CRUDE PALM OIL CLARIFICATION BY THREE PHASE DECANTING CENTRIFUGE: STEADY AND DYNAMIC STATE MODELLING

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ABSTRACT

The quality control performance of the three phase decanting centrifuge was determined using statistical process control techniques. Individual X-charts of feed components: oil, water and solids indicated that these inputs were tending towards positive instability resulting in an overall fourth order polynomial time instability of the oil light phase and decreasing oil composition in the light, heavy and solid phases. This confirms that the settling tank performance was highly variable causing severe quality control deviations in the centrifuge outputs. These disturbances are then transmitted via the output streams to the adjoining units such as sludge tank, oil tank and eventually to the separators. This is in contrast with the role of the settling tank which is to compact the solids and to buffer out outflow deviations.

INTRODUCTION

Decanting centrifuges (scroll type) were used in crude palm oil clarification since 1976 to help the milling operation in reducing the oil losses leaving the system while capturing the solids to reduce the organic load in the effluent ponds. Several trials have been conducted to evaluate the performance of this centrifuge (Mohamad S. et.al., 1987, Southworth A., 1985) Most of the works were focussed in the the monitoring of the total oil losses in the outlet streams and compared the figures with the total oil losses that were obtained from the conventional system (without the decanting centrifuge). Published research report indicated that substantial oil losses reduction were achieved by installing the centrifuge with appropriate configurations. Nevertheless, oil losses figures alone are insufficient to describe the actual performance of the centrifuge without considering the dynamic behaviour of the machine since the process was subjected to the input variations (Mohamad S.,1988). In this study an attemp was made to perform both steady-state and dynamic state modelling in order to describe the performance of the decanting centrifuge separating the oil, water and solids from crude palm oil slurry.

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Steady-state model was developed using simultaneous modular matrix method for oil, water and solids which then is used to predict the outputs, inputs and stream flowrates under steady- state conditions. The quality control of the centrifuge was determined using statistical process control techniques whereby individual X-charts of feed components were analysed for their stability. Furthermore regression analysis was done on the feed components with respect to the output stream components to establish relevant relationships.

RESULTS AND DISCUSSIONS

An example of process flow diagram for crude palm oil clarification using decanting centrifuge is shown in figure 1 and the process flowsheet is given in table 1. Stream and component flowrates were obtained after assigning values in the second last column of individual matrixes and performing matrix operation. Simulated results indicate that only 96.40% oil the total oil were recovered in the light phase stream and the balance were remained in the final discharge (1.61%), recycle stream (1.59%) and solids (0.4%) Oil in final discharge and solids were considered as losses. Simulated distribution of solids were given in figure 1a. Almost half on the total solids were remained in the final discharge and only 35.62% were captured in solids stream. The balance were in light phase (12.24%) and recycle stream (3.62%).

Figure 3,4 and 5 displayed X-bar chart for oil component in the light, heavy and feed streams. At the begining, input oil composition varies widely but later stabilized at mean value of 11.43% which is 40% of the toal time as indicated by Pareto Chart in Figure 6. Consequently, both outlet oil compositions too varies accordingly resulting in an overall fourth order polynomial time instability (Figure 2). This indicates that the settling tank (decanting centrifuge operated with settling tank as shown in figure 11) performance varies causing severe quality control deviation in the output streams. Disturbances were then transmitted via the output stream to the adjoining units like settling tank, oil tank and oil purifier, in contrast with the role of settling tank which supposed to compact the solid layer and buffer outflow deviation.

The regression of feed oil composition with respect to oil in the light, heavy and solids shows a second order polynomial relationships (Figure 8,9 and 10). As indicated in figure 8, increasing oil composition in the feed do not favour optimal oil recovery in the light phase. Therefore lower oil composition in the sludge of settling tank (feed to the decanter) is preferred whenever operating three phase decanting centrifuge in crude palm oil clarification station to ensure high oil recovery in the light phase. Furthermore, high feed oil content contributed to high oil losses in heavy phase stream (Figure 9). Figure 10 shows that the oil composition in solid decreases as feed oil composition increases. However the value increases as feed oil composition approaches 11.24% . This indicates that the oil layer gets too thick and more oil was being absorbed in the solids as it leaves the centrifuge pool.

CONCLUSION

The steady-state model developed is useful in quantifying the total oil losses from the system. It also can be used to study the distribution oil, water and solids in the output streams. The dynamic model provides the stability status of the decanting centrifuge

