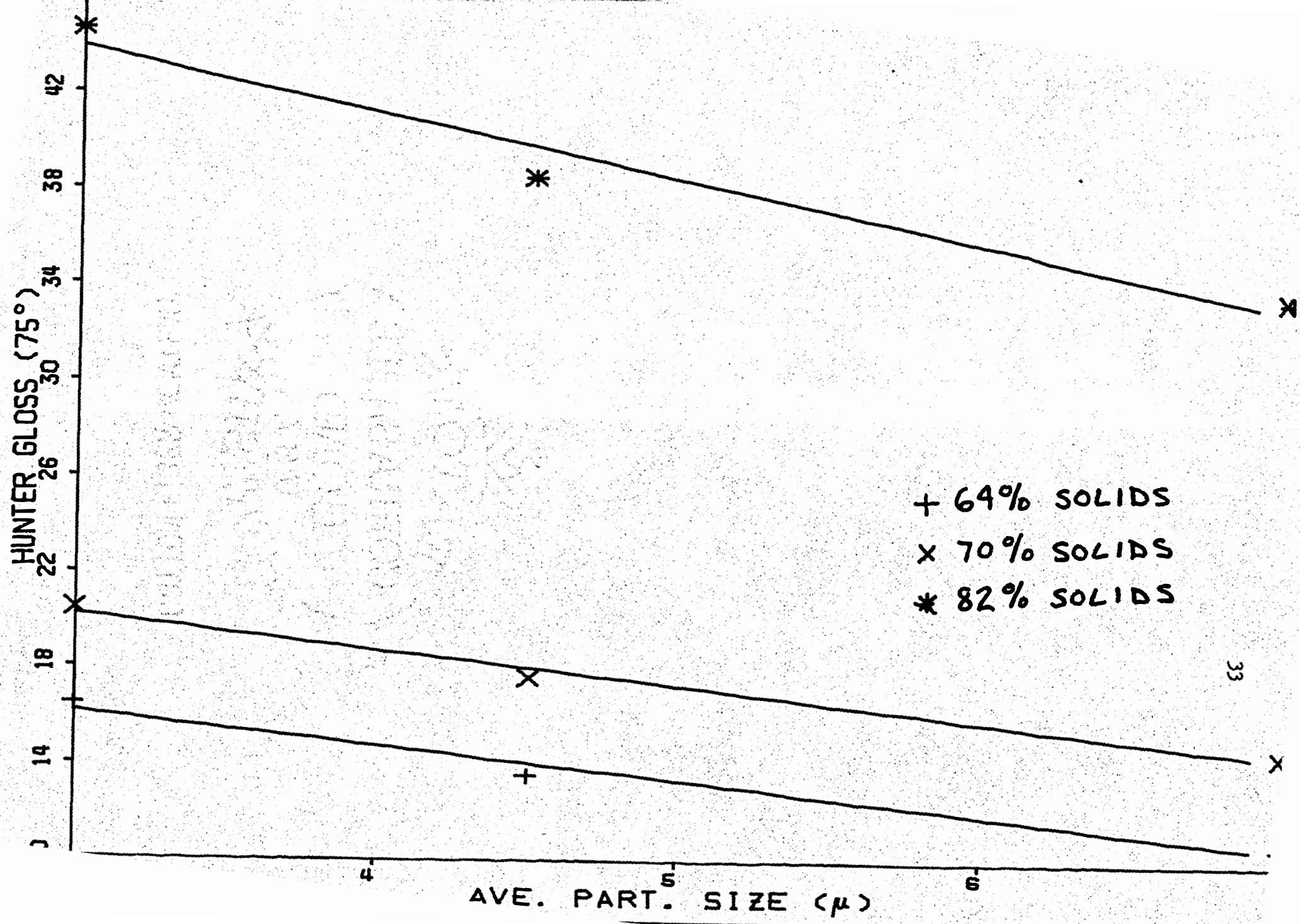


FIGURE 16-DEPENDANCE OF GLOSS ON SOLIDS LEVEL









## CONCLUSIONS

1. Ultrahigh-solid coatings with the proper rheology for use on a blade coater are possible with a minimum amount of blade scratching involved.  
Binder migration is apparently lowered by using an ultrahigh-
3. Water retention of an ultrahigh-solids coating is possible without the aid of a hydrocolloid.
4. There are problems in obtaining low coat weights (less than 12#/3300 ft<sup>2</sup>) when using an ultrahigh-solids coating.
5. The incorporation of half the water associated with the latex in the dispersion of the pigment, apparently did not decrease (shear) the adhesive potential of the latex.
6. Ultrahigh-solid coatings (containing clay and carbonate) yield many desirable finished qualities such as: brightness, opacity, pick strength, ink receptivity, and smoothness, but, sustain relatively poor gloss.

