Optimization for Achieving Higher de-colorization Efficiency in Sugar Refineries

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Abstract: India is known to be the second largest producer and biggest consumer of sugar in the world. The production of sugar is taken up using sugar cane as the raw material in all the factories except for one, which uses sugar-beet as the raw material. Sugar production, in general, remains around 28-33 million tonnes per annum; however, there are years of lower or higher production of sugar as the sugar production in the country is highly cyclic. In contrary to plantation white sugar, refined sugar is produced by two-stage crystallization, firstly raw sugar from sugarcane juice and then further processing the raw sugar to obtain refined sugar. As such, the production of plantation white sugar and raw – refined sugar differs significantly in terms of unit operations, processing technique, quality of the product, CAPEX and OPEX.

As per the Indian scenario most of the backend sugar refineries use ion exchange resin or the granular activated carbon for the secondary decolourisation. The main problem with IER process is the disposal of dark brown brine influent and in case of GAC; it requires high initial investment cost. The paper describes ways & means to produce good quality refined sugar in Indian sugar industry by the use of an energy efficient membrane filter with powdered activated carbon (PAC) as a secondary decolourization agent with optimization of reaction time of PAC and its doses.

Keywords: Carbonatation, phosphatation, raw sugar, refined sugar, powdered activated carbon, membrane filter.

I. Introduction

At present about 95% of the sugar factories in India are producing plantation white sugar by conventional Double Sulphitation process and about 5% sugar factories are back end & stand-alone type refineries, which are producing refined sugar by Phosphatation/Carbonation process followed by decolourization through GAC, PAC & IER. Double Sulphitation, commonly known as plantation white sugar, do not meet the requirement of export quality. For enhancing export share in the world market production of raw and refined sugar is a viable solution. For melt clarification, either Phosphatation or Carbonation process is in use, whereas, for the secondary de- colorization, following process are generally used.

1. Ion Exchange Resin (IER)
2. Granular Activated Carbon (GAC)
3. Powdered Activated carbon (PAC)

Colour removal is one of the most important unit operations in sugar refining. Over the years, there has been a change from one process to another. During the last three decades mostly ion exchange and granular activated carbon plants have been installed. GAC process being more cumbersome, costly, and leading to lower effluent generation & heavy sweet water generation is being used only in very large refineries, IER process has remained much popular, but now due to following problems, there is search for better alternative.

- Stringent requirements of the pollution control board.
- Treatment of dark brine effluent; and
- Installation of other ancillary equipment like the Brine Recovery System (BRS) and Brine Concentrator and Dryer, which are capital intensive.

Due to this, number of plants based on Powdered Activated Carbon (PAC) plants are coming up and their conversion to high performance adsorbents (HPA) has steadily been increasing. In Indian conditions prospective of this process appears to be bright. In view of the above scenario, a detailed study on use of PAC (method in which de-colorization is done with powdered activated method) has been taken up, to make it easy, and viable. In the conventional process of decolourization using PAC, melt is treated with powdered activated carbon, and the activated carbon slurry, which is then filtered through, two stage filters, one is loader and other is polisher. In two stage filtration, filtration cycle becomes large, which leads to inversion losses, and also, effluent generation is more. With the introduction of membrane filters, filtration has been reduced to a single stage, in which de-sweetening and cake drying is in built process. This has advantage of short retention, almost nil effluent and dry cake discharge. PAC process also has following advantages.

- Increased yield.
- Better quality of refined sugar.
- Increased value addition by saving huge quantity of chemical and operation cost.

II. MECHANISM OF DECOLOURISATION BY PAC

Davis (2001) state that appreciation of the types of colour present is important when choosing and operating refinery processes, as different processes may remove different types of colour. There are generally four recognised types of colour associated with sugar crystals, viz. plant pigments, melanoidins, caramels and alkaline degradation products of fructose. The last three are factory produced colour pigments. Other factors that can influence the degree of colour are solution pH and the polarity of the colour molecules. Activated carbon actually removes the impurity, unlike bleaching operations in which the coloured impurity is only changed to a colourless product.

The most important factor determining the decolourisation efficacy of carbon is the non- polar nature of the surface. The surface forces (van der Waal's forces) create a stronger attraction between the carbon surface and the colour molecules than between the colour molecules and the sugar liquor (Truemper, 1968). The enormous surface area due to its porous structure (500 to 5000 m^2/g) means that large quantities of colour may be absorbed before the carbon is exhausted. This is physical adsorption, and is responsible for most of the colour removal from the sugar liquors. However, carbon also has some oxygenated functional groups that cause chemisorption, which allows some polar molecules to be adsorbed. As a result, carbon is not specific for any type of colour, but gives high overall colour removal (typically up to 80%). An important factor to be noted in colour removal by carbon is the size of the colourant molecules relative to the pore sizes. Clearly, before a colourant can be adsorbed onto the carbon, it must diffuse into the carbon pores and orientate itself correctly. The diffusion process determines the rate at which colour can be removed and therefore the smaller particle size of PAC allows more rapid adsorption of colour than in the case with larger GAC particles, although the total colour removed per unit mass is similar (Davis, 2001). The Classification of colorants in cane juice processing is given in table 1.

Table 1: Classification of colorants in cane juice in processing:

Natural Colorants	**Colorants developed during Juice Processing**
Flavonoids, Melanin's, Chlorophylls, Xanthophyils & Carotene	Melanoidins (Maillard Reaction Products), Caramel (Glucose & Fructose degradation in acidic media), HADPs (Hexose Alkaline degradation products).

Van der Waals forces are main attractive forces between chemical groups in contact. Vander Waals force bonding is the main adsorption mechanism taking place on the surface of activated carbon.

III. MATERIALS AND METHODS

Total 21 nos. of experiment were conducted during the research work & all the experiments were conducted in NSI Research laboratory. The samples of raw sugar were taken from Dalmia Bharat Sugar Mills Ltd Unit- Nigohi, Shahjahanpur & Balrampur Chini Mills Ltd Unit- Rauzagaon, Barabanki.
For the purpose, samples of VVHP raw sugars were taken.

During all experiment, spectrophotometer, brix spindle, weighing scale, heaters with automatic control of temperatures, vacuum filtration system, beakers, test tubes etc. were used for conducting the trials.

