Enhancing profitability the smart way - without capex

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ABOUT THE AUTHOR

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ABSTRACT

The Indian Cement Industry, the second largest in the world, is in the grip of a wide-sweeping environmental change. Over capacity, slackening of demand growth, see-sawing prices, shrinking realizations, the now on - now off market agreements, the regional focus of the Global Giants, the accelerated conversion to blended cements - it's all happening! Success, and even survival, depends on how nimbly companies prepare themselves to cope.

With manufacturers wielding a limited control on variables dominated by the external environment, an enhanced focus on internally controllable variables is an absolute imperative.

Most companies have therefore initiated performance improvement programs covering various aspects of cement operations. With markets displaying clear signs of product differentiation, and different products consuming different production resources, the latent potential of appropriate product mix planning in enhancing the bottom-line is being increasingly recognized.

This paper, defines Holtec's approach to product planning. It takes an integrated view of marketing, production, inventory control and related functions in order to optimize selected performance parameters.

The paper also presents two real-life Case Studies in the Indian Cement Industry that highlight the performance outcomes achieved through the application of different features of the proposed approach.

1.0 INTRODUCTION

The Indian Cement Industry is passing through an intensely competitive phase, as growth in production potential continues to outstrip growth in demand. As a natural corollary, returns in the cement industry, despite intermittent upsurges, continue to be severely constrained. While large segments of the industry continue to flounder, progressive companies are increasingly using this as an opportunity to innovate.

Apart from price, brand image and quality, which have so far played significant roles in influencing the push-pull characteristics of cement demand, there appears to be a growing market awareness of the use of different types of cements for different applications. Currently, the options available include:

- 33, 43 and 53 grades of Ordinary Portland Cement (OPC),
- Blended cements such as Portland Pozzolana Cement (PPC) & Portland Slag Cement (PSC), grades for which are currently under consideration.
- A host of special cements such as White Cement, Sulphate Resistant Cement (SRC), Oil Well Cement (OWC), Masonry Cement (MC), Rapid

Hardening Cement (RHC), Low Heat Cement (LHC), etc. meant for very specific applications.

With product specifications, market demands, prices, input requirements, equipment utilisation and costs being different for different products, the zero investment potential of a product planning exercise, in influencing the bottom-line, is clearly evident.

2.0 PRODUCT PLANNING

Integrated product planning is an exercise targeted at basically answering the following two questions:

- What product(s) should the company be manufacturing?
- What facilities and resources should be used in the process of manufacture?

The output of such an exercise is termed as the **optimum product mix**.

Traditionally, product mix decisions in the cement industry have largely been influenced by the market. In the buyers' market of today, **what the consumer requires has to be produced** and not the other way around. However, the success of a company lies in making the optimum choice – a choice between the products that it can sell, after taking into consideration the revenues (read as prices x volumes) it can expect on the demand side and the costs & material/ resource constraints imposed by the supply side.

Each item in a product mix contributes differentially to total sales, profits and resource utilization. Thus, it becomes essential to know the proportion of total sales, profits and resource utilization, contributed/ consumed by each product. The analysis of the current mix is essential to determine the extent of reliance on each product and the possible impact caused by volume changes consequent to external factors.
An appropriate product mix assures the following advantages:

- Superior profit performance.
- Optimum utilisation of available resources, be it money, materials or machines.
- Strategic presence in different market segments.
- Protection against vulnerability due to changes in market characteristics.

Product mix decisions are not as simple as they may appear. This is because the overall profitability of the company is governed by several factors, including the direct & indirect costs incurred in production, distribution and promotion. Moreover, as new cement types are added, several new costs arise, which may include design and engineering costs, inventory costs, manufacturing changeover costs and costs for promoting the entire product range.

A judicious approach, therefore, has to be taken to determine the product mix. Though cement is not a very technologically intensive product, the production planning exercise is nevertheless, governed by a multitude of constraints - both marketing and technical, which are difficult to analyze in isolation. Mathematical modelling provides an efficient method to optimally integrate these.

Holtec Consulting has carried out several exercises in product planning for both, domestic and international, cement companies. This paper describes the methodology adopted and the outcomes achieved in two different cases.

3.0 CASE STUDIES

For reasons of confidentiality, the identity of the companies, have not been revealed.

3.1 Assignment Objective

The clients, in both the exercises, wanted Holtec to recommend an optimum product mix for the immediate future. In addition, they also wished to determine the tangible benefits they would have derived in the period just transpired, had they adopted the prescribed optimization model.

3.2 Assignment Backdrop

The geographical setting for both the cases is the second largest cement market in the world - India.

Case - I : This concerns a 2.8 million tpa cement plant, employing three kilns, 3 cement mills and 7 cement silos. The plant's location enables it to service markets in 8 states of the country. In the past, the plant had been manufacturing and selling differing proportions of 5 products viz. OPC 33, OPC 43, OPC 53, PPC and SRC.

