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Briquette Binder from Hydrogenation Residue

By Dr. Bahr, Ludwigshafen, 9 November 1942
(See also T-360 & T-330)

SYNOPSIS

The various ways for processing hydrogenation residues to briquette binder, particularly for making low temperature carbonization (L.T.C.) coke briquettes were indicated and the results obtained therewith compiled. The recoverable quantity of coke can be radically influenced by various means, such as raising or lowering the softening point of the topping residue and the use of the letdown or centrifuge residues, or mixtures of the same, for making briquette binder. By partial disposal of the binder to outside interests and partial processing in the home plant, the oil balance can be completely equalized.

The plant costs were given and the production cost of L.T.C. coke was taken as RM.26.00, compared to a coke price of RM.29.40 to RM. 31.00 in Politz. No attention was paid to the reduction of costs in centrifuging and residue carbonization (L.T.C.).

By topping the oils to a softening point of the residue of about 70 to 90° C, briquette binders with increasing binding power with rising asphalt content can be recovered from hydrogenation letdown, as well as from centrifuge residue. Accordingly, hydrogenation residues rich in asphalts can be utilized particularly well in this way, which offers the possibility of maintaining alleviating conditions in hydrogenation.

In the production of briquette binder, we can start from 2 hydrogenation products, letdown or centrifuge residue. Briquette binders may be utilized in 2 ways:

1) Sale of the binder to outside interests,

2) Using the binder in the home plant for making coke briquettes for water gas production.

Under certain conditions it may be more appropriate to try both methods together. In practice, starting from hydrogenation residues, the following methods for producing briquette binder may be considered:

I. - The letdown from a stall is topped, whereby

a) briquette binder with a softening point of 70° C, and

b) briquette binder with a softening point of 90° C

can be produced.

The largest possible quantity of briquette binder could be produced in this manner, whereby the product with a softening point of 70° C would

preferably be intended for sale to outside interests and the product with a softening point of 90° C could be used mainly in the home plant for making L.T.C. coke briquettes. But the process is feasible only if a sufficient quantity of pasting oil is available from the other stalls or from L.T.C.

II. - Half the letdown from a stall is topped for processing to briquette binder, while the other half is used for making pasting oil. Here, again, the above 2 cases may be considered separately from the point of view of the amount of binder desired for briquetting:

a) making briquette binder with a softening point of 70° C, and

b) making briquette binder with a softening point of 90° C.

When using half the letdown as briquette binder, the other half, with the addition of cold catch pot heavy oil and L.T.C. oil or L.T.C. tar, can be used for making the necessary pasting oil of about the same composition as the oil recovered in centrifuging. With this operating method the necessary pasting oil supply can be assured, even without centrifuging, by using the hydrogenation letdown, if the briquette binder is used for making L.T.C. coke in the home plant entirely or to such an extent that the L.T.C. tar obtained thereby will suffice to supplement the pasting oil.

III. - Letdown is centrifuged in the normal manner and the centrifuge residue is processed to briquette binder by topping:

a) with a softening point of 70° C, and

b) with a softening point of 90° C.

The topped centrifuge residue is hardly fit for sale to outside interests for briquette binder and is properly used only for making L.T.C. briquettes in the home plant. The necessary pasting oil is recovered in centrifuging, supplemented by the tar obtained in L.T.C.