ACKNOWLEDGEMENT

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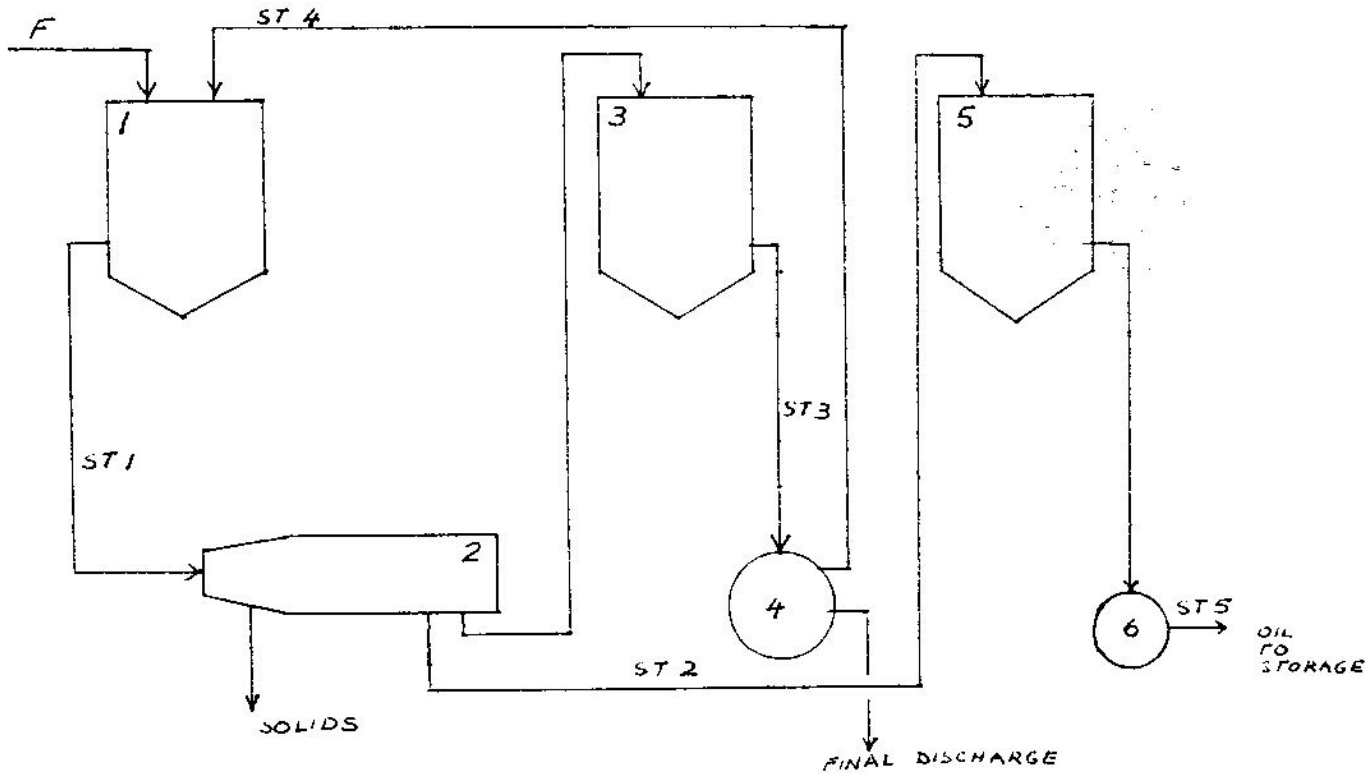
FIGURE 1. CRUDE PALM OIL CLARIFICATION BY DECANTING CENTRIFUGE



ST - STREAM
1 - OVERHEAD FEED TANK
2 - THREE PHASE DECANTING CENTRIFUGE
3 - HEAVY PHASE TANK
4 - SLUDGE SEPARATOR
5 - OIL TANK
6 - OIL PURIFIER

TABLE 1. PROCESS FLOWSHEET FOR CRUDE PALM OIL CLARIFICATION BY THREE-PHASE DECANTING CENTRIFUGE DESCRIBED IN FIGURE 1

COMPONENT			STREAMS FLOWRATES				
	MASS	MASS%	1.00	2.00	3.00	4.00	-5.00
oil	3 725.65	0.39	3 785.89	3 649.57	121.15	60.25	3 649.57
water	5 612.66	0.58	5 706.66	2.67	5 135.99	469.99	2.67
solids	338.70	0.04	351.45	43.03	182.75	12.75	43.03
TOTAL=	9 677.00						

In COMMAND MODE:-
For range names, press alt-n
For matrix operations, press alt-m

TOTAL FEED= 9 677.00
COMPONENT = oil
PERCENTAGE= 38.50

	1	2	3	4	5	IN/OUT	FLOWS
1	1.000			-1.000		3725.645	3785.89 a
2	-0.968	1.000				-15.180	3649.57 b
3	-0.032		1.000				121.15 c
4			-1.00	1.000		-60.900	60.25 d
5		-1.00			1.000		3649.57 e

COMPONENT = water
PERCENTAGE= 58.00

		2	3	4	5	IN/OUT	FLOWS
1	1.000			-0.20		5612.660	5706.66 f
2	-0.100	1.000				-568.000	2.67 g
3	-0.900		1.000				5135.99 h
4			-1.00	1.000		-4 666.00	469.99 i
5		-1.00			1.000		2.67 j

