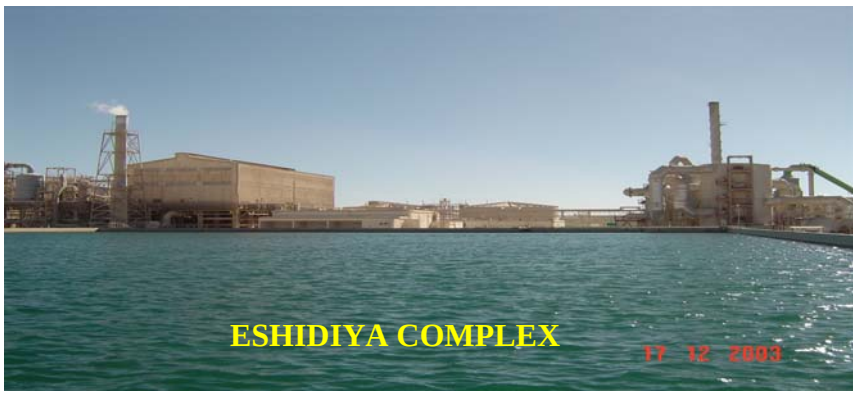
USE OF SUB COMMERCIAL(60-65 TCP) ROCK PHOSPHATE IN HEMI PHOSPHORIC ACID PLANT- CHALLENGES AND OPPORTUNITIES



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PREAMBLE

INDO - JORDAN CHEMICALS COMPANY LTD. (IJC)

IS A JOINT VENTURE PROMOTED BY:

- SOUTHERN PETROCHEMICALS INDUSTRIES CORPORATION LTD (SPIC) - INDIA
- JORDAN PHOSPHATE MINES COMPANY LTD (JPMC) - JORDAN
- THE ARAB INVESTMENT COMPANY SAA (TAIC) - SAUDI ARABIA

IJC HAS ESTABLISHED A PHOSPHORIC ACID COMPLEX IN THE SPECIAL INDUSTRIAL FREE ZONE IN ESHIDIYA – JORDAN.

PREAMBLE (contd.)

THE PHOSPHORIC ACID COMPLEX CONSISTS OF :

- A 2,000 MT/ day MONSANTO DCDA SULPHURIC ACID PLANT
- A 700 MT/day HYDRO - AGRI SINGLE-STAGE HEMI - HYDRATE PHOSPHORIC ACID PLANT
- ASSOCIATED UTILITIES AND OFFSITES

PREAMBLE (contd.)

- IJC COMMISSIONED ITS PLANTS EARLY 1997.
- IJC CROSSED 100 % CAPACITY UTILISATION OF ITS PLANTS FOR SIX OUT OF EIGHT YEARS SINCE ITS COMMISSIONING.

ANALYSIS OF COMMERCIAL AND SUB COMMERCIAL ROCK PHOSPHATE PROCESSED

ANALYSIS OF COMMERCIAL ROCK PHOSPHATE PROCESSED

Description	1998	1999	2000	2001	2002	2003	2004	2005
TCP	70.52	70.57	71.07	71.13	71.78	71.93	72.25	71.73
P_20_5	32.28	32.30	32.52	32.55	32.85	32.92	33.07	32.83
CaO	48.82	48.00	48.15	49.14	50.25	50.44	50.72	50.18
CO2	4.13	3.47	3.60	3.83	3.99	4.19	4.22	3.56
SiO_2	4.63	6.37	6.41	4.68	4.09	4.39	3.05	4.24
Fluoride	3.08	2.97	3.38	3.70	3.91	3.76	3.77	2.94
Chloride	0.025	0.04	0.039	0.049	0.068	0.040	0.04	0.04
Al_2O_3	0.31	0.26	0.22	0.29	0.35	0.36	0.40	0.47
Fe_2O_3	0.19	0.32	0.25	0.25	0.31	0.25	0.27	0.35
Moisture	15.90	15.25	14.59	14.68	14.82	14.99	15.83	13.30

ANALYSIS OF SUB COMMERCIAL ROCK PHOSPHATE PROCESSED

Description	1999	2000	2001	2002	2003	2004	2005
TCP	63.06	63.59	64.77	63.68	62.32	62.74	61.81
P_20_5	28.86	29.10	29.64	29.14	28.52	28.71	28.29
CaO	41.44	42.80	44.64	44.72	43.73	44.13	43.36
CO2	3.02	3.55	3.56	3.93	4.02	3.72	3.60
SiO_2	14.59	14.92	9.98	10.62	11.36	10.43	10.41
Fluoride	2.52	3.11	3.52	3.61	3.65	3.70	2.87
Chloride	0.036	0.0	0.047	0.081	0.081	0.08	0.082
Al_2O_3	0.27	0.27	0.37	0.61	0.64	0.76	0.77
Fe_2O_3	0.49	0.45	0.41	0.52	0.50	0.55	0.59
Moisture	15.56	15.01	11.05	5.93	4.28	5.21	3.68