If the binder is sold to outside interests, the oil recoverable from it is lost to hydrogenation. From the standpoint of the largest possible oil production, therefore, it appears advantageous to use the topped hydrogenation residues for coal briquetting for the production of L.T.C. coke, because the residue hereby performs valuable work in the formation of coke in the form of a briquette binder. At the same time the L.T.C. oil is recovered, which can be supplied to hydrogenation, together with the L.T.C. tar from the coal. With the aid of Fig. 1, this process is described as follows:

Hydrogenation is conducted in the normal manner, whereby the letdown is drawn off the hot catch pot and is either topped directly or is separated in a centrifuge into centrifuge oil and residue after diluting with centrifuge oil. The centrifuge oil is used for pasting new coal while the centrifuge residue or the letdown is topped in a column or ball kiln (Kugelofen) to a softening point of the residue of about 70 to 90° C. The topping oil is added to the cold catch pot product and this is decomposed into middle oil and heavy oil in the normal way. The topped centrifuge residue or letdown is used as briquette binder for making L.T.C. briquettes, which are processed to L.T.C. coke and tar in carbonization. The coke is used for the production

of water gas for hydrogenation, while the tar is added either to the pasting oil or the cold catch pot product and is further processed in the liquid or vapor phase. Topping the centrifuge residue can be varied within certain limits, i.e. a softening point of about 70° C is selected for the briquette binder, if the quantity of coke to be produced is to be as large as possible, while with a lesser quantity of coke the softening point is raised to 90° C. With a softening point of 70° C about 7 to 8% of these binders are required for briquetting, while with a softening point of 90° C about 14% are required. By adjusting the softening point, therefore, it is possible to vary the quantity to be produced as desired.

The quantity of material to be converted in a stall with the above described 3 operating methods are compiled in Table I, following, in which these assumptions were made:

Stall thruput = 37.5 t coal paste, of which
30.4 t thick paste and 7.1 t pasting oil.
Quantity of coal = 14.9 t dry or 13.7 t pure coal.
Letdown produced = 18.7 t, to which 12.7 t
thinning oil is added to make 31.4 t
centrifuge mixture, from which are
obtained 23.4 t centrifuge oil and 8 t
centrifuge residue.

The compilation is based on the following specific figures:

The following data apply to 13.7 t pure coal when processed to:

	Auto Gasoline (without $C_1 - C_4$)	Aviat. Gasoline (without $C_1 - C_4$)
Yield	60%	55%
Production/Stall, t/h	8.23	7.54
H_2 Consumption, m^3/t	2750	3200
H_2 Consumption/Stall, m^3/h	22700	24100
Watergas (CO + H_2 = 100), m^3/h	24600	26200
Coke Consumpt. (0.85 kg/m^3), t/h	20.9	22.3

Table I indicates that, on the one hand, the oil contained in the residue is recovered together with the L.T.C. tar, and on the other hand, a considerable surplus of oils and L.T.C. tar is obtained above the normal production. It further indicates that the recoverable L.T.C. coke in the 3 different operating methods varies between 130 t and 30 t and that any desired quantity of coke can be produced between these limits. This may be determined as desired on the one hand by varying the adjustment of the softening point of the binder and, on the other hand, by using either letdown or centrifuge residue for the production of binders. The quantity of coke to be produced can further be varied as desired within these limits of 30 and 130 tons by using mixtures of letdown and centrifuge residue. Besides the coke yield and the surplus production of tar and oil a considerable quantity of surplus gas is produced at the same time. For the hydrogen used in one stall, between 21 and 22.4 t/h of coke are required, so that 110 to 6.5 tons of coke are produced in excess of the quantity required in one stall, depending upon the operating method used, I, II or III. Table II shows the most important production data.