## SUGGESTIONS FOR FURTHER WORK

1. Experimentation with other clay to carbonate ratios and different lattices while observing the rheological as well as finished coating properties produced.
2. Expanded study of increased coater speeds on the rheological properties of an ultrahigh-solids coating at the blade tip.
3. Attempt to determine the minimum amount of drying needed for an ultrahigh-solids coating as compared to a typical commercial coating solids.
4. Study variations necessary in the calendering operations of ultrahigh-solid coatings (containing clay and carbonate) with the purpose of improving gloss.

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## APPENDIX I

FIGURE 19-DEPENDANCE OF VISCOSITY ON PIGMENT COMPOSITION INVOLVING CAMEL-WITE

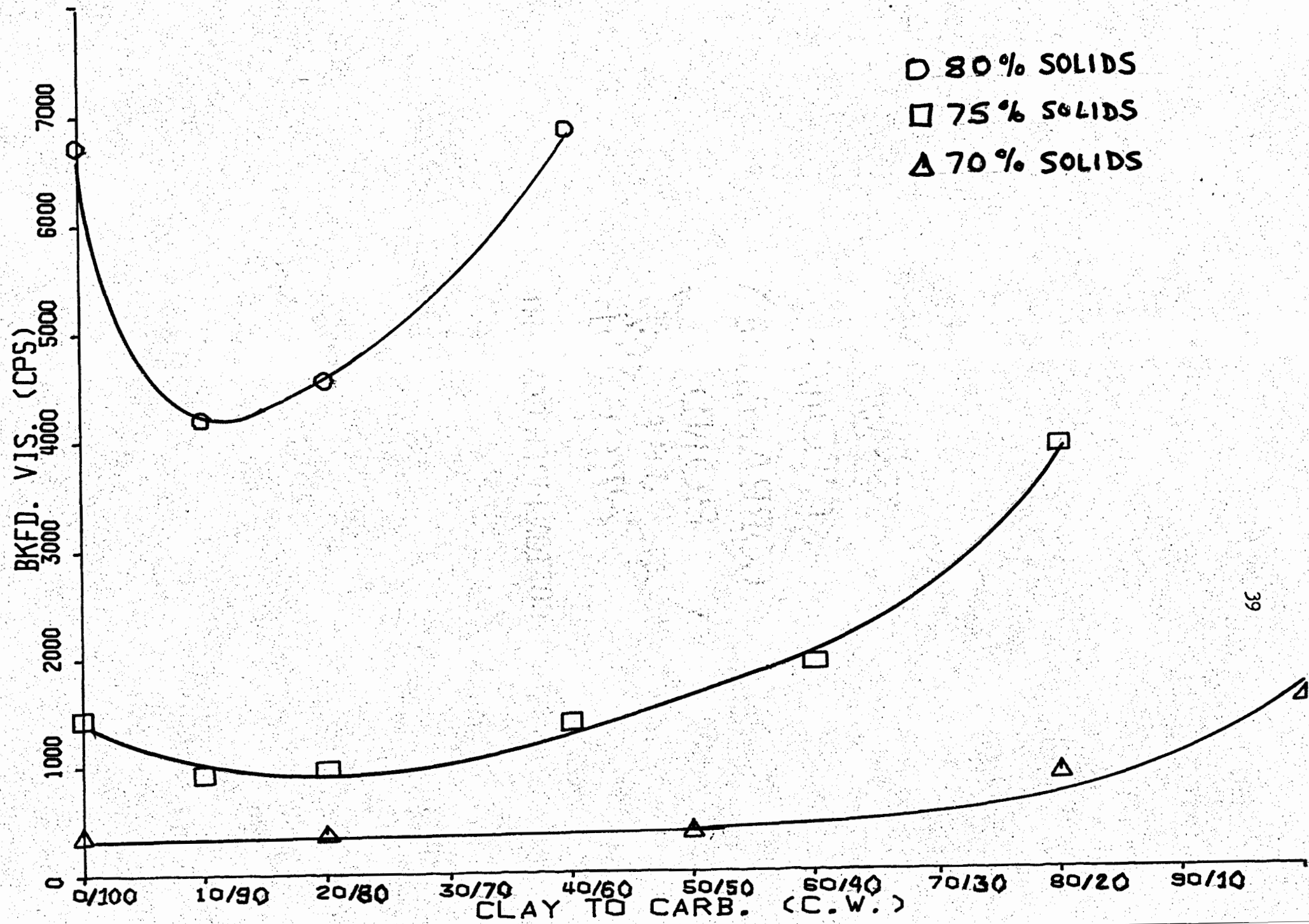