Trails were conducted at different doses of powdered activated carbon and at different reaction time i.e. 0.05, 0.10, 0.15, 0.20 & 0.25 % on sugar solids and 20, 30, 40 & 50 minutes for optimization of reaction time & doses of PAC.

Application of only milk of lime was carried out for maintaining the re-melt liquor pH of about 8.20 for carried out the experiments in alkaline conditions and 0.10N HCl solution was used to maintain the pH in acidic conditions.
In each experiment re-melt liquor and decolourised liquor at various reaction time & doses of PAC were analysed for the parameters of brix %, pH & colour to see the effectiveness of the treatment.
The quality of powdered activated carbon which was utilised in the experiment is given in table 2.

Table 2: Specifications of Powdered Activated Carbon

Parameters	Units	PAC
Surface area	m2/gm.	1550
Iodine No.	mg/gm	1100
Molasses No.	mg/gm	125
Methylene blue	gm/ 100 gm	NA
Total pore volume	cm3/gm	NA
Apparent density	Kg/m3	340-400
Moisture %	%	6
Ash content	%	3-5

pH	No.	6-7
Particle size		
Above 75 micron	NA	10
Below 75 micron	NA	90

Analytical methods

The physicochemical parameters of raw sugar & treated liquor like color, pH, etc. were observed as per the following procedure.

Color:

The ICUMSA method GS1/3-7 (2011) using a wavelength of 420 nm was applied for testing the color of raw sugar, clear melt / treated melt. Apparatus used for the purpose were; spectrophotometer equipped with 1cm cells, membrane filters of pore size 0.45 µm, precision refractometer and reagents used was 0.1 mol/l HCl and 0.1 mol/l NaOH solution.

The pH

pH of the intermediate molasses samples were determined using glass electrode attached to pH meter after calibration at pH 4.00, 7.00 and 9.00 at 20°C following ICUMSA method GS1/2/3/4/7/8-23.
Brix. Brix of intermediate molasses was observed by the IS 15279 method as per method described in book for System of Technical control.

Process Description of PAC system with Membrane filter press

The flow diagram of decolourisation process envisaged & tried on laboratory scale is given in figure-1. The raw sugar sample was mixed with pure water (distil water) to adjust the brix of the solution up to 55-600 so as to have better filtration at laboratory level. The temperature of the sugar solution was kept at 80°C. The experiment was also carried out at ambient temperature and it was observed that the result at ambient temperature were not satisfactory. Thereafter, the temperature of sugar solution was kept at 800C for better process efficacy. The quantity of powdered activated carbon used was in the range of 0.05 % - 0.25 % on sugar solids. Different quantities of powdered activated carbon such as 0.15 gm, 0.30 gm, 0.45 gm., 0.60gm, 0.75gm. were added to 300 gms of raw sugar solids solution.
The laboratory filters were pre-coated in a manner similar to pressure filters in the commercial plants with CELITE-Hyflo-supercel, diatomaceous filter aid. The powdered activated carbon was mixed with raw melt liquor/ clarified liquor, a retention time from 20 minutes to 50 minutes was maintained in all the experiments.

The trials were conducted in three mediums, i.e. Neutral, Acidic and Alkaline. The tables drawn contains average data for four different readings taken under same conditions. Table 3 gives the idea of dosing rate of 0.05-0.25 % PAC in raw sugar melt solids.

Table 3: Dosing rate of 0.05-0.25 % PAC in raw sugar melt solids.

Powdered activated carbon used (in Grams)	Quantity of raw sugar(in Grams)	Powdered activated carbon dosing rate (Kg/Ton of sugar)
0.15	300	0.50
0.30	300	1.00
0.45	300	1.50
0.60	300	2.00
0.75	300	2.50

IV. DETAILS OF EXPERIMENTS

EXPERIMENT-1

Neutral condition & at normal temperature

Trial with powdered activated carbon in acidic condition & normal temperature at 350C with powdered activated carbon doses @ 0.25 % on sugar solids were conducted in NSI research laboratory. Details of the experiment performed in neutral condition & normal temperature is given as below in table 4.

Table 4: Neutral Condition & Normal temperature @ doses 0.25 % on solids

Particulars	pH	Brix %	Colour (I.U.)	Retention (Minutes)	% colour removal
Raw melt	6.50	47.25	771	0	0

Raw melt + PAC	6.45	46.61	695	20	9.86
Raw melt + PAC	6.40	46.40	690	30	10.51
Raw melt + PAC	6.40	46.51	685	40	11.15
Raw melt + PAC	6.40	46.50	683	50	11.41

EXPERIMENT-2

300 gm of raw sugar sample taken and mixed with pure water (distil water) to adjust the brix of the solution up to 55-600 so as to have better filtration at laboratory level. The temperature of the sugar solution was kept at 80°C and thereafter 15 0 Be milk of lime added to maintain the alkalinity @ pH 8.0-8.20 & thereafter the solution is filtered with ordinary filter paper and clear melt received in another beaker. The clear melt again kept on heater to maintain the temperature of 800C and thereafter the powdered activated carbon doses @ 0.05 % to 0.25 % on sugar solids in alkaline condition pH at 8.0-8.20.The trails were conducted in NSI research laboratory. Details of all the experiments in alkaline conditions are tabulated from table no. 5 -8.

Table 5: Alkaline Condition @ doses 0.05 % on solids

Particulars	pH	Brix %	Colour (I.U.)	Retention (Minutes)	% colour removal
Raw melt	6.50	50.43	775	0	0
Raw melt+MOL+Filtration	8.20	51.20	488	7	37.03
Raw melt + PAC	8.00	54.00	357	20	26.84
Raw melt + PAC	8.00	57.00	350	30	28.28
Raw melt + PAC	7.95	58.00	353	40	27.66
Raw melt + PAC	7.90	61.00	358	50	26.64

Table 6: Alkaline Condition @ doses 0.10 % on solids

Particulars	pH	Brix %	Colour (I.U.)	Retention (Minutes)	% colour removal
Raw melt	6.50	50.43	775	0	0
Raw melt+MOL+Filtration	8.20	51.20	488	7	37.03
Raw melt + PAC	7.96	54.00	312	20	36.07
Raw melt + PAC	7.93	57.00	300	30	38.52
Raw melt + PAC	7.90	58.00	303	40	37.91
Raw melt + PAC	7.82	61.00	307	50	37.09