TABLE I

Briquet Binder from Letdown or Hydrog. Residue, Use in Home Plant

Operating Method	I		II		III	
Production per Stall/h	a	b	a	b	a	b
A. - Using Binder in Home Plant						
Soft. Point of Feed °C	18.7	18.7	18.7	18.7	17.0	17.0
Soft. Point of Binder °C	70.0	90.0	70.0	90.0	70.0	80.0
	t/h %	t/h %	t/h %	t/h %	t/h %	t/h %
Topping Oil Yield	13.3 17.6	4.6 24.5	1.65 8.8	2.3 12.25	1.8 22.0	2.2 27.0
Binder Yield	15.4 82.4	14.2 75.5	7.7 41.2	7.05 37.8	6.2 78.0	5.8 73.0
Consumption of Binder %	8.0	10 - 14	8.0	10 - 14	9.0	12 - 14
Coal (Dry), t	178.0	127 - 86	89.0	63.5 - 43	63.0	42 - 36
Coal (10% H_2O), t	198.0	141 - 96	99.0	70.5 - 48	70.0	47 - 40
Briquets Produced, t	193.0	141 - 100	96.5	70.5 - 50	69.0	48 - 42
Gross Coke Yield (68%), t	131.0	96 - 68	65.5	48 - 34	47.0	33 - 29
Excess L.T.C. Gas, m^3/1000 Kcal	108000	79 - 54000	54000	39500 -28000	38600	27 - 22400
L.T.C. Tar & Gasol. Yield (10%), t	19.3	14.1 - 10	9.65	7.05 - 5.0	6.9	4.8 - 4.2
Topping Oil Yield, t	3.3	4.6	1.65	2.3	1.8	2.2
Topp. Oil & L.T.C. Tar, t	22.6	18.7 - 14.6	11.3	9.35 - 7.3	8.7	7.0 - 6.4
L.T.C. Oil from Binder t	8.4	6.4	4.2	3.2	2.4	2.3
Excess Prod. of Tar or Oil, t	10.9	7.7 - 3.6	5.45	3.85 - 1.8	4.5	2.5 - 1.9
B. - Sale of Binder to Outside Interests.						
Loss of L.T.C. Oil in Binder t	8.4	6.4	4.2	3.2	2.4	2.3

TABLE II

Products in the Making of L.T.C. Coke Briquets,
Using Briquet Binder from Letdown or Centrifuge Residue

Operating Method		I		II		III	
Data/Stall/h		a	b	a	b	a	b
Raw Coal (10% H_2O),	t	198	141 - 96	99	70.5 - 48	70	47 - 40
Gross Coke	t	131	96 - 68	65.5	48 - 34	47	33 - 29
Surplus Tar & Oil compared to normal operating method,	t	10.9	7.7 - 3.6	5.45	3.85 - 1.8	4.5	2.5 - 1.9
Surplus L.T.C. Gas, m^3/1000 Kcal		108000	79-54000	54000	39500-28000	38600	27-22400
Coke Consumption for 1 Stall,	t	21	21	21	21	21	21
for auto gasol.	t	21	21	21	21	21	21
for aviat. gasol.	t	22.5	22.5	22.5	22.5	22.5	22.5
Surplus Coke for: auto gasoline,	t	110	75 - 47	44.5	27 - 13	26	12 - 8
aviat. gasoline,	t	108.5	73.5 - 45.5	43	25.5 - 11.5	24.5	10.5 - 6.5

The above calculations were made with the assumption that the briquet binder is used in the home plant for the production of L.T.C. coke briquets. If some binder is sold to outside interests, the oil contained in the binder and recoverable by L.T.C. is lost. This oil loss may be assumed to be 544 kg/t of binder from letdown with a softening point of 70° C and 450 kg with a softening point of 90° C or 400 kg for binder from centrifuge residue with a softening point of 70° C.

But since a surplus of tar or oil is produced, if the binder is used at home a mixed operating method could also be considered, whereby the oil loss due to sale of the binder could be balanced by the oil surplus in domestic processing. The relation between domestic processing and sale of the binder was calculated and compiled in Table III.