COMPARISON OF COMMERCIAL & SUB COMMERCIAL ROCKS

Description	Commercial (70 - 72 TCP) rock			Sub commercial rock (60-65 TCP)			% change
	min	max	ave	min	max	ave	
CaO/P2O5	1.480	1.534	1.514	1.436	1.537	1.507	0%
F/SiO2	0.466	1.236	0.774	0.173	0.354	0.289	63%
R2O3/P2O5	0.014	0.025	0.018	0.025	0.048	0.036	-94%
R2O/P2O5	0.013	0.018	0.015	0.015	0.020	0.017	-9%
F/P2O5	0.090	0.119	0.105	0.087	0.129	0.114	-8%
CO2/P2O5	0.108	0.128	0.119	0.105	0.141	0.126	-6%

COMPARISON OF COMMERCIAL & SUB COMMERCIAL ROCKS

1. The silica content is much higher in sub commercial rock due to low TCP content.
2. The CaO/P2O5 ratio is almost same in commercial and sub commercial rocks, even though there is wide difference in TCP content.
3. The R2O3/P2O5 ratio in sub commercial rock is more than that of commercial rock.
4. The other constituents are high on relative basis.

COMPARISON OF COMMERCIAL & SUB COMMERCIAL ROCKS

5. In other words, for one MT of P_2O_5 production, the total amount of constituents (R_2O_3, R_2O, F, SiO_2 etc) fed to the reactors is much higher when sub commercial rock is processed compared to that of commercial rock.
6. Accordingly, suitable changes in process parameters and operating procedures / equipment, based on the blending ratio, have been employed.

EVALUATION OF PLANT PERFORMANCE

FEED ROCK QUALITY

Year	Yearly wt. Av.TCP (%)	Yearly wt. Av.P2O5 (%)
1998	70.55	32.29
1999	70.36	32.20
2000	69.00	31.58
2001	67.76	31.01
2002	66.18	30.29
2003	64.83	29.67
2004	64.46	29.50
2005	63.76	29.18

PLANT PERFORMANCE

Year	Production (MT P2O5)	On stream days achieved	Capacity Utilisation (%)	Onstream Factor (%)	Onstream efficiency (%)
1998	237,874	325	106	89	119
1999	224,847	314	100	86	117
2000	224,123	288	100	79	127
2001	192,010	257	86	70	122
2002	250,422	325	112	89	126
2003	231,884	326	104	89	116
2004	218,523	330	98	90	108
2005	229,307	324	102	89	115

PLANT PERFORMANCE

- The yearly average TCP content in rock fed to the reactors got reduced from 70.55 (1998) to 63.76 (2005), as the ratio of sub commercial rock fed is increased.
- During the year 2002, the average TCP content was 66.18, and highest capacity utilization of 112% was achieved.

PLANT PERFORMANCE

- The on stream days achieved during the years 2002 to 2005 (around 50% is sub commercial rock) are around 325 days and almost same as that achieved during the year 1998 (100% commercial rock) as against the design stream days of 320.
- The on stream efficiency is maintained well above 100% during the period 1998 to 2005 even while using sub commercial grade rock phosphate by optimization of critical process parameters.

PLANT PERFORMANCE

- The specific consumption of raw materials and chemicals has increased when high blend ratios of sub commercial rock are used.
- The plant maintenance expenditure has also increased during last three years.

QUALITY OF PHOSPHORIC ACID PRODUCED

QUALITY OF PHOSPHORIC ACID PRODUCED

Year	P2O5 (%)	R2O3 / P2O5
1998	54.51	0.008
1999	54.14	0.015
2000	56.17	0.020
2001	56.30	0.019
2002	56.39	0.022
2003	55.95	0.024
2004	56.12	0.024
2005	55.95	0.029

QUALITY OF PHOSPHORIC ACID PRODUCED

- The product acid concentration is higher than design 54%.
- Product acid concentration is maintained at 56% since 2000 to reduce transportation costs, even though sub commercial rock was used.
- Lower throughput from concentrators due to high R2O3 and low P2O5 in feed acid.
- Increase of R2O3 in product acid, but within the acceptable range.

QUALITY OF PHOSPHORIC ACID PRODUCED

Product acid contains low heavy metals due to :

1. **Process employed is hemi hydrate process.**
2. **Jordan rock phosphate is used.**

MAIN PROBLEMS FACED AND SOLUTIONS ADOPTED

MAIN PROBLEMS FACED AND SOLUTIONS ADOPTED

a) Not same as blending two commercial rocks.

b) It was a great challenge to operating and maintenance personnel.

c) Severe operating problems to sustain the rated production and plant availability.

d) Wash cycle time for filters / scrubbers / concentrators got reduced leading to lower on stream factor.

e) Severe erosion of pump impellers and brick lining.