FIGURE 20-DEPENDANCE OF VISCOSITY ON PIGMENT COMPOSITION INVOLVING CAMEL-TEX

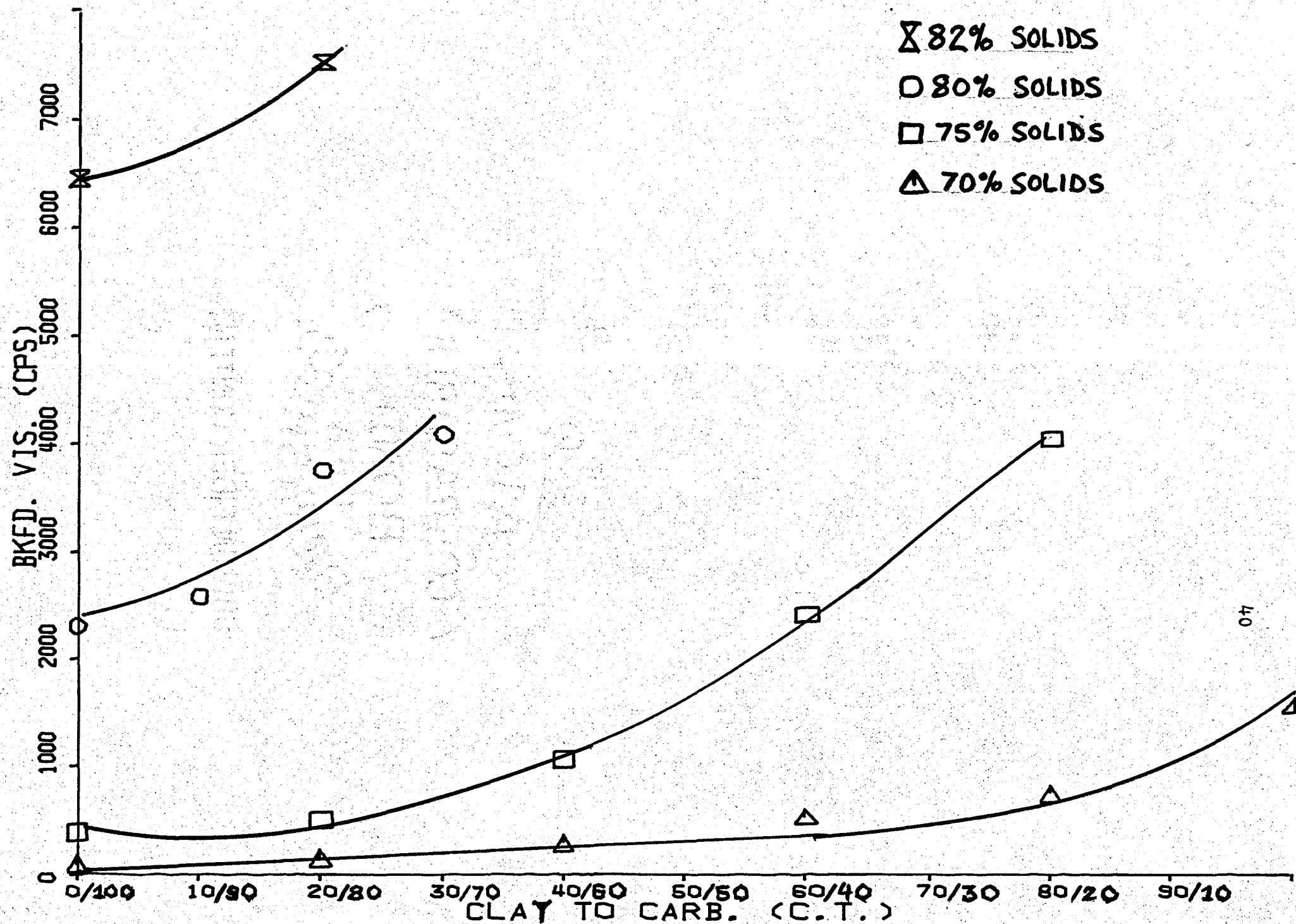


FIGURE 21-DEPENDANCE OF VISCOSITY ON PIGMENT COMPOSITION INVOLVING CAMEL-CARB

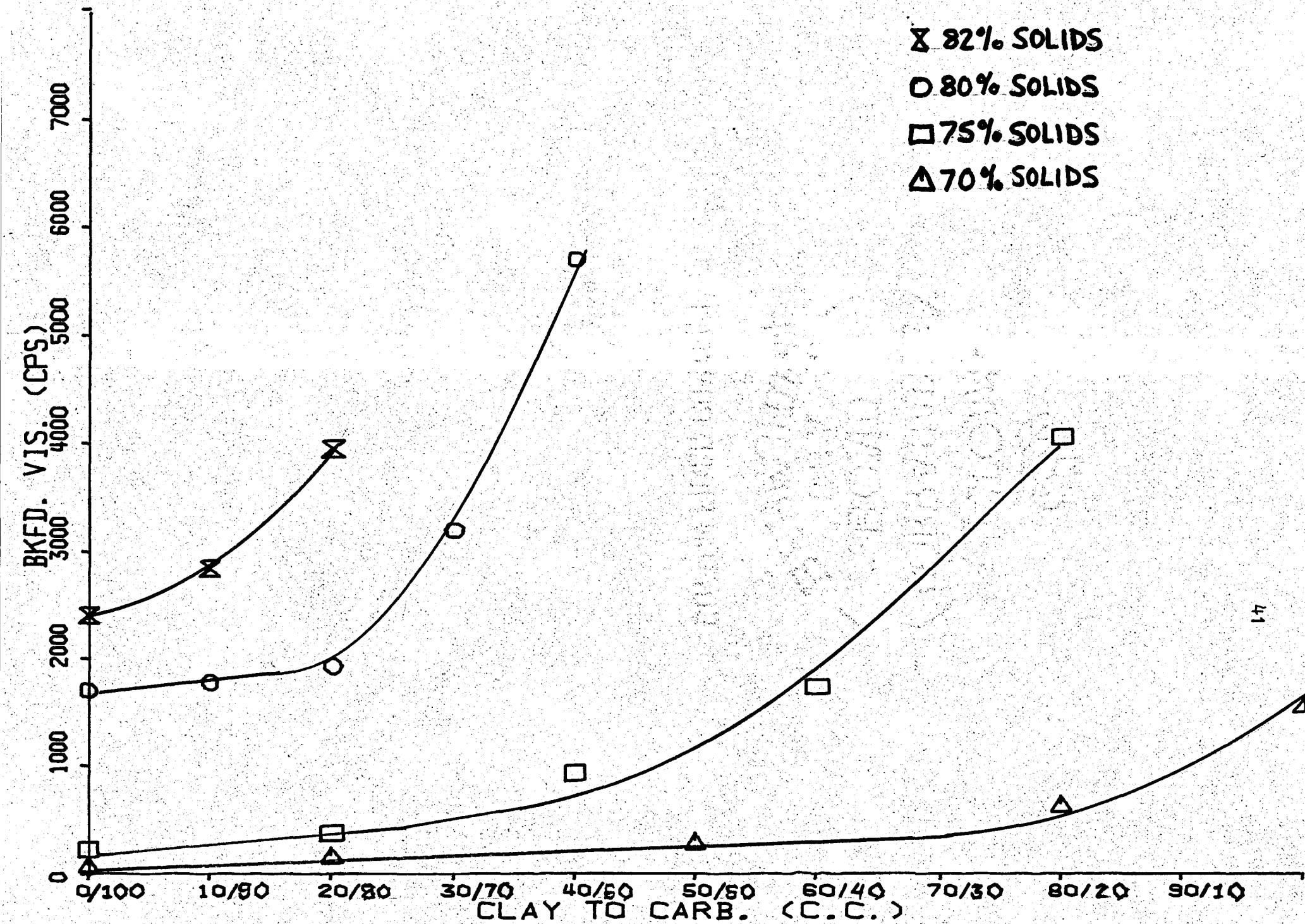




FIGURE-22--EXAMPLE OF THE PROGRESSION OF HERCULES HIGH SHEAR RHEOGRAMS  
FOR COATINGS CONTAINING DIFFERENT CLAY TO CARBONATE RATIOS  
(SEE TABLE IV (p. 48) FOR CURVE DESCRIPTIONS)