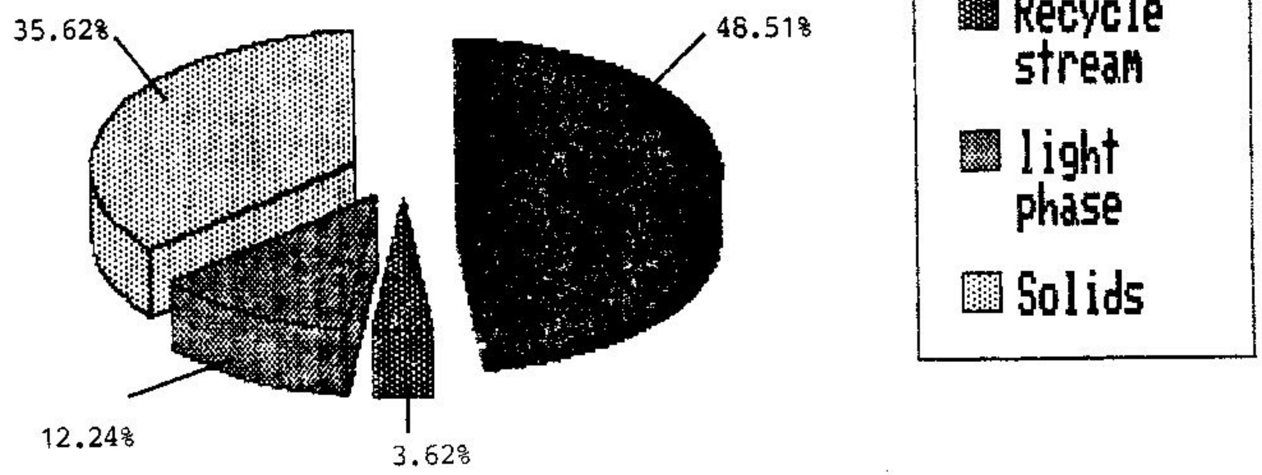
COMPONENT = solids
PERCENTAGE= 3.50

	1	2	3	4	5	IN/OUT	FLOWS
1	1.000			-1.00		338.695	351.45 k
2	-0.48	1.000				-125.670	43.03 l
3	-0.520		1.000				182.75 m
4			-1.00	1.000		-170.00	12.75 n
5		-1.00			1.000		43.03 o

a,f and k - component flow + recycle
b,g and l - component flow in stream 1
c,h and m - component flow in stream 3
d,i and n - recycle stream flow
e,j and o - component flow in stream 5

FIGURE 1a:

SIMULATED DISTRIBUTION OF SOLIDS IN CRUDE PALM OIL CLARIFICATION BY THREE PHASE DECANTING CENTRIFUGE



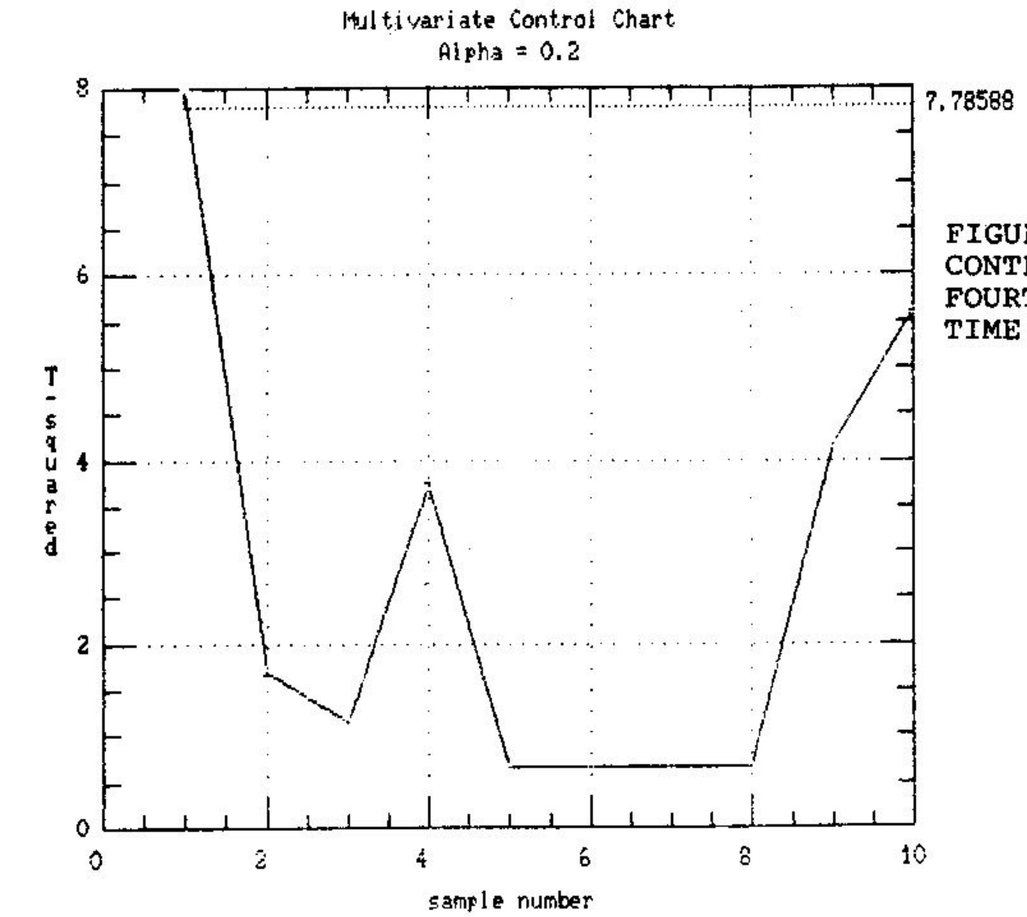


FIGURE 2. MULTI VARIATE CONTROL CHART OF THE FOURTH ORDER POLYNOMIAL TIME INSTABILITY