Case - II : This concerns a 2.2 million tpa cement plant, employing two kilns, 3 cement mills and 5 cement silos. The plant markets its products in 7 states. Till now the plant had been manufacturing and selling 3 products viz. OPC 43, OPC 53 and PPC.

3.3 Determinants

Determinants, that governed the development of the optimization model were:

- The respective **demand volumes** for each product were different in different markets. Since it was not possible to differentially estimate product demands for each grade of product, banding was done with respect to product types. Thus, while it was possible to forecast the demands for OPC and PPC separately, demands for OPC 33, OPC 43 and OPC 53 were considered to be in the same proportion to overall OPC, as manifested in previous consumption.
- Due to reasons of relative competitive advantage, the **ceiling market shares** that this plant could potentially capture were different for different markets. These were determined using Holtec's proprietary Competitive Advantage - Market Attractiveness (CAMA) Model.
- To be able to maintain an insurance presence in each market, product sales below certain floor limits, were not admissible. This resulted in the specification of **floor market shares** for each market.
- The average price realized at the factory gate, for each product, was different. These were back calculated from the respective **market prices** for each product, by removing all elements of the price waterfall, subsequent to the factory gate.
- For each product, **mill output rates**, as well as **unit energy consumption**, were different.
- **Material costs**, while being different for each cement type, were independent of the mill in which grinding was effected. However, **material availabilities** governed their maximum degree of usage.
- Due to a variety of **technical considerations** including plant layout, equipment connectivity, storage capacities, etc., it was not possible for the plant in **Case - I** to grind each cement type in each mill. However, the plant in **Case - II** had no such restrictions.

3.4 Model Selection

Mathematical models, available for product mix decisions, include linear programming, non-linear programming and integer programming. On account of the variables being continuous (i.e. not assuming integer values only) & non-negative, and the objective function & constraints being representable by linear equations, the **linear programming model** was found appropriate.

To carry out the product mix planning exercise **Holtec** employed proprietary software built specifically for these exercises. This package conveniently runs on a reasonably configured, Pentium class PC.

3.5 Decision Variables

The decision variables selected were the **production volumes of various cement types that needed to be ground in various mills**. It was assumed that separate runs would be carried out for different periods. Consequently, the time period does not appear as a component variable.

These variables are represented by "X_{ij}", which denote the tons of cement type "i", required to be ground in mill "j".

For **Case - I**, "i" varied between 1-5, with i=1 being OPC 33, i=2 being OPC 43, i=3 being OPC 53, i=4 being PPC and i=5 being SRC. Likewise, "j" varied between 1-3, with j=1 representing Mill No. 1, j=2 representing Mill No. 2 and j=3 representing Mill No. 3.

For **Case - II**, "i" varied from 1-3, with i=1 denoting OPC 43, i=2 denoting OPC 53 and i=3 denoting PPC; "j" varied from 1-3, each value respectively representing each of the 3 mills. Since this plant also sold clinker it was assumed that X_k would denote the quantity directly sold.

3.6 Objective Function

Maximization of total contribution was selected to be the overall objective.

The unit contribution was computed by subtracting the unit cost "C_{ij}" of producing cement type "i" from mill "j", from the factory gate price "R_i" of product type "i". "C_{ij}" itself was computed by adding the unit material cost "M_i" of product type "i" to the unit energy cost "P_{ij}" of grinding cement type "i" in mill "j". Given the existing energy tariff and the unit energy consumption in each mill for each product type, "P_{ij}", was easily computable. All other costs, common to the production of all cement types, could be conveniently ignored since these negated each other in making a choice and thus had no effect on the final solution.

In **Case - II**, the unit contribution from clinker directly sold was computed by subtracting the unit cost (C_k) from the factory gate price (R_k)

The objective function was thus written as:

For Case - I

$$\textbf{Maximise} \sum_{i=1}^{5} \sum_{j=1}^{3} X_{ij} (R_i - C_{ij})$$

For Case - II

$$\textbf{Maximise} \sum_{i=1}^{3} \sum_{j=1}^{3} X_{ij} (R_i - C_{ij}) + X_k (R_k - C_k)$$

3.7 Constraints

The objective functions stated above, were required to be maximised subject to simultaneously satisfying several sets of constraints.

3.7.1 Market Constraints

The tonnages of each cement type were constrained by the limits imposed by summing the volumes across each market computed from potential values of ceiling market shares and floor market shares.

However, in **Case – II**, the limiting volumes of clinker directly sold, due to strategic reasons, constituted an additional constraint.

The volumes thus arrived at appeared as Right Hand Side (RHS) constants "V_{iUL}" and "V_{iLL}", denoting the Upper Limit (UL) and the Lower Limit (LL) for cement type "i".