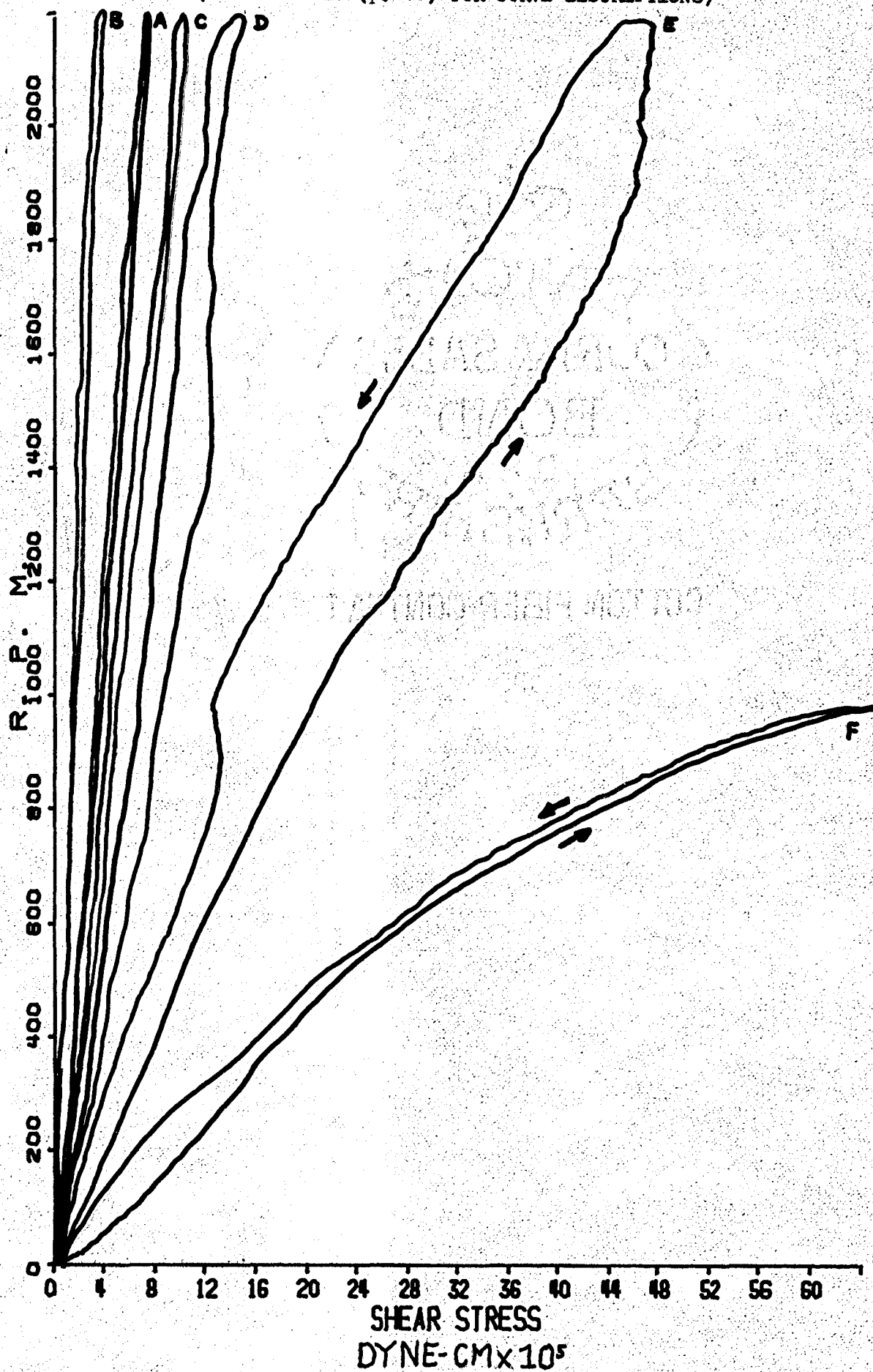


TABLE II  
COATER TRIAL COATING FORMULATIONS\*

	Camel-Wite			Camel-Tex			Camel-Carb		
Clay (parts)	25	25	25	25	25	25	25	25	25
CaCO <sub>3</sub> (parts)	75	75	75	75	75	75	75	75	75
TSPP/Calgon-T (25 pts/75 pts)	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%
Kelgin Q**	0.58%	0.28%	--	0.68%	0.38%	--	0.67%	0.35%	--
Latex (.48%)(parts) (Dow 640)	12	12	12	12	12	12	12	12	12
Defoamer (ml)	2	2	2	2	2	2	2	2	2
Water (parts)	63	48	28	63	48	26.3	63	48	24.6
Calculated Solids Level	64%	70%	80%	64%	70%	81%	64%	70%	82%
Bkfd. Vis. (cps) #5 spindle @100 rpm	1178	1102	968	1677	1838	1457	1924	1686	1696
Determined Solids Level	64.4%	70.2%	80.8%	64.3%	70.9%	82.1%	64.4%	69.9%	82.3%

\*All calculations based on 100 parts dry pigment.

\*\*Experimentally determined values.

TABLE III

## COAT WEIGHT DETERMINED BY BLADE PRESSURE VARIATION

<u>Carbonate *</u> <u>Type</u>	<u>Solids</u> <u>Level</u>	<u>Blade Pressure</u> <u>(psi)</u>	<u>Coat Weight</u> <u>(#/3300 ft<sup>2</sup>)</u>
C.W.	64%	1	8.71
		2	9.05
		3	8.54
C.W.	70%	1	11.97
		2	10.38
		3	9.89
C.W.	80%	20	14.04
		22	13.43
		24	12.11
C.T.	64%	1	10.51
		2	8.91
		3	8.00
C.T.	70%	1	11.49
		2	9.71
		3	9.03
C.T.	81%	20	16.32
		22	15.77
		24	12.41
C.C.	64%	1	10.96
		2	9.91
		3	8.40
C.C.	70%	1	12.82
		2	10.72
		3	9.33
C.C.	82%	20	16.52
		22	16.40
		24	14.72

\*Camel-Wite (C.W.)  
 Camel-Tex (C.T.)  
 Camel-Carb (C.C.)