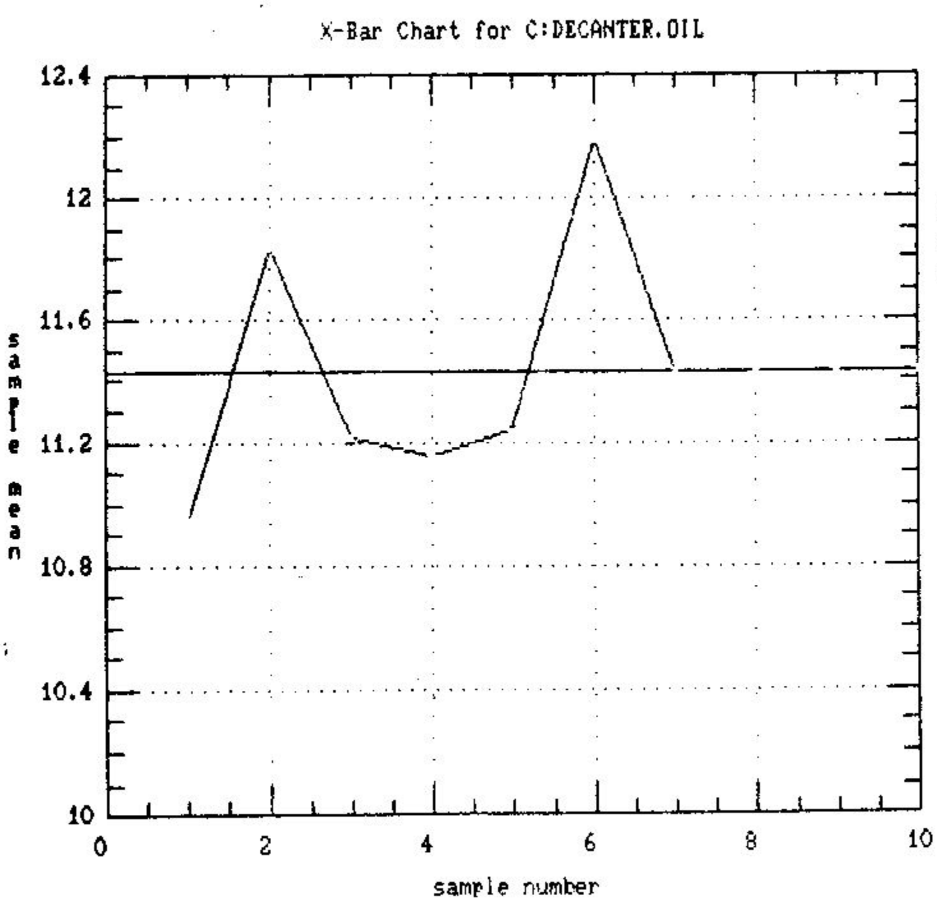


FIGURE 3. X-BAR CHART FOR OIL COMPOSITION IN FEED STREAM

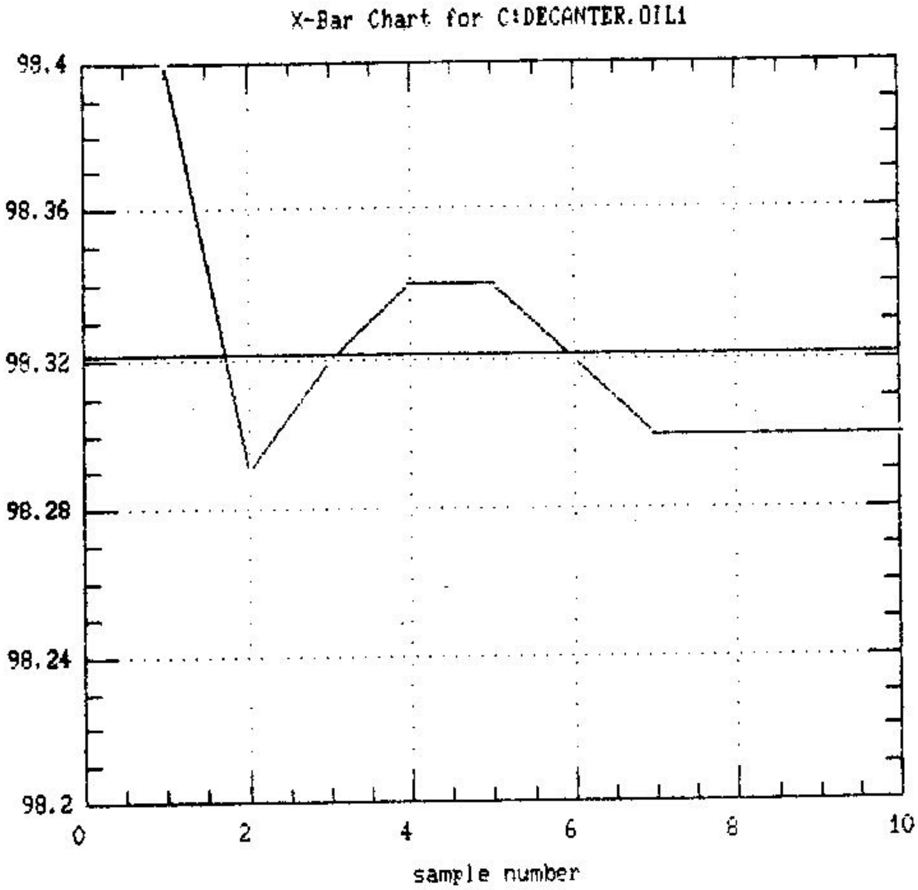


FIGURE 4. X-BAR CHART FOR OIL COMPOSITION IN LIGHT PHASE

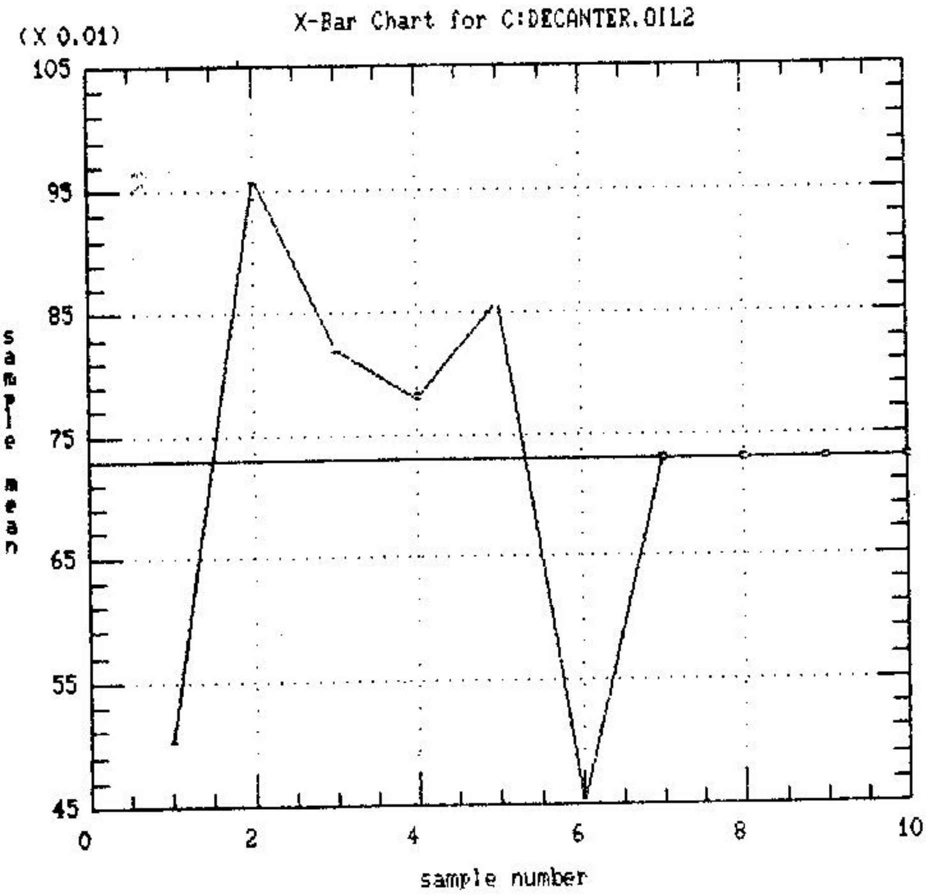