MAIN PROBLEMS FACED AND SOLUTIONS ADOPTED

A. Foreign materials in rock phosphate

- Foreign materials (hard stones, metals pieces etc) were noticed in rock supplies. Damages to the rock feeder belts, conveying equipment and cause severe erosion in reactors.
- Two vibrating screens were introduced, Additionally, grids are provided for all underground rock feeders (extractors for the storage piles).

MAIN PROBLEMS FACED AND SOLUTIONS ADOPTED

B. Coarse material in rock phosphate

- Larger than 2 mm (design 100% < 2 mm) is noticed. Settling in first reactor without undergoing any reaction. Severe erosion of carbon brick lining of the reactors.
- Increasing the quality checks. Periodically draining the first reactor and recycling the decanted acid. Additional layer of brick lining at critical areas of reactors.

MAIN PROBLEMS FACED AND SOLUTIONS ADOPTED

C. Reaction system

- For a given rock feed rate, the P_2O_5 fed to reactors is lower and impurities are higher as the blending ratio increases. Wide fluctuation in reaction parameters .
- Modification of plant water balance and optimisation of process parameters. Slurry parameters in last reactor (R2) are: P_2O_5 – 38 to 40%, Solid content – 29 to 32% w/w and SO_4 – 1.6 to 2.0%. No change in reaction temperatures.

MAIN PROBLEMS FACED AND SOLUTIONS ADOPTED

D. Filtration system

- Filter cake produced is higher as the blending ratio is increased.
- Wash ratios and filter cycle time are slightly reduced to optimise the filtration efficiency and the acid concentration. The speed of the vacuum pumps is increased to meet the additional vacuum load and higher plant loads. The width of the filter cloth is increased by 100 mm.

MAIN PROBLEMS FACED AND SOLUTIONS ADOPTED

E. Gas Scrubbing system

- Total silica content is high. 70 to 80% of total silica is reactive. Frequent fouling of gas scrubbing system.
- The concentration / temperature of circulating liquor in scrubbing system are reduced. The frequency of manual cleaning increased to once in a month. One additional scrubbing fan is installed.

MAIN PROBLEMS FACED AND SOLUTIONS ADOPTED

F. Concentration system

- Filter acid concentration is lower at 38-40%. The throughput from the existing two concentrators is not adequate.
- Additional recycling of sludge settled in product storage tank (56% P2O5) to filter acid storage tank (40% P2O5) to increase the acid concentration to 42% P2O5. Addition of a third concentration unit of same capacity during May 2005.

OPTIMUM BLEND RATIO OF SUB COMMERCIAL ROCK PHOSPHATE

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- Production rate
- Plant Availability
- On stream efficiency
- Maintenance / Chemicals cost

OPTIMUM BLEND RATIO OF SUB COMMERCIAL ROCK PHOSPHATE

A. Production rate:

- IJC phosphoric acid plant is designed to process 70 TCP rock phosphate and able to produce 800 MT P2O5/day.
- While processing feed rock with average 66 TCP, the existing reaction system is able to produce 800 MT P2O5/day.

OPTIMUM BLEND RATIO OF SUB COMMERCIAL ROCK PHOSPHATE

A. Production rate:

- The production rate has started declining when the average TCP content in rock feed is lower than 66 TCP, which corresponds to around 50% blend ratio.
- This is essentially due to the fact that the original reactor volume of 2 m3/MT P2O5/day has not been increased.

OPTIMUM BLEND RATIO OF SUB COMMERCIAL ROCK PHOSPHATE

B. Plant Availability:

- The scaling was found to be increasing exponentially with blend ratio of sub commercial rock due to high silica content and other impurities.
- At blend ratios of 30 to 50%, the frequency of cleaning the scrubbing system is once a month, and it reduces to 15-20 days at higher blend ratios of 70% and more.

OPTIMUM BLEND RATIO OF SUB COMMERCIAL ROCK PHOSPHATE

B. Plant Availability:

- The filter and concentrator cycle times also get reduced drastically at higher blend ratios. This results in additional down time and lower plant availability.

OPTIMUM BLEND RATIO OF SUB COMMERCIAL ROCK PHOSPHATE

C. On stream efficiency:

The average on stream efficiency is lower at higher blend ratios, which could be due to

- lower P_2O_5 in rock feed to reactors,
- more vapour evolution per MT of P_2O_5 production and foaming problems in reaction system
- very tight water balance in the plant.

