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APP for Optimizing Number of Trucks for Dispatching Operation of Concrete Plant

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Abstract: ***Ready Mix Concrete (RMC) batch plant manager dispatches RMC trucks to different construction sites as per the demands and availability of RMC trucks at plant. To have maximum production and profit of the plant, generally more and more number of trucks are send to the sites with the thumb rules or logic of the batch plant manager, through his experience and depending on the capacity of the plant (CP). To avoid discontinuous (interrupted) RMC casting he requires sufficient number of RMC trucks at plant as well as at sites. This logic may be inefficient and might present the loss of profits. Also this may demands more number of trucks. In this research attempt is made to minimize the number of trucks along with reduction in waiting time of trucks by applying Genetic Algorithm (GA) optimization and simulation of operations through App. The flexibility has been given to the dispatching manager to make changes in the data parameters if required. A user-friendly App is developed in MATLAB environment to help the plant manager to decide dispatching schedule with less number of RMC trucks, compared with present industry logic.***

Key words: GA's applications, optimization of RMC trucks, reducing number of RMC trucks, Optimization of transit mixers for Dispatching schedule, App for reducing RMC trucks.

I. INTRODUCTION

Looking to the infrastructural development in all over India, especially in Maharashtra, concrete in the form of RMC is most commonly and popularly used material due to many advantages like: uniformity in the production quality per batch, faster production, less pollution during production etc. But in last decade the production of the RMC is about 15 to 20 million m^3 / year as against the market demand of 300 million m^3 / year. But in present scenario the market has grownup very rapidly with many challenges like: Supply in crowded areas, Setting up of pumps supply line, deciding the quantity of the last TM (Transit Mixer), Planning in advance is need of time as delay at one site, for any reason, will change the schedule of the entire line, The regular repairs and maintenance of the plant, pump and TM during peak season, The coordination and timing of dispatch and distance of the site from the plant.

If one has to catch this market by overcoming these challenges, one should have some tool or a technique, the presented research is just one off such tool.

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This present research first describes analysis of the factors that impact the RMC delivery process then generation of a model using Genetic Algorithms (GA) optimization with (Graphical User Interface) GUI finds optimal dispatching schedule with least number of trucks.

Results show that this new approach with the implemented GUI can quickly generate efficient and flexible un-interrupted schedules for dispatching RMC trucks which reduces number of trucks on single window interface by giving scope to the Dispatching Manager to make change in decision making parameter if required. Sakchai Srichandum & Rujirayangong (2010) explained the advantages of Bee-colony Optimization over GA and Tabu search (TS) methods. Fritz Payr and Verena Schmid (2009) have also discussed about the delivery of RMC. Zayed and Nosair (2006) also have explained 'Cost management aspect for batch plant using stochastic mathematical models'. We have also generated a model in MATLAB which produces optimized dispatching schedule by reducing number of RMC trucks required for satisfying the demand of RMC.

II. GOVERNING PARAMETERS

Fig.1, shows important parameters of decision making for preparing dispatching schedule of RMC trucks: Outer are the parameters pertaining to batch plant like: Capacity of plant to produce concrete per hour, number of trucks available for dispatching, location of site from plant which decides travel time of truck, whereas, those inside the circle are pertaining to the construction site like: Time of Casting (TC), Number of Deliveries (ND) required by each site, Start time of casting (STC) site etc. The allowable buffer duration (ABD) is kept to give flexibility for a truck to align with the pumps and pour concrete at required location. Few other parameters like, strikes, accidents, traffic concessions are not taken in to account.