TABLE III

Briquet Binders from Hydro. Residue, Balancing the Hydro. Oil by Partial Sale and Partial Home Consumption

Operating Method		I		II		III	
Data per ton binder		a	b	a	b	a	b
A. - Binder Consumption at Home.							
Binder Consumpt.	%	8	10-14	8	10-14	9	12-14
Briquet	t	12.5	10-7.1	12.5	10-7.5	11.1	8.3-7.1
Tar Yield	t	1.25	1.0-0.71	1.25	1.0-0.75	1.11	0.83-0.71
B. - Binder Sold Outside							
L.T.C. oil loss	t	0.544	0.45	0.544	0.45	0.40	0.4
Binder for sale/t binder used at home,	t	2.3	2.2-1.6	2.3	2.2-1.6	2.75	2.1-1.8
Processing Hydr. Resid.							
Letdown Yield,	t/h	18.7	18.7	9.4	9.4	8.0	8.0
TOTAL Binder,	t	15.4	14.1	7.7	7.05	6.2	5.8
of which are available, without hydr. oil losses, for processing:							
1) - outside	t	10.7	9.8-8.7	5.4	4.95-4.35	4.55	3.9-3.7
2) - at home	t	4.7	4.3-5.4	2.3	2.1-2.7	1.65	1.9-2.1
Yield in:							
Briquets	t	58.6	43-38.4	28.8	21-19.2	18.3	15.7-15
Tar	t	5.9	4.3-3.8	2.9	2.1-1.9	1.8	1.6-1.5
Gross Coke	t	40	29-26	19.5	14-13	12.5	10.7-10.2
Coal Input (dry)	t	53.9	39.7-33	26.5	20-16.5	16.7	13.8-12.9
Coal (10% H_2O)	t	60	44-36.6	29.5	22-18.4	18.6	15.4-14.3
Surplus Gas m^3/1000 Kcal		33000	24-21500	16000	113-10800	10300	88-8400

932

I-361

According to operating methods I to III, 40 to 10 tons of coke can be produced, which offers a further possibility to adjust the coke production to suit existing conditions at will. The most favorable operating methods are Ib or IIa, wherein the H_2 requirement of a stall for auto or aviation gasoline may be covered by the coke production.

Plant Costs for Combined Residue Processing with L.T.C. Coke Production

The quantities of briquets put thru L.T.C. per annum for the various operating methods I to III and cases "A" and "B" were calculated and compiled in Tables IV and V. The plant costs for a flushing gas plant by Lurgi, as well as those for a briquet plant, were also determined from bids by Lurgi and Schüchtermann & Kremer-Baum respectively. Besides complete erection, the following additions are included in the plant costs:

Spare Parts	3%
Contingencies	5%
Construction Taxes	5%

Costs of starting up and getting settled, RM 1.1/ton briquets/ann.

TABLE IV

Case "A": Processing the Binder at Home

Operating Method	I		II		III	
	a	b	a	b	a	b
Briquets/ann t	1575000	1150-816000	787000	575-408000	563000	392-342500
L.T.C. plant costs (RM. 22.00/t/ann) Millions RM.	31.5	25.3-17.95	17.3	12.65-9.0	12.4	8.6 7.53
Binder plant costs (RM. 3.6/t/ann) Millions RM.	4.7	4.1-2.94	2.8	2.1-1.47	2.0	1.4-1.2
Total plant costs Mill. RM.	36.2	29.4-20.89	20.1	14.75-10.47	14.4	10.0-8.73
Gross Coke Prod/annt	1070000	782-555000	535000	492-277000	383000	266-233000
Tar Prod/ann t	157500	115-816000	78700	575000-408000	56300	39200-34250
Coke Consumption pr. stall/ann for auto gasol. t	71000					
for aviat. gasol. t	76500					

TABLE V

Case "B": Processing the Binder with Equalized Oil Balance

Operating Method		I		II		III	
		a	b	a	b	a	b
Briquets/ann	t	478000	351-313000	235000	171-156000	149000	128-122500
Plant Costs:							
L.T.C.	Mill. RM.	10.5	7.7-6.9	5.17	3.76-3.43	3.28	2.8-2.7
Briquetting	"	1.72	1.26-1.12	0.85	0.61-0.56	0.54	0.46-0.44
Total	"	12.22	8.96-8.02	6.02	4.37-3.99	3.82	3.26-3.14
Gross Coke/ann	t	325000	248-212000	159000	115-106000	101000	87-83200
Tar/ann	t	47800	35100-31300	23500	17100-15600	14900	12800-12250
Coke Consumption pr. Stall/Ann.							
for auto gasol.	t	71000					
for aviat. gasol.	t	76500					