Thus for cement type "1", the relevant constraints were:

$$\sum_{j=1}^{3} X_{1j} <= V_{1UL} \text{ and,}$$

$$\sum_{j=1}^{3} X_{1j} >= V_{1LL}$$

Likewise, Upper and Lower Limit Market Constraints were developed for each product type in both **Case - I** and **II**.

Similar constraints were also imposed on the clinker directly sold in **Case - II**. These were :

$$X_k <= V_{kUL} \text{ and,}$$
$$X_k >= V_{kLL} \text{ and,}$$

The client in **Case - II** however desired that V_{kUL} be assumed to be the same as V_{kLL}.

3.7.2 Operating Hours Constraints

The mill capacities in terms of tons per hour of each cement type produced from each mill were already available as inverse coefficients "MC_{ij}". Given the operating hours available for each mill to be the RHS constants, "R_j", the relevant constraints were written for each mill.

Thus, for Mill No.1, the operating hours constraint was written as:

For Case - I

$$\sum_{i=1}^{5} X_{i1} / MC_{i1} <= R_1$$

For Case - II

$$\sum_{i=1}^{3} \mathbf{X_{i1} / MC_{i1}} <= \mathbf{R_1}$$

Likewise, equations were developed for the other mills as well.

3.7.3 Material Availability Constraints

For the types of cement considered, the materials required for their manufacture were clinker, pozzolana (fly ash) and gypsum. It was assumed that there were no limits on the materials (limestone, correctives and fuel) required to produce clinker equivalent to the actual kiln capacity. While there were definite limits on the availability of clinker (Cl) for both the plants, the availability of gypsum (G), in both plants, was unrestricted.
The availability of pozzolana (P) was restricted in **Case - I**. However, in **Case – II**, while availability from the current source was restricted, an alternate unconstrained source of supply was potentially available, albeit at a higher cost than that from the current source. Consequently, in **Case – II**, two scenarios were considered, one with restricted availability and the second without such an imposition.

Knowing that one ton of cement of type "i" required "Cl_i", "P_i" and "G_i" tons of the three materials, irrespective of the mill in which it is produced, the relevant constraints for material availability were formulated.

Thus, for clinker, the material availability constraint was written as:
For Case - I

$$\sum_{i=1}^{5} \mathbf{Cl_i} \sum_{j=1}^{3} \mathbf{X_{ij}} <= \mathbf{Cl}$$

For Case - II

$$\sum_{i=1}^{3} \mathbf{Cl_i} \sum_{j=1}^{3} \mathbf{X_{ij}} + \mathbf{X_k} <= \mathbf{Cl}$$

Similar constraints for pozzolana too were developed for both the cases. In **Case – II,** under the scenario of unlimited availability of pozzolana, the constraint equation was deleted from the total constraint set.

3.7.4 Technical Constraints

As already explained under 3.3, viz. Determinants, restrictions placed by the layout, equipment connectivity, storage capacities (cement silos in this case) and other technical considerations, it was not physically possible to grind each cement type in each mill in the plant considered in **Case - I**. This resulted in the following set of constraints:

$$\mathbf{X_{13}, X_{32}, X_{43}, X_{51}, X_{52} = 0}$$

However, for the plant in **Case - II,** no such constraints needed to be imposed

3.7.5 Non-negativity Constraints

As is apparent from physical considerations as well as the variable bounds applicable for Linear Programming problems, no variable can assume a negative value. Thus, for both cases:

$$\mathbf{X_{ij}} >= \mathbf{0} \quad \text{and} \quad \mathbf{X_k} >= \mathbf{0}$$

3.8 Situations Considered

The Base Situation for both **Case - I** and **II** were assumed to be the same as were prevalent in the period just transpired. Based on an appraisal of the relevant operational scenarios, 10 "What If" situations were analysed for each case. The Base Situation along with 3 selected "What If" Situations for each case are being reported in this paper. The conditions relevant to each of these situations and the respective outcomes are reproduced below.

3.8.1 Case - I

3.8.1.1 Base Situation

Conditions

- Same as those in the transpired period

Outcomes

- Revenue : 58.60 mio Euros
- Contribution : 11.60 mio Euros
- Production : 2.67 mio tons

3.8.1.2 "What If" Situation # 1

Conditions

- All conditions same as the Base Situation, except
- The quantities produced in each mill were assumed to be variable. However, the total production for each of the 5 types of cement was assumed to be the same as the Base Case.