FIGURE 5. X-BAR CHART FOR OIL COMPOSITION IN HEAVY PHASE

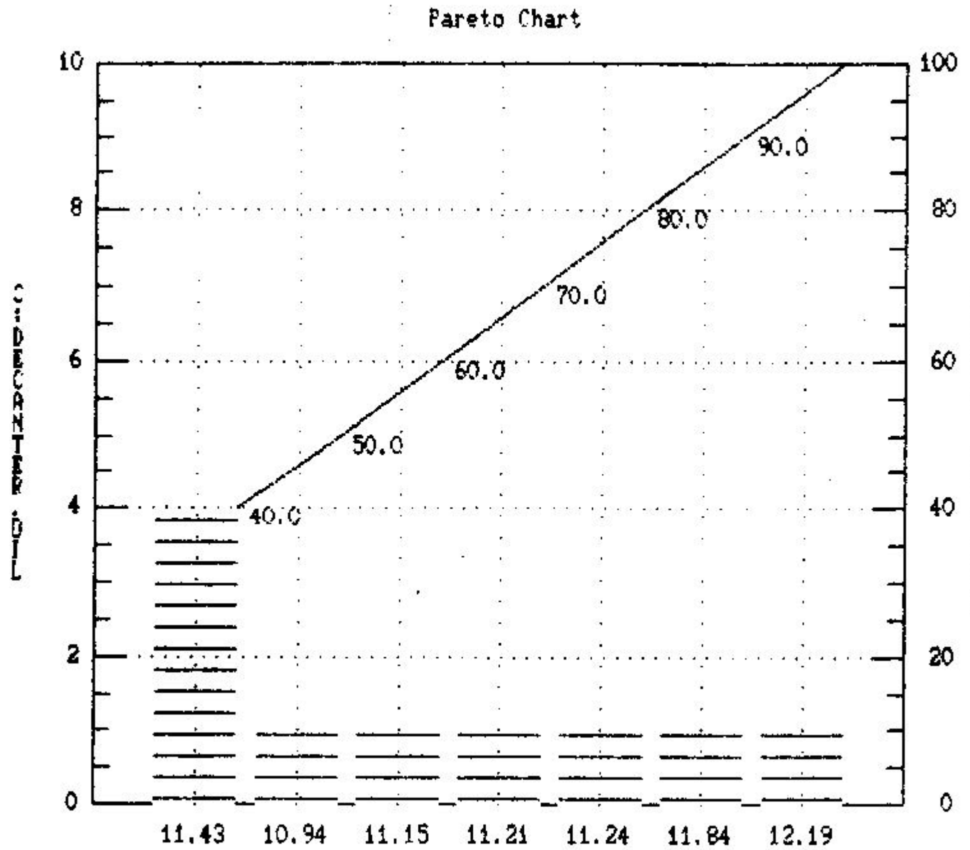


FIGURE 6. PARETO CHART FOR OIL COMPONENT IN THE FEED STREAM

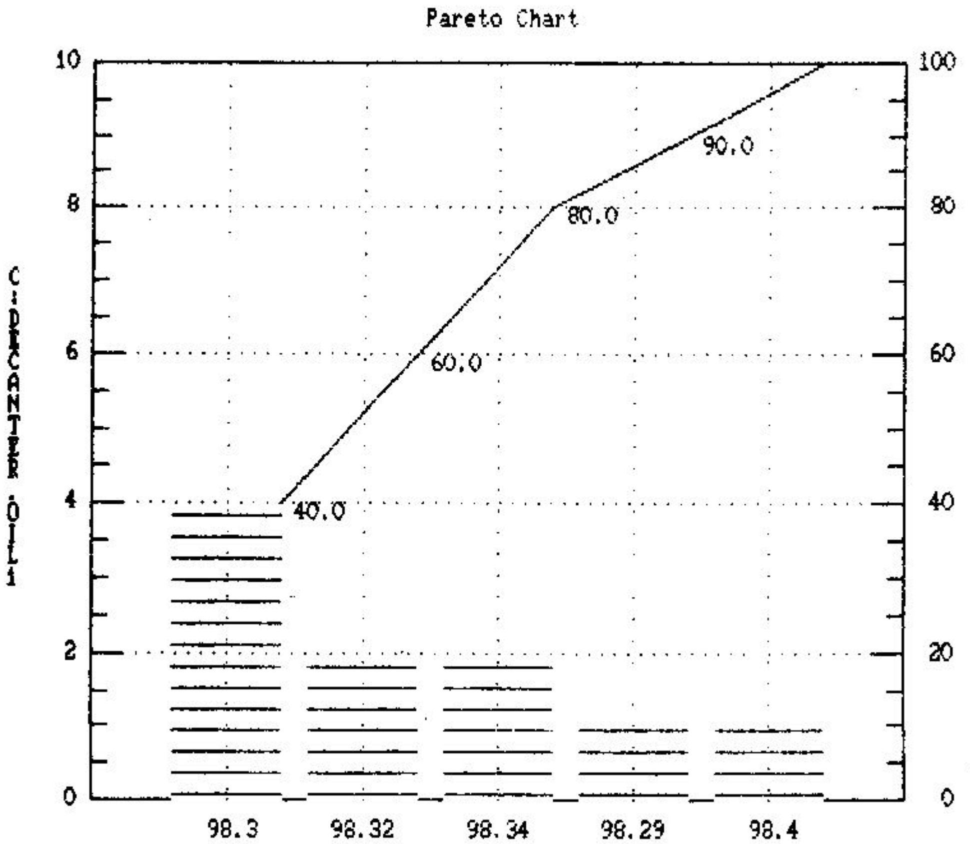
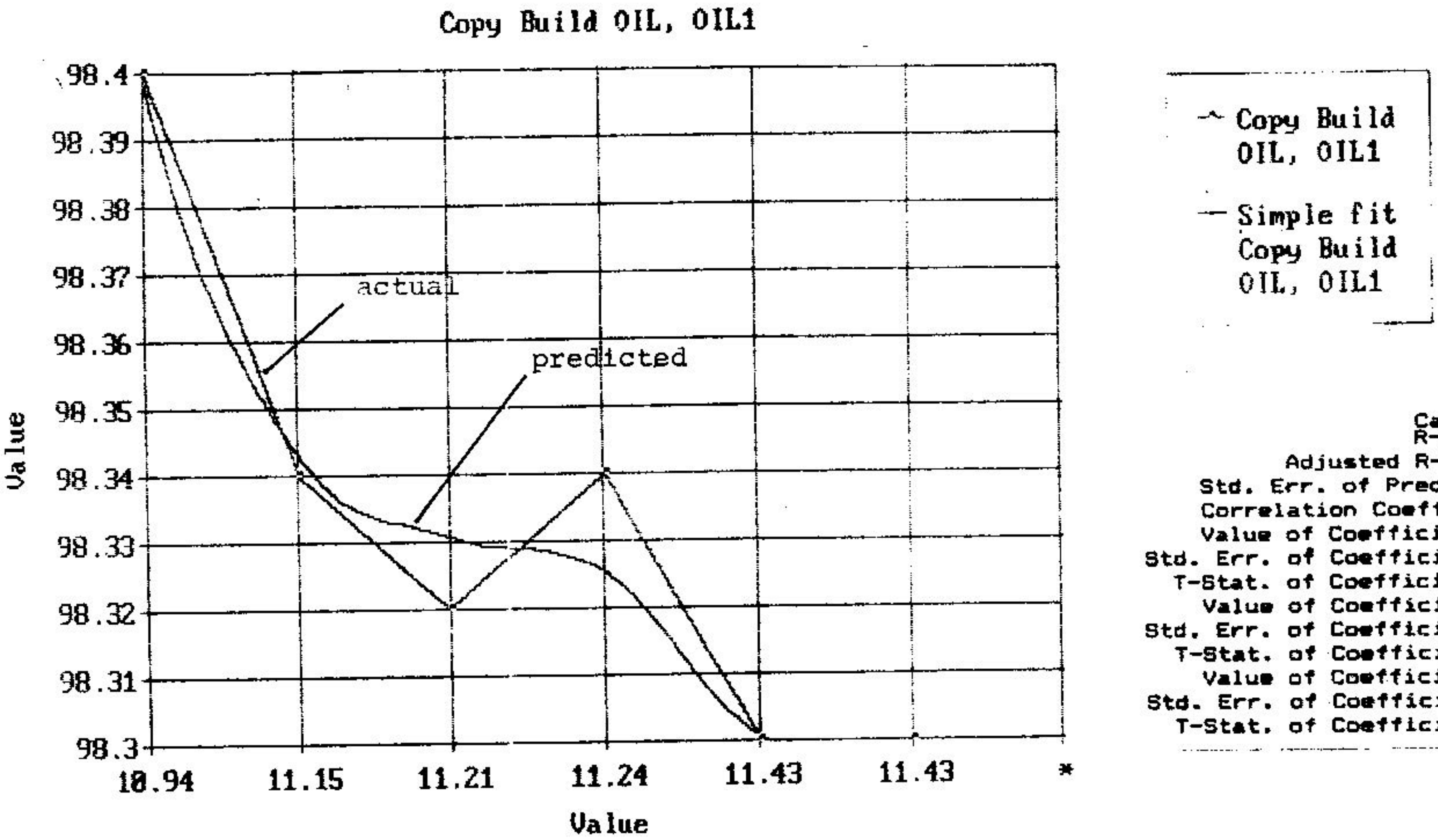