Table 7: Alkaline Condition @ doses 0.15 % on solids

Particulars	pH	Brix %	Colour (I.U.)	Retention (Minutes)	% colour removal
Raw melt	6.50	50.43	775	0	0
Raw melt+MOL+Filtration	8.20	51.20	488	7	37.03
Raw melt + PAC	7.92	54.00	284	20	41.80

Raw melt + PAC	7.80	57.00	273	30	44.05
Raw melt + PAC	7.73	58.00	276	40	43.44
Raw melt + PAC	7.64	61.00	280	50	42.62

Table 8: Alkaline Condition @ doses 0.25 % on solids

Particulars	pH	Brix %	Colour (I.U.)	Retention (Minutes)	% Colour removal
Raw melt	6.50	50.43	775	0	0
Raw melt+MOL+Filtration	8.20	51.20	488	7	37.03
Raw melt + PAC	7.75	54.00	217	20	55.53
Raw melt + PAC	7.67	57.00	203	30	58.40
Raw melt + PAC	7.56	58.00	198	40	59.43
Raw melt + PAC	7.50	61.00	210	50	56.97

EXPERIMENT-3

Neutral Condition with doses of Dry PAC

300 gm of raw sugar sample taken and mixed with pure water (distil water) to adjust the brix of the solution up to 55-600 so as to have better filtration at laboratory level. The temperature of the sugar solution was kept at 80°C and thereafter measured a solution pH and found 6.85-6.98 and thereafter the powdered activated carbon doses @ 0.05 % to 0.25 % on sugar solids in almost neutral condition pH at 6.85-6.95. The trails were conducted in NSI research laboratory. Details of all the experiments in neutral conditions with doses of dry PAC are tabulated from table no. 9-19.

Table 9: Neutral Condition @ doses 0.05 % on solids

Particulars	pH	Brix %	Colour (I.U.)	Retention (Minutes)	% colour removal
Raw melt	6.85	60.00	392	0.0	0.0
Raw melt +PAC	6.50	62.00	250	20	36.22
Raw melt +PAC	6.35	63.00	255	30	34.94
Raw melt +PAC	6.32	64.50	257	40	34.43
Raw melt +PAC	6.30	66.00	259	50	33.92

Table 10: Neutral Condition @ doses 0.075 % on solids

Particulars	pH	Brix	Colour (I.U.)	Retention (Minutes)	% colour removal
Raw melt	6.85	54.00	392	0.0	0.0
Raw melt +PAC	6.43	55.50	205	20	47.70
Raw melt +PAC	6.30	58.00	200	30	48.97
Raw melt +PAC	6.28	61.00	203	40	48.21
Raw melt +PAC	6.25	62.50	208	50	46.93

Table 11: Neutral Condition @ doses 0.10 % on solids

Particulars	pH	Brix %	Colour (I.U.)	Retention (Minutes)	% colour removal
Raw melt	6.85	54.00	392	0.0	0.0
Raw melt + PAC	6.45	55.00	171	20	56.38
Raw melt + PAC	6.37	55.70	164	30	58.16
Raw melt + PAC	6.22	57.50	170	40	56.63
Raw melt + PAC	6.20	59.50	173	50	55.87

Table 12: Neutral Condition @ doses 0.15 % on solids

Particulars	pH	Brix %	Colour (I.U.)	Retention (Minutes)	% colour removal
Raw melt	6.90	53.77	392	0.0	0.0
Raw melt + PAC	6.75	55.70	147	20	62.50
Raw melt + PAC	6.65	55.90	135	30	65.56
Raw melt + PAC	6.60	56.30	136	40	65.31
Raw melt + PAC	6.50	59.22	137	50	65.05

Table 13: Neutral Condition @ doses 0.20 % on solids

Particulars	pH	Brix %	Colour (I.U.)	Retention (Minutes)	% colour removal
Raw melt	6.80	54.00	392	0.0	0.0
Raw melt + PAC	6.45	55.00	132	20	66.32
Raw melt + PAC	6.37	55.70	120	30	69.39
Raw melt + PAC	6.30	57.50	118	40	69.90
Raw melt + PAC	6.28	59.50	121	50	69.13

Table 14: Neutral Condition @ doses 0.25 % on solids

Particulars	pH	Brix %	Colour (I.U.)	Retention (Minutes)	% colour removal
Raw melt	6.90	54.00	392	0.0	0.0
Raw melt + PAC	6.52	55.00	105	20	73.21
Raw melt + PAC	6.42	55.70	95	30	75.76
Raw melt + PAC	6.38	57.50	97	40	75.26
Raw melt + PAC	6.35	59.50	99	50	74.74

Table 15: Neutral Condition @ doses 0.05 % on solids

Particulars	pH	Brix %	Colour (I.U.)	Retention (Minutes)	% colour removal
Raw melt	6.98	50.83	458	0	0
Raw melt + PAC	6.73	51.42	329	20	28.17
Raw melt + PAC	6.72	52.23	321	30	29.91
Raw melt + PAC	6.70	52.39	323	40	29.48
Raw melt + PAC	6.67	53.00	327	50	28.60

Table 16: Neutral Condition @ doses 0.10 % on solids

Particulars	pH	Brix %	Colour (I.U.)	Retention (Minutes)	% colour removal
Raw melt	6.98	50.83	458	0	0
Raw melt + PAC	6.70	51.85	225	20	50.87
Raw melt + PAC	6.65	52.50	221	30	51.75
Raw melt + PAC	6.60	53.00	224	40	51.09
Raw melt + PAC	6.60	53.65	228	50	50.22

Table 17: Neutral Condition @ doses 0.15 % on solids

Particulars	pH	Brix %	Colour (I.U.)	Retention (Minutes)	% colour removal
Raw melt	6.98	53.77	458	0	0
Raw melt + PAC	6.45	55.70	210	20	54.15
Raw melt + PAC	6.35	55.9	198	30	56.77