The production costs of the L.T.C. coke are based on the following figures:

		Flushing Gas L.T.C. by Lurgi	Briquetting by Schüchtermann	Total Consumption
Power, etc/t briquets:				
Current,	KWH	17	13	30
Steam, 2-12 atm,	t	0.09	0.035	0.125
Fresh Water,	m^3	3.4	--	3.4
Return Coolg. Water	m^3	13.3	--	13.3
Heat Consumption,	Kcal	320000	--	320000
Dry Coal	t	--	0.02	0.02
Personnel	Men	0.07	0.021	0.091
Iron Req'd. kg/t/ann		15.0	2.5	17.5
Capital Investment	%	21.95	21.95	21.95
Total operating capital without material costs or credits, pr. t briquets, RM.		8.83	2.30	11.13

Proceeds from 1 ton briquets without binder (90%)

Fuel Oil, RM. 120./t	5.93%	= RM.	6.40
Pitch, RM. 45./t	3.81%	=	1.54
Gasoline, RM. 200./t	0.89%	=	1.60
Surplus Gas, m^3/1000 Kcal @ 0.004		=	1.94
L.T.C. coke, 0-5 mm, RM. 15/t	1.44%	=	0.21
5-20mm, RM. 20/t	4.315%	=	0.97
Proceeds from 1t briquets without coke		RM.	12.66
Operating costs			11.13
Surplus per ton		RM.	1.53
L.T.C. coal, incl. freight + 10% H_2O,		RM.	18.80
Dry coal in 1t briquets, incl. freight		RM.	19.20
Price of coke in Pölitz		RM.	29.40 to 31.00

Based on these consumptions and prices, the cost of coke =

$$\frac{19.20-1.53}{0.68} = \text{RM. } 26.00/t$$

The price of coke at Pölitz is RM. 29.40 to RM. 31.00 per ton. In operating methods I to III the L.T.C. of the centrifuge residue is eliminated, the letdown or centrifuge residue is topped in the ball kiln instead. In operating methods I and II centrifuging is eliminated. The costs of processing the residues are included in the price of coke. In addition, 540000 Kcal surplus gas are recovered per ton of briquet thruput, which saves roughly 110 kg of coal for fuel gas production.

Results of investigations of binders from letdown and centrifuge residue from Pölitz are shown in Table VI.