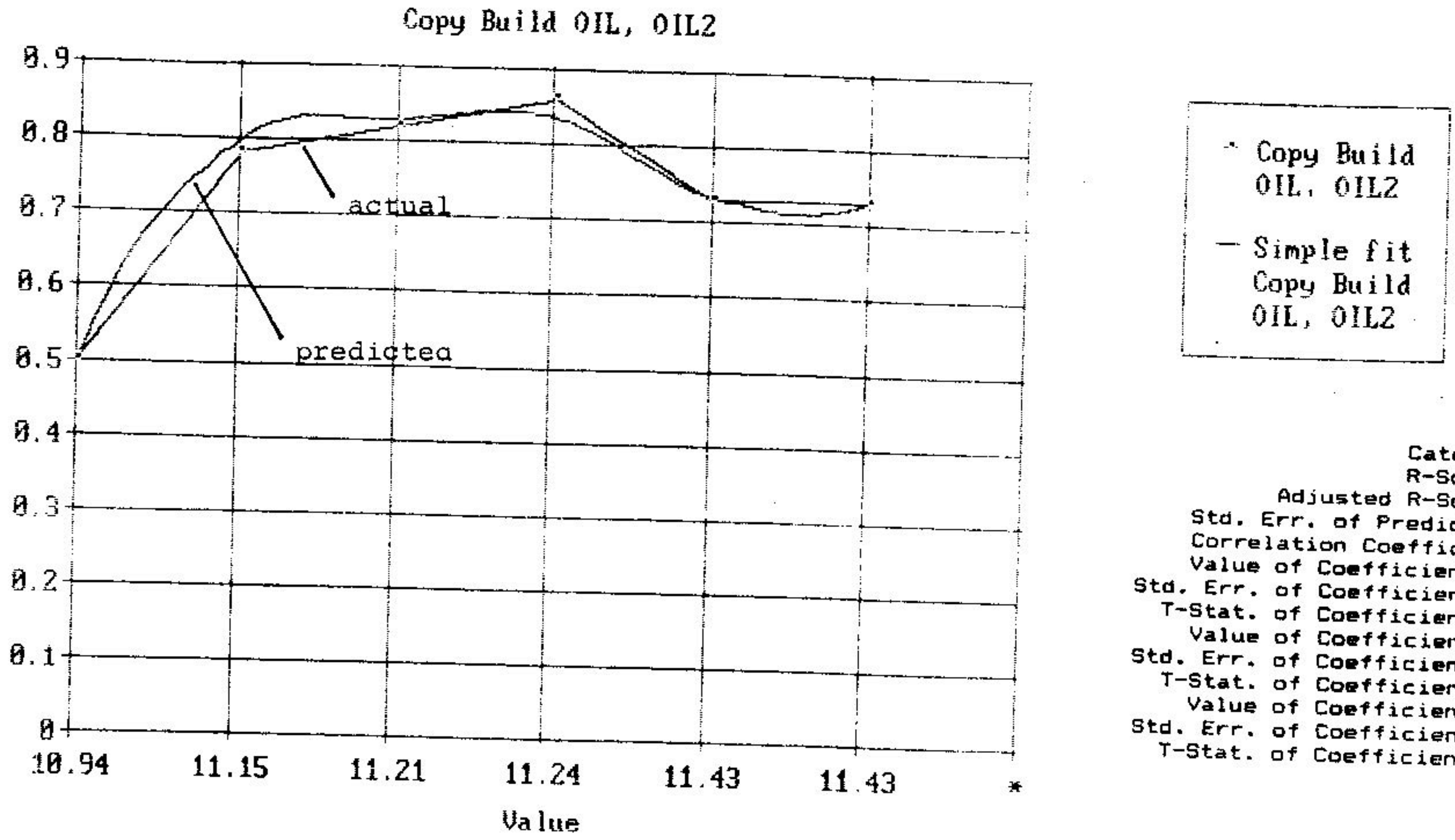
FIGURE 7. PARETO CHART FOR OIL COMPONENT IN THE LIGHT PHASE

FIGURE 8.   REGRESSION OF FEED OIL COMPOSITION WITH RESPECT TO LIGHT PHASE OIL COMPOSITION



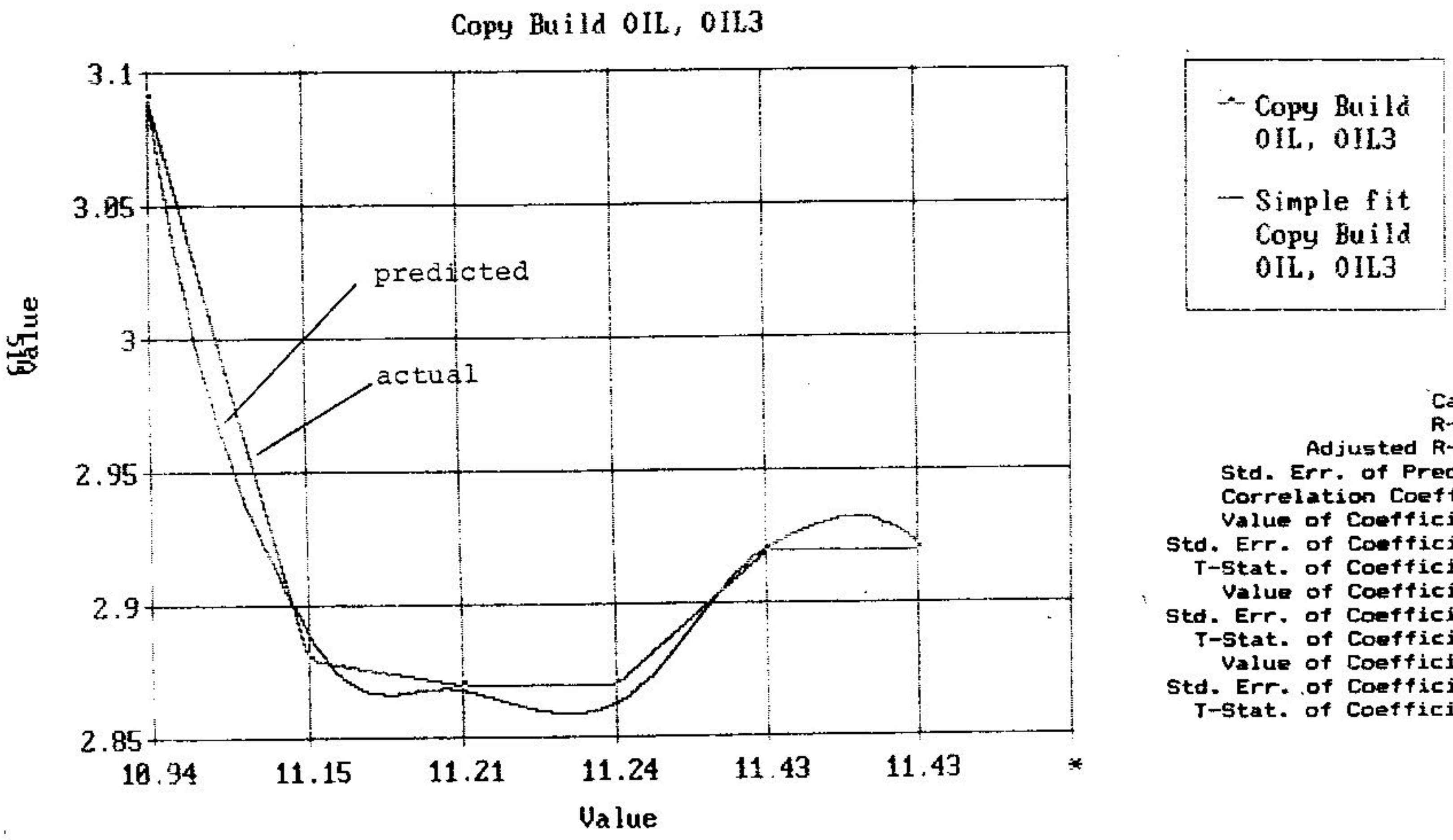
Category	V
R-Square	-17.2639819
Adjusted R-Square	-29.4399699
Std. Err. of Prediction	0.2054509568
Correlation Coefficient	-0.9547094892
Value of Coefficient A0	129.
Std. Err. of Coefficient A0	367.7150179
T-Stat. of Coefficient A0	0.3535118057
Value of Coefficient A1	-5.4
Std. Err. of Coefficient A1	65.659780511
T-Stat. of Coefficient A1	-0.083156337495
Value of Coefficient A2	0.23
Std. Err. of Coefficient A2	2.9305607879
T-Stat. of Coefficient A2	0.080230378077

FIGURE 9. REGRESSION OF FEED OIL COMPOSITION WITH RESPECT TO HEAVY PHASE OIL COMPOSITION



Category	Value
R-Square	0.98707864559069
Adjusted R-Square	0.97846440931782
Std. Err. of Prediction	0.01857804439069
Correlation Coefficient	0.53032052594948
Value of Coefficient A0	-428.937004
Std. Err. of Coefficient A0	33.250883963608