FIGURE-23--HERCULES HIGH SHEAR RHEOGRAMS FOR COATINGS  
INVOLVING CAMEL-WITE IN COATER DEMONSTRATION

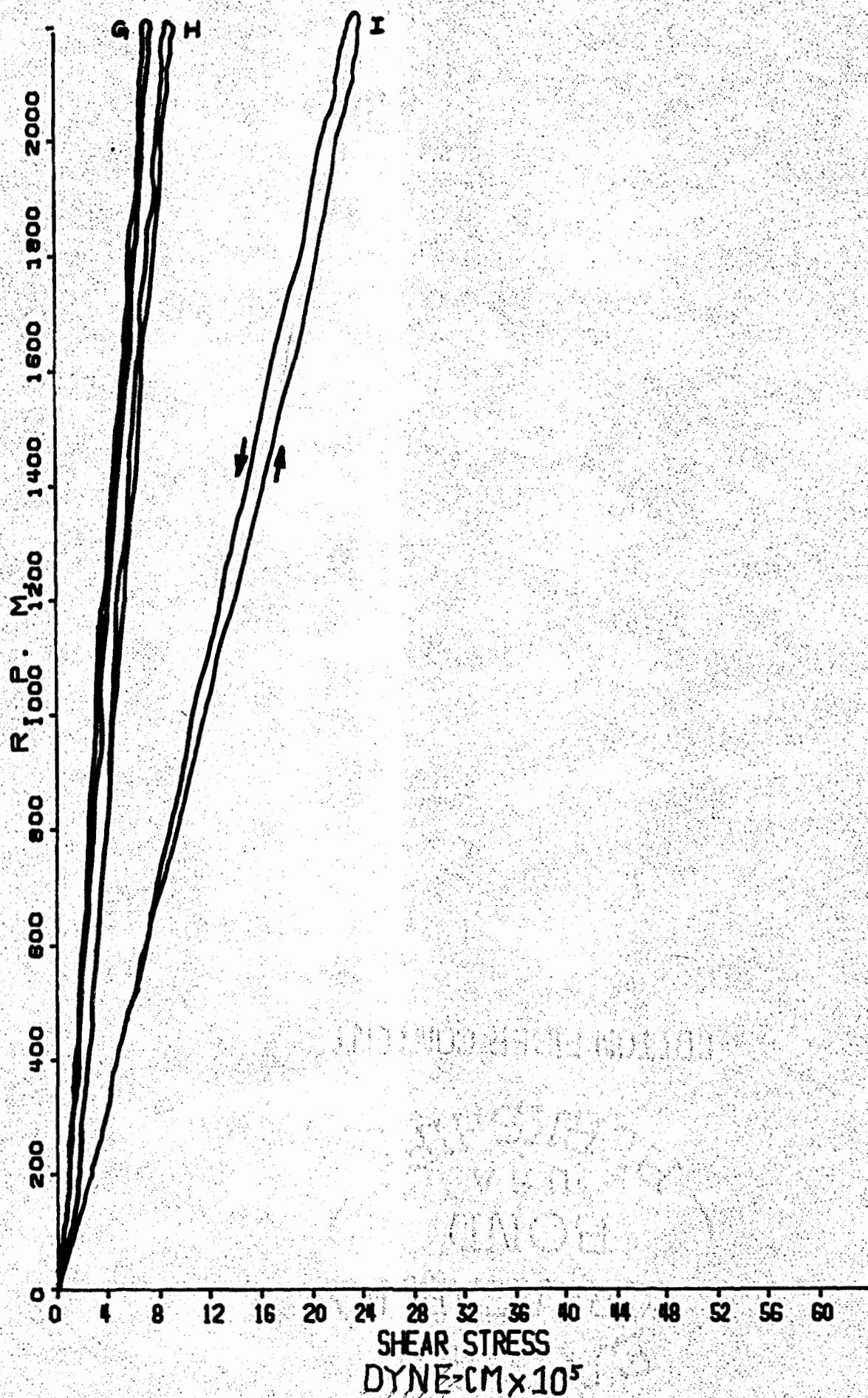


FIGURE-24--HERCULES HIGH SHEAR RHEOGRAMS FOR COATINGS  
INVOLVING CAMEL-TEX IN COATER DEMONSTRATION

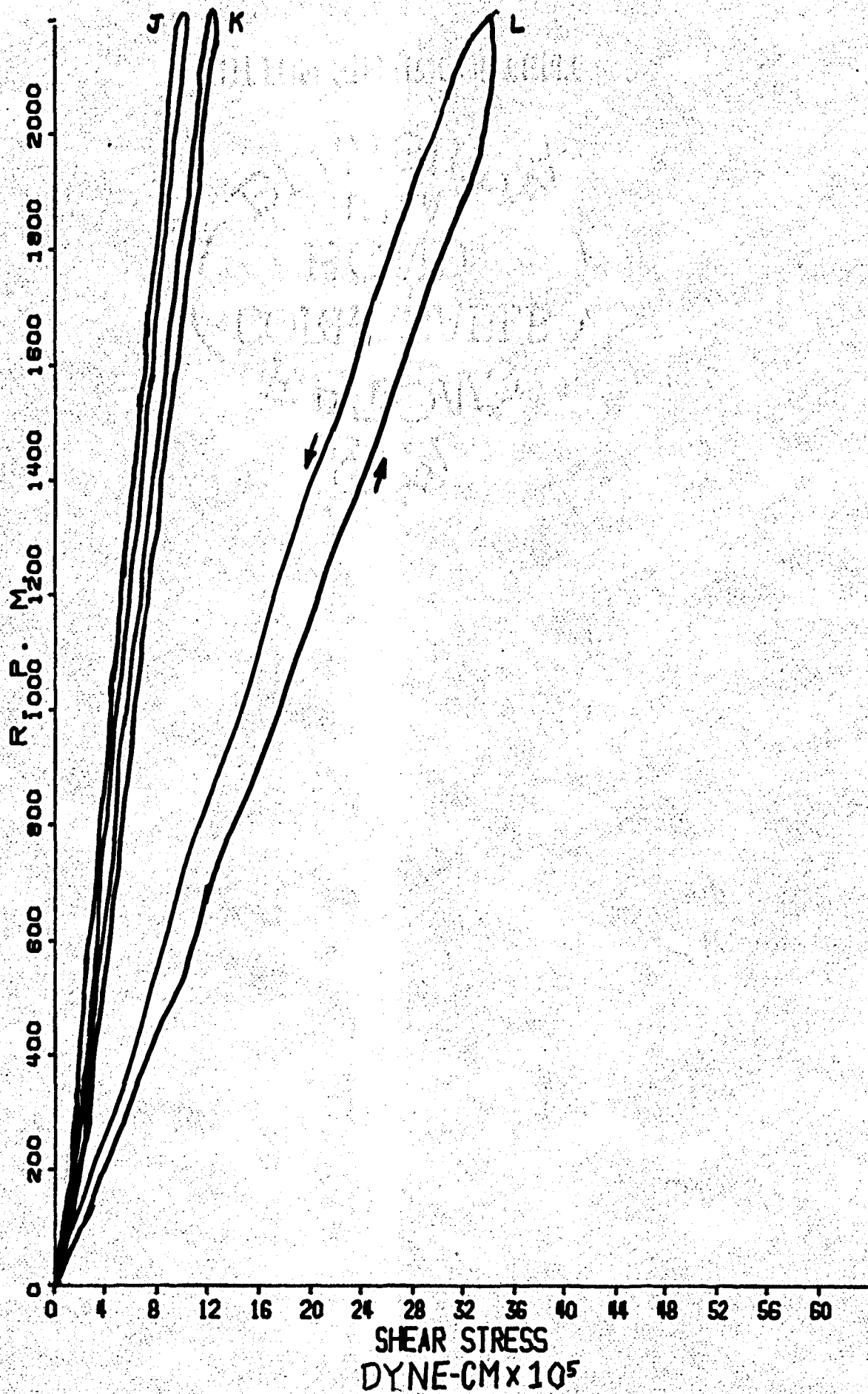


FIGURE-25--HERCULES HIGH SHEAR RHEOGRAMS FOR COATINGS  
INVOLVING CAMEL-CARB IN COATER DEMONSTRATION

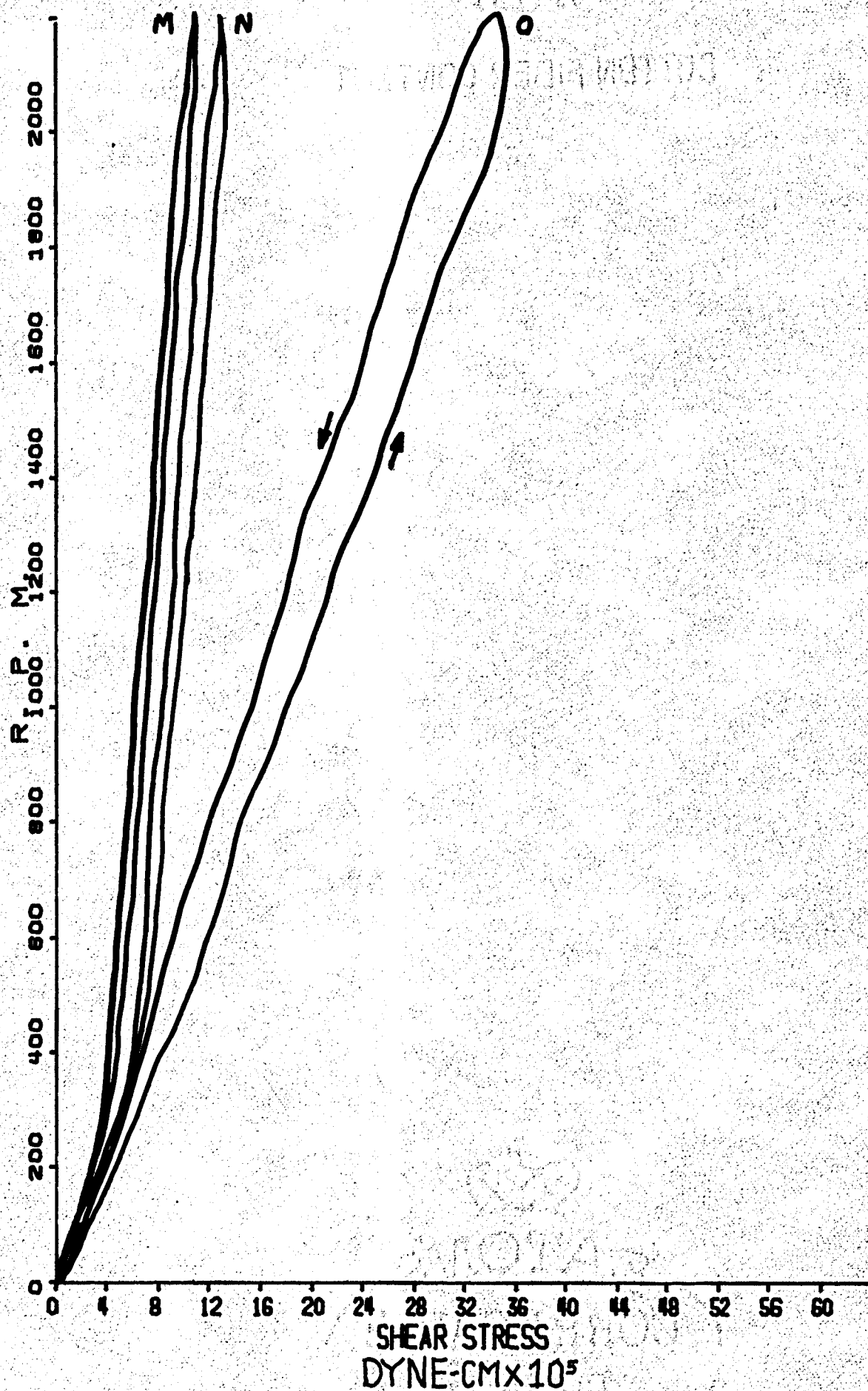




TABLE IV\*