Raw melt + PAC	6.30	56.30	200	40	56.33
Raw melt + PAC	6.27	59.22	207	50	54.80

Table 18: Neutral Condition @ doses 0.20 % on solids

Particulars	pH	Brix %	Colour (I.U.)	Retention (Minutes)	% colour removal
Raw melt	6.98	52.00	458	0	0
Raw melt + PAC	6.70	52.50	147	20	67.90
Raw melt + PAC	6.65	53.00	139	30	69.65
Raw melt + PAC	6.60	53.45	143	40	68.78
Raw melt + PAC	6.60	54.00	145	50	68.34

Table 19: Neutral Condition @ doses 0.25 % on solids

Particulars	pH	Brix %	Colour (I.U.)	Retention (Minutes)	% colour removal
Raw melt	6.98	52.00	458	0	0
Raw melt + PAC	6.68	52.50	136	20	70.31
Raw melt + PAC	6.63	53.00	129	30	71.83
Raw melt + PAC	6.58	53.45	130	40	71.62
Raw melt + PAC	6.57	54.00	133	50	70.96

EXPERIMENT-4

Acidic Condition with Doses of Dry PAC

300 gm of raw sugar sample taken and mixed with pure water (distil water) to adjust the brix of the solution up to 55-600 so as to have better filtration at laboratory level and then the melt pH 6.57 adjusted by the use 0.1N HCl solution. The temperature of the sugar solution was kept at 80°C and thereafter the powdered activated carbon doses @ 0.05 % to 0.25 % on sugar solids in acidic condition pH at 6.57. The trails were conducted in NSI research laboratory. Details of all the experiments in acidic conditions with doses of dry PAC are tabulated from table no. 20-24.

Table 20: Acidic Condition @ doses 0.05 % on solids

Particulars	pH	Brix %	Colour (I.U.)	Retention (Minutes)	% colour removal
Raw melt	6.57	55.00	392	0	0
Raw melt + PAC	6.35	57.00	205	20	47.70
Raw melt + PAC	6.27	59.00	203	30	48.21
Raw melt + PAC	6.25	60.30	204	40	47.96
Raw melt + PAC	6.25	61.50	205	50	47.70

Table 21: Acidic Condition @ doses 0.10 % on solids

Particulars	pH	Brix %	Colour (I.U.)	Retention (Minutes)	% colour removal
Raw melt	6.57	50.50	392	0	0

Raw melt + PAC	6.35	53.61	197	20	49.74
Raw melt + PAC	6.25	59.30	189	30	51.79
Raw melt + PAC	6.20	61.70	196	40	50.00
Raw melt + PAC	6.20	63.50	198	50	49.49

Table 22: Acidic Condition @ doses 0.15 % on solids

Particulars	pH	Brix %	Colour (I.U.)	Retention (Minutes)	% colour removal
Raw melt	6.57	52.00	392	0	0
Raw melt + PAC	6.32	53.50	165	20	57.91
Raw melt + PAC	6.24	54.25	160	30	59.18
Raw melt + PAC	6.23	55.50	164	40	58.16
Raw melt + PAC	6.23	56.50	167	50	57.40

Table 23: Acidic Condition @ doses 0.20 % on solids

Particulars	pH	Brix %	Colour (I.U.)	Retention (Minutes)	% colour removal
Raw melt	6.57	52.00	392	0	0
Raw melt + PAC	6.32	53.50	140	20	64.29
Raw melt + PAC	6.24	54.25	135	30	65.56
Raw melt + PAC	6.23	55.50	136	40	65.31
Raw melt + PAC	6.23	56.50	138	50	64.80

Table 24: Acidic Condition @ doses 0.25 % on solids

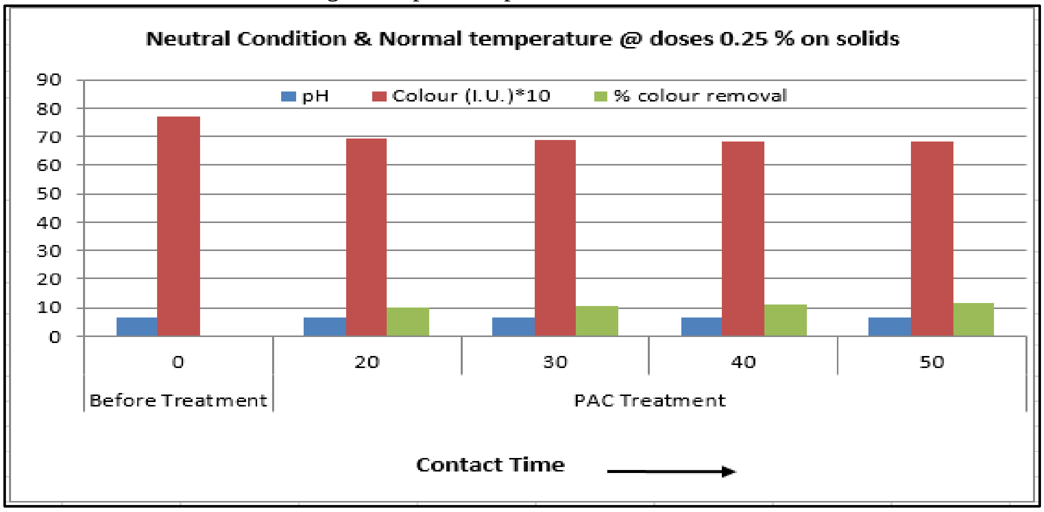
Particulars	pH	Brix %	Colour (I.U.)	Retention (Minutes)	% colour removal
Raw melt	6.57	52.00	392	0	0
Raw melt + PAC	6.30	53.50	119	20	69.64
Raw melt + PAC	6.21	54.25	115	30	70.66
Raw melt + PAC	6.20	55.50	117	40	70.15
Raw melt + PAC	6.20	56.50	120	50	69.39

V. RESULT & DISCUSSIONS

EXPERIMENT-1

With reference to the above experiments of table 4, it was observed that the maximum colour reduction of about 11-12 % only & there were no more changes found for the reaction of PAC at normal temperature. Therefore, the temperature of the re-melt liquor increases to 800C and found good result at different doses of PAC & reaction time @ 30 minutes. The trial was basically conducted to check the effectiveness of reaction time. The graphical representation of table 4 is given as below:

Fig 1: Graphical representation of table-4



EXPERIMENT-2

With reference to experiments as per data contained in table 5 to 8, it was observed that the maximum colour reduction occurred at 30 minutes' retention time & thereafter the colour moves on higher side which might be due to the higher retention time at higher temperatures. The trial was basically conducted to check the effectiveness of reaction time. The graphical representation of table 5 to 8 is given as below:

Fig 2: Graphical representation of table 5

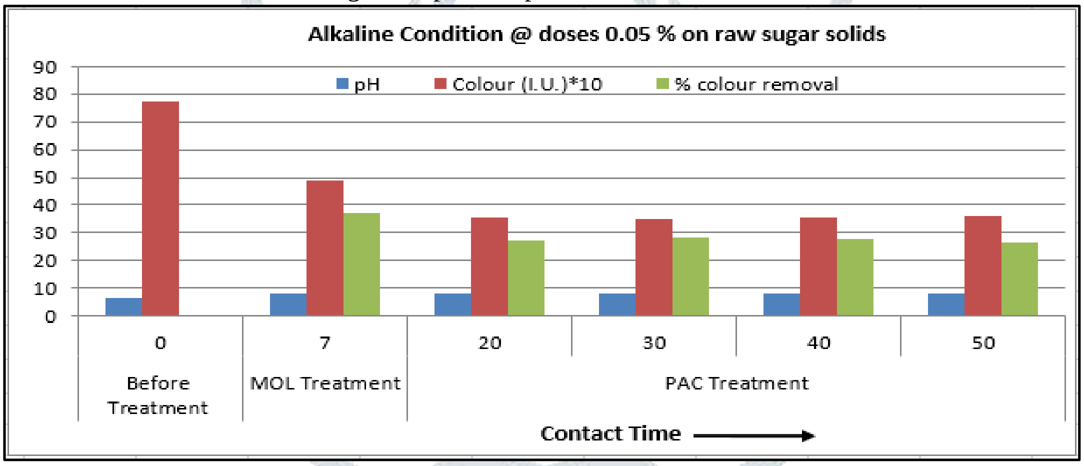


Fig 3: Graphical representation of table 6

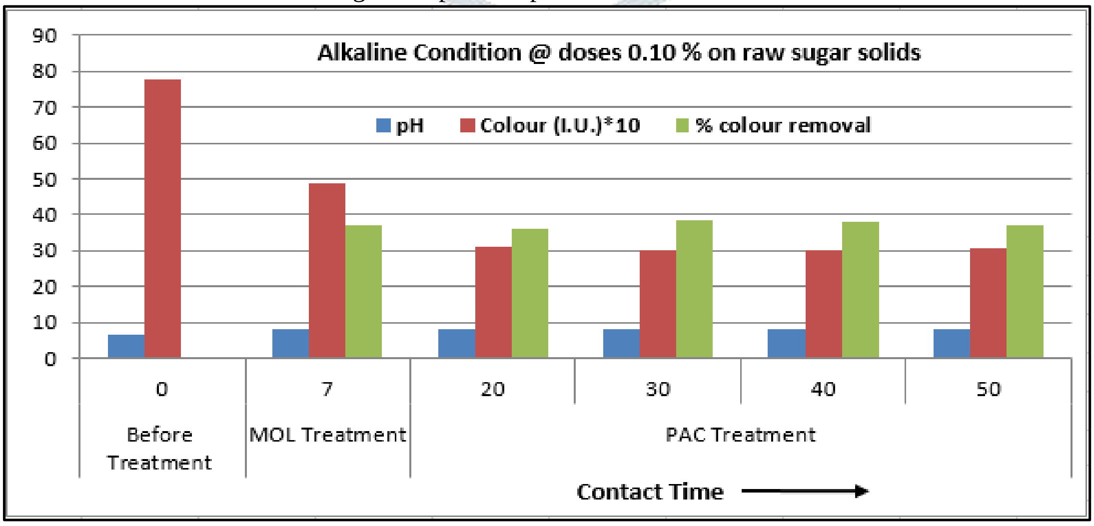


Fig 4: Graphical representation of table 7

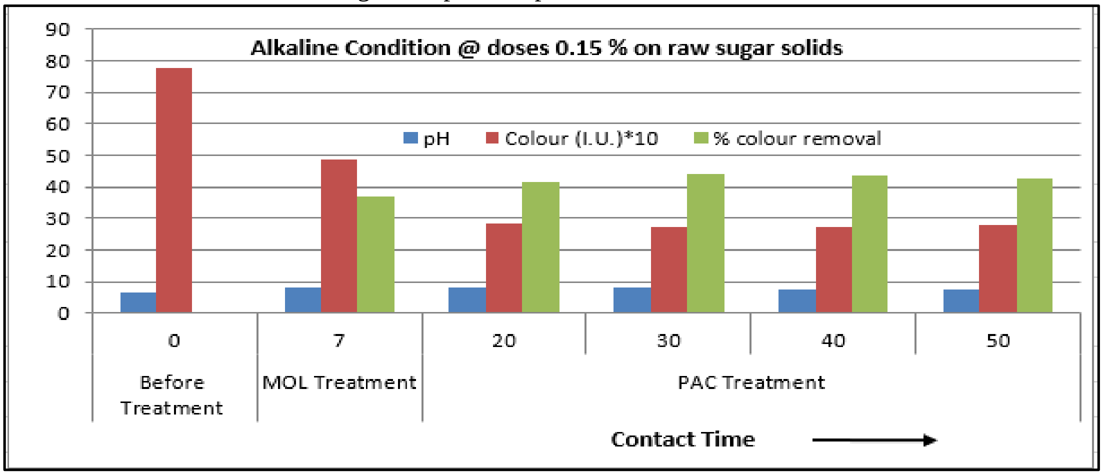
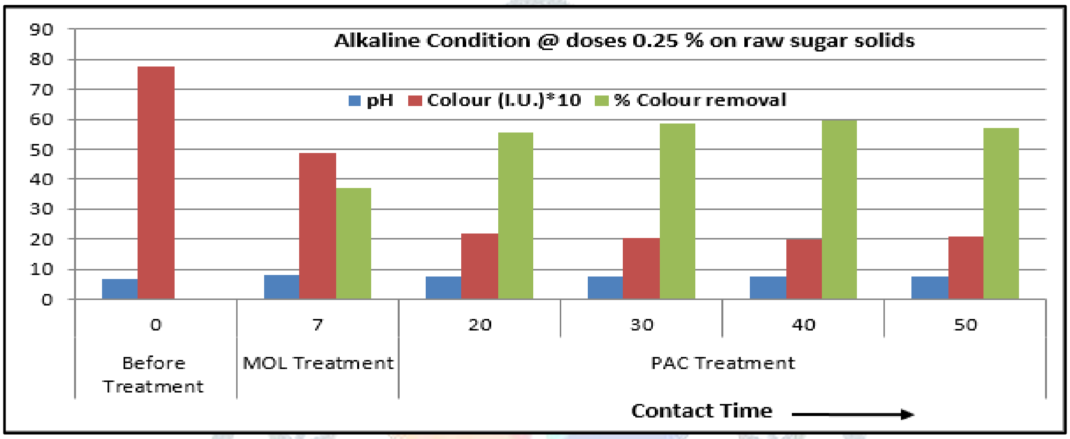