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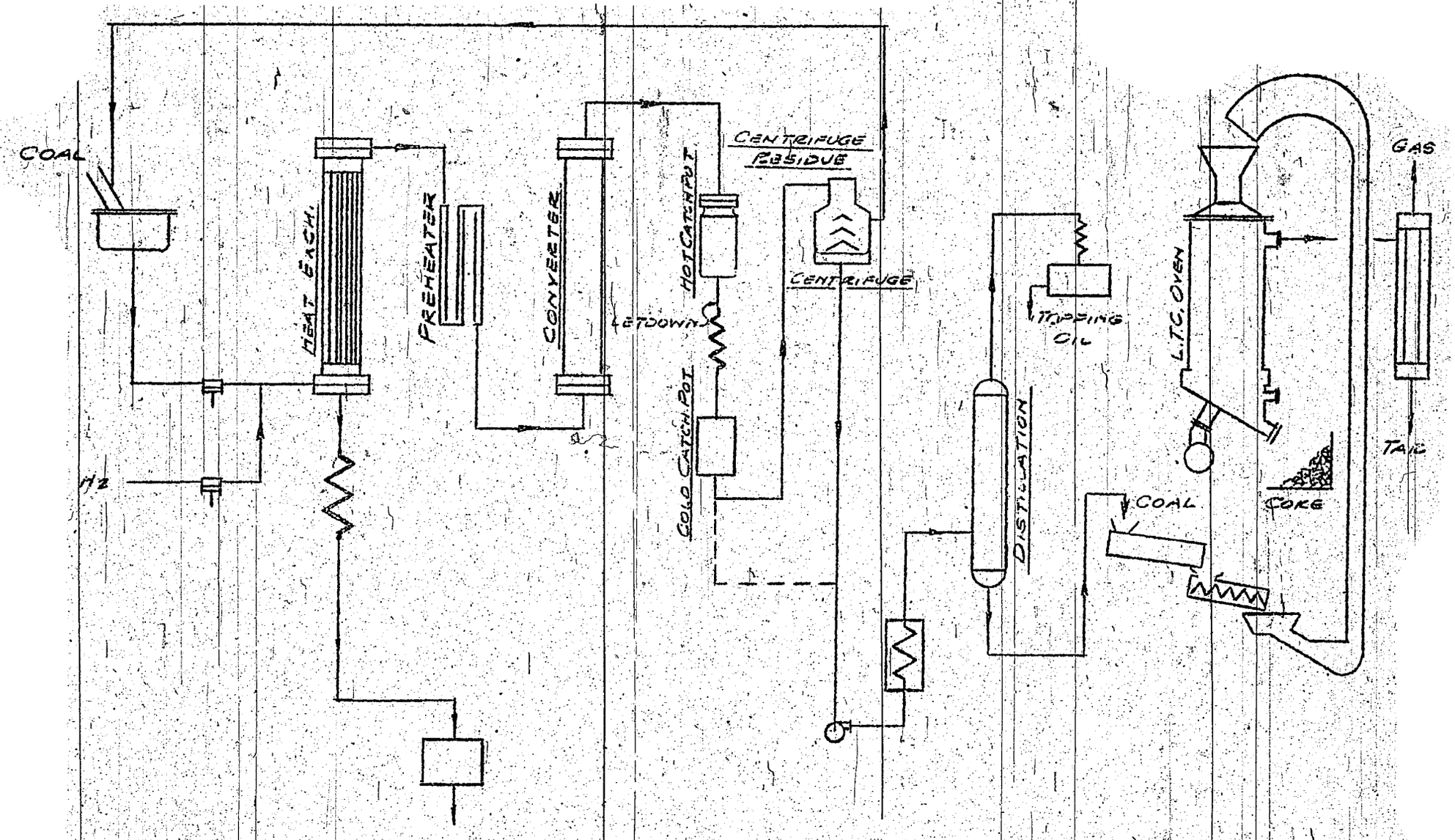
TABLE VI

Investigation of Hydro. Residues from Pölitz and their Usefulness as Binders.

Designation	Softening Point °C	Yield in		Composition of the Hydro-Residues					Character of L.T.C. Coke
		Briquet Binder %	Topping Oil %	Solids %	Ash in Solids %	Benzol Solubles %	β-asph. in benzol solubles %	Binder Consumpt. %	
Original Letdown	18.7	--	--	30.0	50.5	70.0	19.4	--	--
Topped Letdown	70.0	82.4	17.6	32.2	48.8	67.8	26.9	10.0	good
Topped Letdown	90.0	75.5	24.5	34.9	44.0	65.1	42.6	10-14	very good
Original Centrif. Resid.	17.0	--	--	37.8	62.7	62.2	10.2	--	--
Topped Centrif. Resid.	70.0	78.0	22.0	53.1	59.1	46.9	20.7	7-8	bad
Topped Centrif. Resid.	80.0	73.0	27.0	60.3	54.7	39.7	22.5	12-15	medium

936
T-361



HYDROGENATION WITH PROCESSING OF THE LETDOWN OR CENTRIFUGE RESIDUE TO BRIQUETTE BINDER

T-361
FIG. 1