T-Stat. of Coefficient A0	-12.900018070781
Value of Coefficient A1	76.364574
Std. Err. of Coefficient A1	5.9373309123082
T-Stat. of Coefficient A1	12.861768213339
Value of Coefficient A2	-3.39223346
Std. Err. of Coefficient A2	0.26499797930302
T-Stat. of Coefficient A2	-12.800978592071

FIGURE 10. REGRESSION OF FEED OIL COMPOSITION WITH RESPECT TO SOLIDS OIL COMPOSITION



Category	Value
R-Square	0.99070114002829
Adjusted R-Square	0.98450190004715
Std. Err. of Prediction	0.010467674035386
Correlation Coefficient	-0.58790629458118
Value of Coefficient A0	277.201244
Std. Err. of Coefficient A0	18.734986707961
T-Stat. of Coefficient A0	14.795913566472
Value of Coefficient A1	-48.710484
Std. Err. of Coefficient A1	3.345349129503
T-Stat. of Coefficient A1	-14.560657831022
Value of Coefficient A2	2.1622003
Std. Err. of Coefficient A2	0.14931132734133
T-Stat. of Coefficient A2	14.481153831398

FIGURE 11. CRUDE PALM OIL CLARIFICATION BY DECANTING CENTRIFUGE OPERATED WITH HORIZONTAL CONTINOUS CLARIFIER.