OPTIMUM BLEND RATIO OF SUB COMMERCIAL ROCK PHOSPHATE

D. Maintenance / Chemicals cost:

The maintenance cost of equipment has gone up steeply (at higher ratios of sub-commercial rock), due to severe erosion of pump impellers / agitator blades, conveyor belts/rollers and rubber lined ducts / equipment.

The cost of chemicals also increased due to high foaming problems leading to higher consumption of defoamer.

OPTIMUM BLEND RATIO OF SUB COMMERCIAL ROCK PHOSPHATE

D. Maintenance / Chemicals cost:

The total cost of production increases exponentially with blend ratio beyond 50%.

OPTIMUM BLEND RATIO OF SUB COMMERCIAL ROCK PHOSPHATE

Considering the overall plant performance (production rate, plant availability, on stream factor and maintenance/chemicals cost) as well as the various technical problems faced at higher blend ratios, the recommended optimum blend ratio is 50% to derive maximum benefits from the use of sub commercial rock phosphate.

BENEFITS FROM USE OF SUB COMMERCIAL ROCK PHOSPHATE

BENEFITS FROM USE OF SUB COMMERCIAL ROCK PHOSPHATE

- It is unique situation wherein both the buyer and the seller of rock phosphate would benefit.
- As the sub commercial rock needs to be disposed off suitably, phosphate producer (seller) needs to incur an additional expenditure. If this rock phosphate were supplied to/used in phosphoric acid plant, this would generate an additional revenue for the seller due to value addition to the sub commercial rock phosphate.

BENEFITS FROM USE OF SUB COMMERCIAL ROCK PHOSPHATE

- As the unit cost of sub commercial rock is obviously lower compared to commercial rock, phosphoric acid producer (buyer) would generate additional revenue due to reduction in cost of production of phosphoric acid.
- A part of the revenue generated has to be spent for additional maintenance expenditure and higher chemicals consumption based on the blend ratio employed.

BENEFITS FROM USE OF SUB COMMERCIAL ROCK PHOSPHATE

- The optimum blend ratio for each plant needs to be evaluated based on actual plant operating data to derive maximum benefits.
- Additionally, use of sub commercial rock would either increase the opportunity for export of equivalent quantity of commercial rock or improve the phosphate reserves for extended time. This would in turn increase the foreign earnings for the country.

BENEFITS FROM USE OF SUB COMMERCIAL ROCK PHOSPHATE

The other benefits include:

- Sub commercial rocks, which contain high R_2O_3, can be blended with commercial rock containing low Al_2O_3. to reduce/ eliminate external dosing of Al_2O_3.
- Sub commercial rocks, which contain high SiO_2, can be blended with commercial rock with high fluorine to alter F/SiO_2 ratio in rock feed, thereby reducing the corrosion.
- Environmental benefits for the phosphate mines.

FUTURE PROSPECTS FOR SUB COMMERCIAL ROCK PHOSPHATE

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Scenario 1:

Considering the general decline in quality of rock phosphate in the existing operating phosphate mines, the emphasis on processing of low grade rocks will continue to increase due to obvious logistics.

FUTURE PROSPECTS FOR SUB COMMERCIAL ROCK PHOSPHATE

Scenario 2:

For those plants, which are located / being located close to the phosphate mines, use of sub commercial rocks, as a blend, would eventually be an economical proposition, though suitable technical solutions/practices need to be considered.

FUTURE PROSPECTS FOR SUB COMMERCIAL ROCK PHOSPHATE

With the advent of developments in phosphate technology / industry, use of sub commercial/ low grade rocks, which are considered not feasible hitherto, would become a viable option for phosphoric acid producers in the future.

CONCLUSION

1. Use of sub commercial or low grade rock phosphate at optimum blend ratio with commercial rock phosphate is technically feasible and the overall plant performance can be maintained at almost the same level as that achieved with the use of commercial rock alone.
2. The optimum blend ratio for continuous plant operation is 50% for deriving the maximum benefits from plant availability as well as on stream efficiency keeping the maintenance / Chemicals costs at reasonable level.

CONCLUSION

3. The experience gained at IJC would offer an excellent opportunity for Phosphoric Acid producers who are located close to the phosphate mines to seriously consider processing sub commercial / low grade rock phosphate to achieve maximum benefits.

PLANT PERFORMANCE

Year	Filter washing details			Concentrator washing details			
	Filter - I	Filter - II	Total no.of washings	Conc - I	Conc - II	Conc - III (#)	Total no. of washings
1998	71	74	145	42	42	-	84
1999	46	47	93	41	45	-	86
2000	43	38	81	27	38	-	65
2001	22	29	51	22	22	-	44
2002	31	33	64	40	37	-	77
2003	39	32	71	30	36	-	66
2004	30	29	59	45	43	-	88
2005	30	33	63	26	25	14	65
	# Concentrator III was commissioned during May 2005.						