Fig 5: Graphical representation of table 8



EXPERIMENT-3

With reference to the above experiments as per data contained in table 9 to 19, it was observed that the maximum colour reduction took place at retention time 30 minutes & thereafter the colour increased due to the higher retention time at higher temperatures. The trial was basically conducted to check the effectiveness of reaction time. The graphical representation of table 9 to 13 is given as below:

Fig 6: Graphical representation of table 9

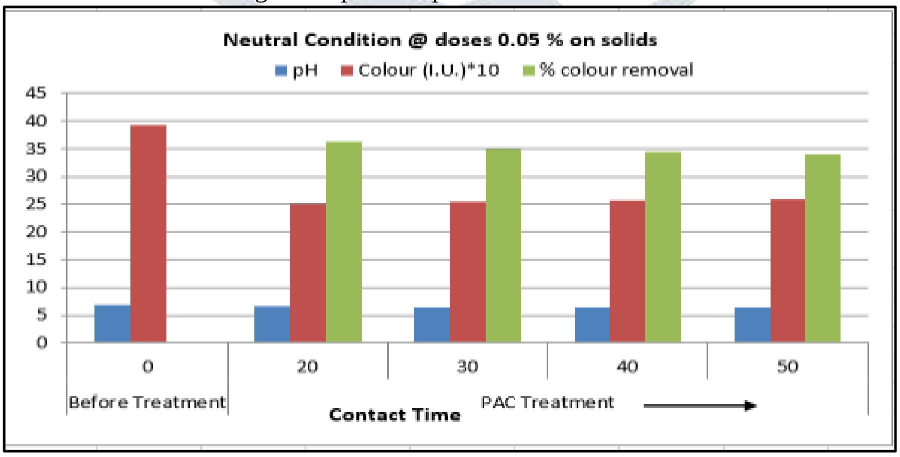


Fig 7: Graphical representation of table 10

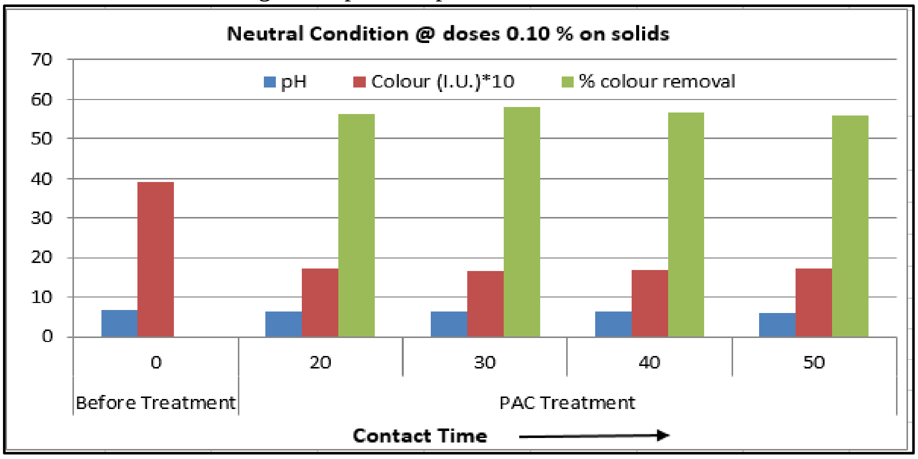


Fig 8: Graphical representation of table 11

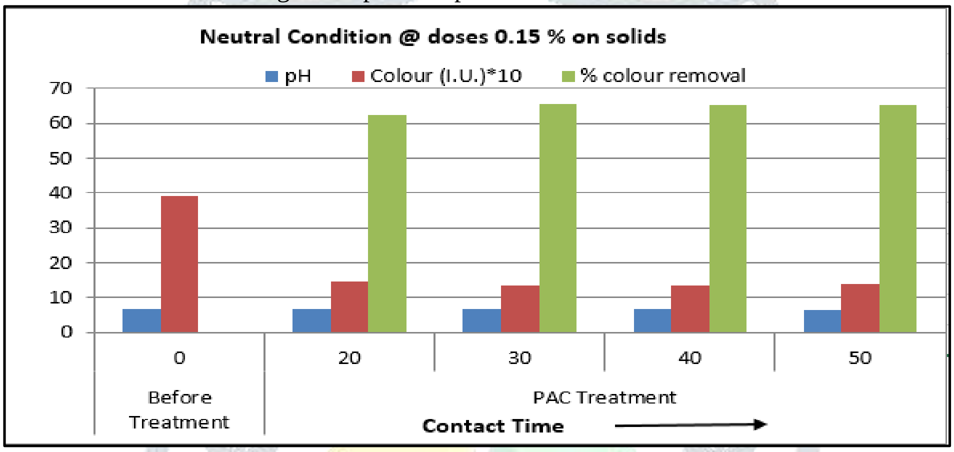


Fig 9: Graphical representation of table 12

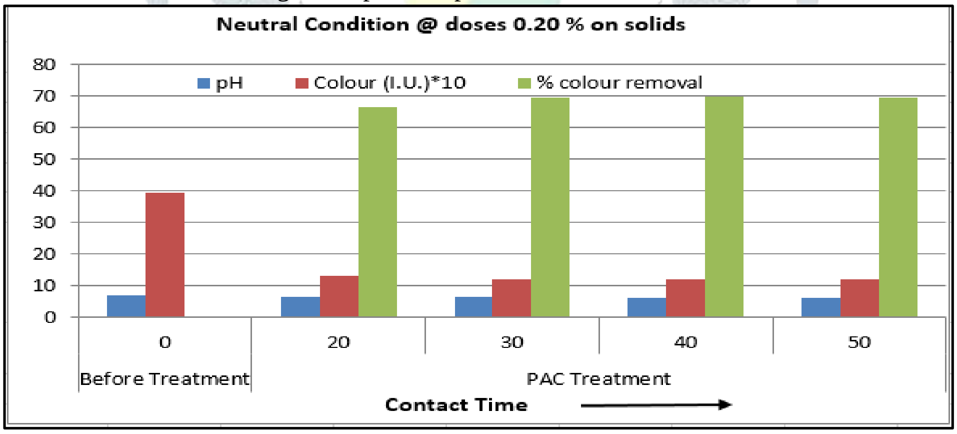
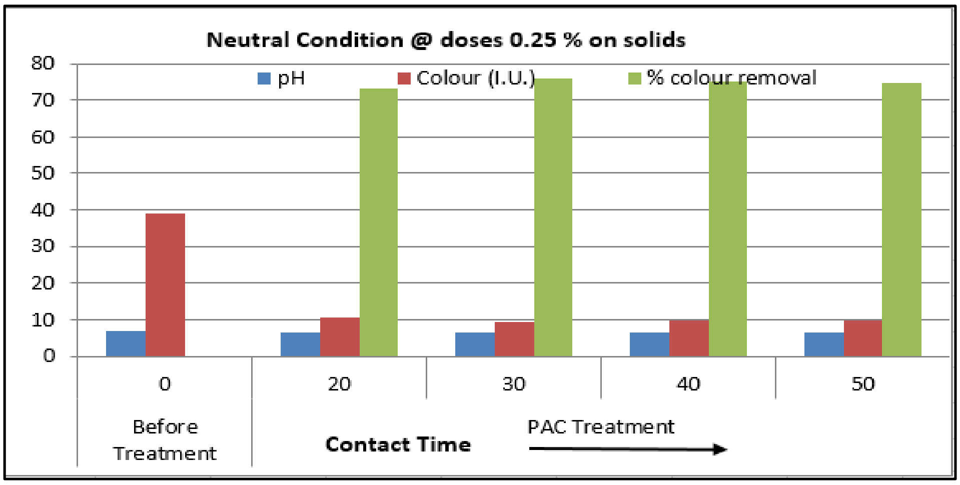


Fig 10: Graphical representation of table 13



EXPERIMENT-4

In this set of experiments also it was observed that the maximum colour reduction occurs at retention time 30 minutes & thereafter the colour goes on higher side due to the higher retention time at higher temperatures. The trial was basically conducted to check the effectiveness of reaction time. The graphical representation on the basis of data contained in table 20 to 24 is given as below:

Fig 11: Graphical representation of table 20

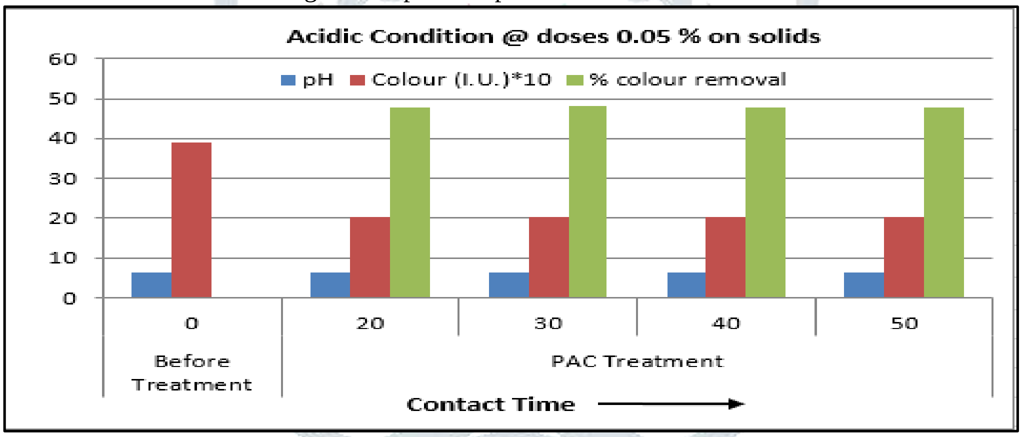


Fig 12: Graphical representation of table 21

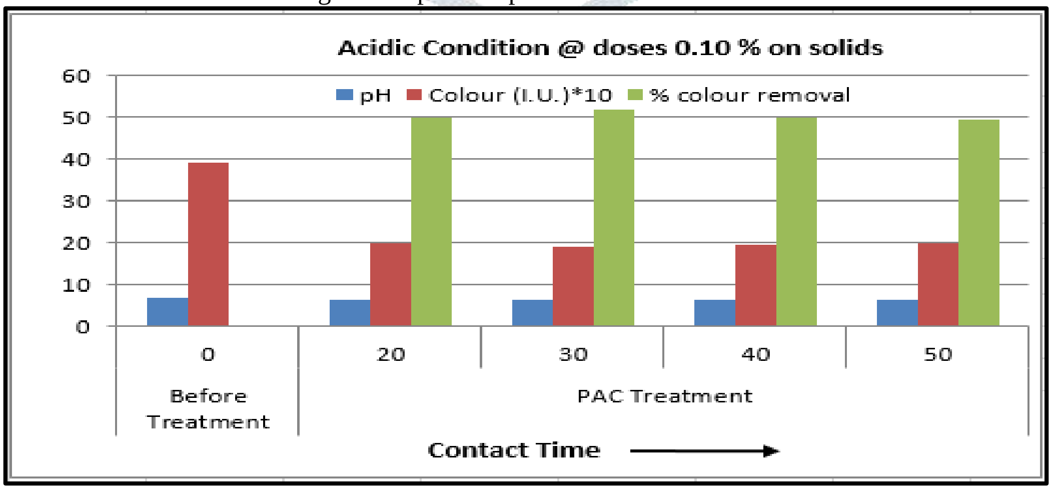


Fig 13: Graphical representation of table 22

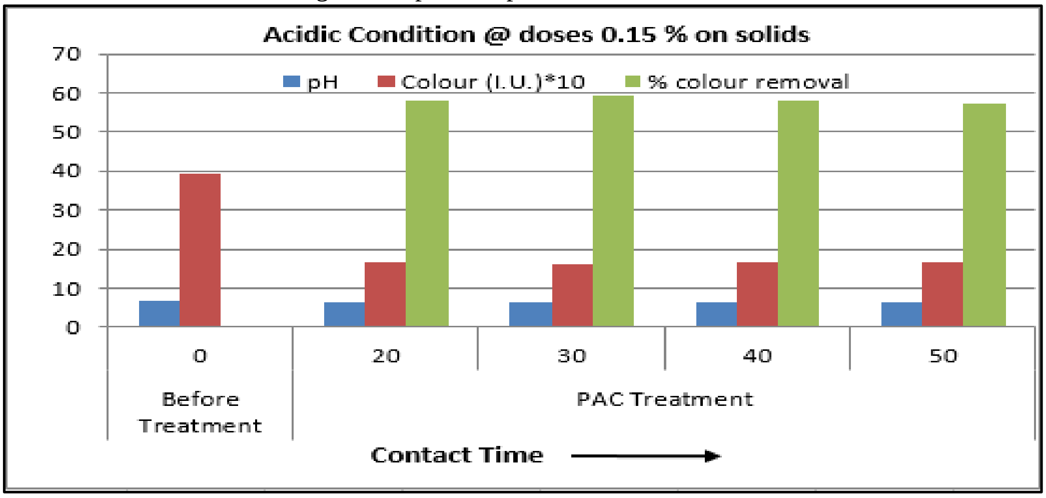


Fig 14: Graphical representation of table 23

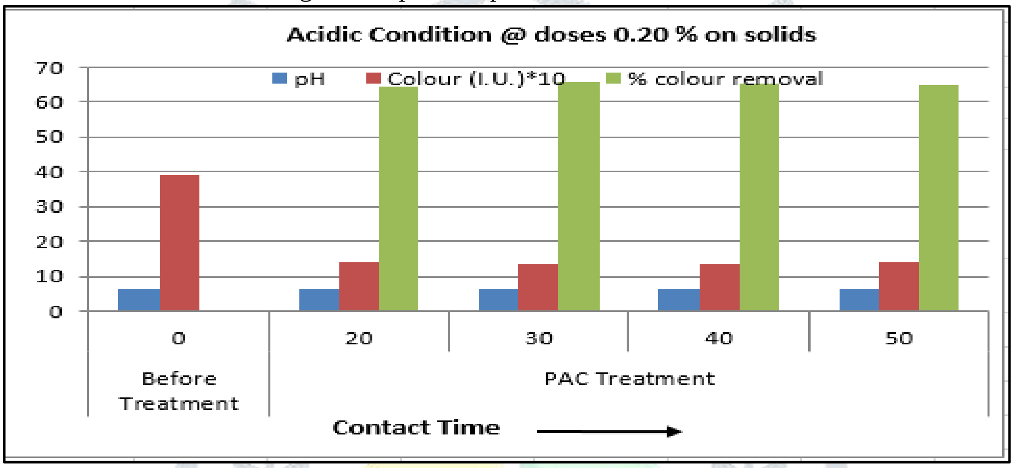
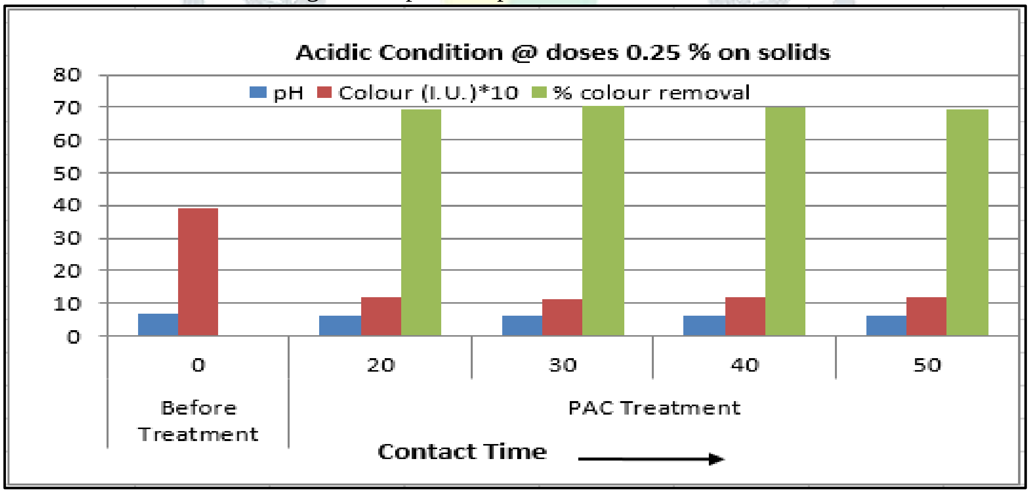


Fig 15: Graphical representation of table 24



Conclusion

With reference to the results of experiments as discussed, it is observed that PAC does not show the desired decolourisation effect at normal temperature for the cane raw sugar melt under any conditions i.e. Alkaline, Acidic or Neutral. In all the cases, the decolourisation effect is limited up to 11-12 % maximum, which is not a good indicative figure for decolourisation of clarified melt considering the cost of activated carbon and dosage rate in sugar liquor considered.
It is observed that PAC has higher adsorptive properties in Acidic and Neutral medium ranging pH values between 6.45 to 6.98 for the cane raw sugar melt. In Alkaline conditions, the decolourisation effect is limited up to 37 % maximum considering the highest dosage rate i.e. addition of 0.10 % PAC dose on remelt sugar solids.

However in Neutral medium with the same dose rate of PAC, the decolourisation effect is up to 58 % which is lucrative / beneficial as it can also avoid further inversion of melt due to acidic medium.

Thus, it may be inferred that PAC has higher adsorptive properties in Acidic and Neutral medium than alkaline conditions.

With reference to conduct, it is also observed that optimum retention time in all the cases is 30 minutes. In all the cases, whenever retention time increases beyond 30 minutes, the remelt liquor colour increases.

From the observations made by experiment of all the three different types of medium selected to use powdered activated carbon to raw melt decolourisation, it is concluded that the process as described in earlier paragraph may be the beneficial for smaller refineries.

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