Outcomes

- Revenue : 58.60 mio Euros
- Contribution : 11.79 mio Euros i.e. an increase of 0.19 mio Euros over the Base Case
- Production : 2.67 mio tons

Sensitivities

- Contributions could be increased by Euros 12.74 and Euros 23.84 for each additional operating hour available in Mill 2 and Mill 3, respectively

3.8.1.3 "What If" Situation # 2

Conditions

- All conditions same as the Base Situation, except
- Maximum demand restrictions were imposed on OPC 33, 43, 53 and PPC based on potentially achievable market shares. A maximum demand restriction, 20% greater than that achieved in the year transpired was imposed on SRC. Minimum demand restrictions, however, were imposed only on PPC and SRC, at levels attained in the year transpired.
- Potential availability of pozzolana was enhanced to equal the maximum volume contracted with the supply source.

Outcomes

- Revenue : 58.20 mio Euros; i.e. a decrease of 0.40 mio Euros from the Base Case
- Contribution : 11.90 mio Euros; i.e. an increase of 0.30 mio over the Base Case
- Production : 2.60 mio tons; i.e. a decrease of 0.07 mio tons from the Base Case.

Sensitivities

- Contributions could be increased by Euros 12.74 and Euros 23.84 for each additional operating hour available in Mill 2 and Mill 3, respectively.

3.8.1.4 "What If" Situation # 3

Conditions

- All conditions same as the Base Situation, except
- No production of OPC 33 and SRC

Outcomes

- Revenue : 57.80 mio Euros; i.e. a decrease of 0.80 mio Euros from the Base Case
- Contribution : 11.77 mio Euros; i.e. an increase of 0.17 mio over the Base Case
- Production : 2.60 mio tons; i.e. a decrease of 0.07 mio tons from the Base Case.

Sensitivities

- Contributions could be increased by Euros 9.56 and Euros 26.96 for each additional operating hour available in Mill 2 and Mill 3, respectively.
- Contribution could be increased by Euros 0.03 for every 1 ton increased in the maximum demand for OPC 43.

3.8.2 Case - II

3.8.2.1 Base Situation

Conditions

- Same as those in the transpired period

Outcomes

- Revenue : 47.60 mio Euros
- Contribution : 10.70 mio Euros
- Production : 2.17 mio tons

3.8.2.2 "What If" Situation # 1

Conditions

- All conditions same as the Base Situation, except
- The quantities produced in each mill were assumed to be variable. However, the total production for each of the 3 types of cement, as well as the direct clinker sales, were assumed to be the same as the Base Case.

Outcomes

- Revenue : 47.60 mio Euros
- Contribution : 10.86 mio Euros i.e. an increase of 0.16 mio Euros over the Base Case
- Production : 2.17 mio tons

Sensitivities

- Contributions could be increased by Euros 40.69 and Euros 91.40 for each additional operating hour available in Mill 1 and Mill 2, respectively.

3.8.2.3 "What If" Situation # 2

Conditions

- All conditions same as the Base Situation, except
- Maximum and minimum demand restrictions imposed on OPC 43 and OPC 53.

Outcomes

- Revenue : 47.68 mio Euros i.e. an increase of 0.08 mio Euros over the Base Case
- Contribution : 10.92 mio Euros i.e. an increase of 0.22 mio Euros over the Base Case
- Production : 2.17 mio tons.

Sensitivities

- Contributions could be increased by Euros 40.69 and Euros 91.40 for each additional operating hour available in Mill 1 and Mill 2, respectively.
- Contribution could be increased by Euro 0.50 for each ton of OPC 53 sold beyond the maximum demand restriction.
- Contribution could be increased by Euros 7.72 for each additional ton of pozzolana made available.

3.8.2.4 "What If" Situation # 3

Conditions

- All conditions same as the Base Situation, except
- Additional pozzolana available from new source albeit at a higher cost.
- Maximum and minimum sales of total cement are respectively 2.60 mio tpa and 2.10 mio tpa.

Outcomes

- Revenue : 48.35 mio Euros i.e. an increase of 0.75 mio Euros over the Base Case
- Contribution : 11.31 mio Euros i.e. an increase of 0.61 mio Euros over the Base Case
- Production : 2.22 mio tons.

Sensitivities

- Contributions could be increased by Euros 427.25, Euros 750.51 and Euros 270.36 for each additional operating hour available in Mill 1, Mill 2 and Mill 3, respectively.
- Contribution could reduce by Euro 0.34 for each ton of OPC 43 sold beyond the minimum demand restriction.
- Contribution could be increased by Euros 6.13 for each additional ton of clinker sold over that done in the Base Case.

4.0 CONCLUSIONS

As demonstrated in the two cases, the advantage of such product planning exercises is that these help in optimizing decision making under varied environmental conditions. In addition, through an analysis of what (in linear programming terminology) are termed as "relative loss" and "shadow prices" it helps in identifying key decision variables, which have the most significant impact on performance parameters.

It is therefore strongly recommended that cement companies employ this method to re-assess the appropriateness, or otherwise, of their current product mix and use the conclusions, thus derived, for future planning. **A significant, sans investment contribution to the bottom line is almost certainly assured**!