SPECIFIC QUANTITIES ASSOCIATED WITH  
CURVES A-O IN FIGURES 22-25

<u>Curve</u>	<u>Parts clay/ parts carb.</u>	<u>Description</u>	<u>Bkfd. vis. (cps) (#5 spin. @ 100 rpm)</u>	<u>High shear vis. (cps @ 2200 rpm)</u>
A	0/100	(C.W. @ 75% T.S.)	1434	64
B	10/90	(C.W. @ 75% T.S.)	924	61
C	20/80	(C.W. @ 75% T.S.)	964	82
D	40/60	(C.W. @ 75% T.S.)	1382	132
E	60/40	(C.W. @ 75% T.S.)	1914	458
F	80/20	(C.W. @ 75% T.S.)	3898	dilatant
G	25/75	(C.W. @ 64.4% T.S.)	1178	64
H	25/75	(C.W. @ 70.2% T.S.)	1102	78
I	25/75	(C.W. @ 80.8% T.S.)	968	205
J	25/75	(C.T. @ 64.3% T.S.)	1677	88
K	25/75	(C.T. @ 70.9% T.S.)	1838	111
L	25/75	(C.T. @ 82.1% T.S.)	1457	302
M	25/75	(C.C. @ 64.4% T.S.)	1924	96
N	25/75	(C.C. @ 69.9% T.S.)	1686	109
O	25/75	(C.C. @ 82.3% T.S.)	1696	299

\* All rheograms were obtained using the A Bob and a speed factor of 2200 rpm.

All curves (A-O) are calibrated to a Torque of  $1 \times 10^5$  dyne-cm.