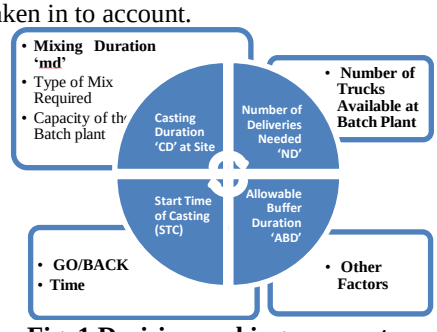
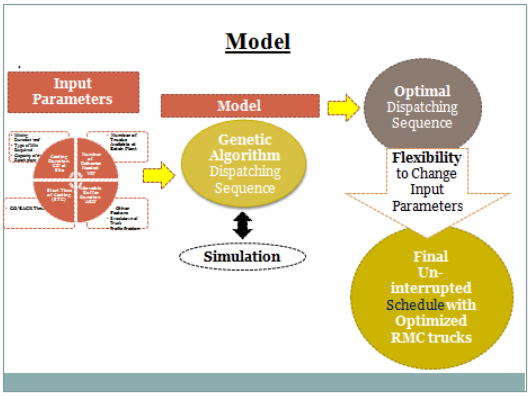


Fig. 1 Decision making parameters

III. MODEL

A model, as shown in Fig.2, is generated through MATLAB coding and using genetic algorithm (GA) optimization for waiting time and RMC trucks is done to achieve final dispatching sequence.

Use of simulation helped for determining time of travel and time of total waiting done. Fitness function is defined to optimize number of trucks and getting uninterrupted dispatching schedule.



The TWT is calculated through simulation. As shown in Fig. 3, the sum total of WC is the TWT.

The Fitness function Value (FFV) for optimization through Genetic Algorithm (GA) is calculated as,

FFV = TWT + (interruptions)*24*60;

All the settings for GA optimizations are kept default settings in the MATLAB.

As per Darwin's principle the iterations are conducted for fitness value. The best fitness will be decoded and displayed as final dispatching order. Keeping this final order of GA as same, the changes in the data parameters is done as shown in Step 5 and the final count for number of truck is maintained for less TWT.

IV. OPTIMIZING RMC TRUCKS

Consider a condition, Case 1, of dispatching demand of a particular day in case of CP-60, where CP stands for capacity of plant and 60 indicates 60 m^3 of concrete produced per hour. CP-60 requires 8 minute (mixing duration 'md') for filling a truck of 6 m^3 (Capacity of One RMC truck). This plant has total 'C'=12 trucks available for dispatching demands of a day.

Case 1

Table 1 Consider a dispatching situation:

Site Number	TC	GO	CD	BACK	ABD	ND
I	8:00 am	30	20	25	30	6
II	8:00 am	25	30	20	30	6

Step 1: Fill all the above data in the MATLAB App and determine the Total waiting time (TWT) for the given dispatching sequence according to the industry thumb rule using "RUN" tab provided on the App shown in Fig.2. Thumb rule for CP-60 is six trucks per demanding site one by one with balancing earlier remaining demands i.e. for 12 RMC trucks demand for 3 sites as shown in Case 1 above, it will be 1 1 1 1 1 1 (six trucks for first site) 2 2 2 2 2 2 (next six trucks for second site) . The final dispatching schedule as per thumb rule will be: 1 1 1 1 1 1 2 2 2 2 2 2. Then the result of the schedule will be 'TWT= 10.12 minutes', for 'C' = 12 trucks.

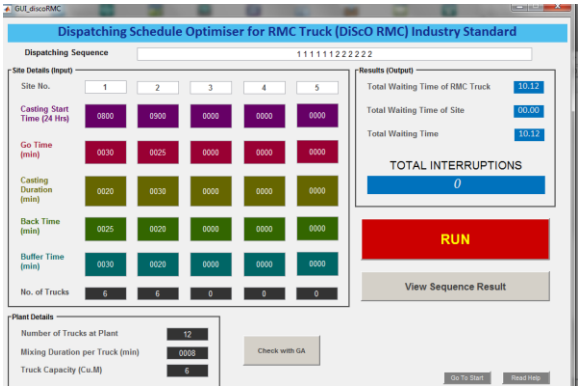


Fig.2 Result of MATLAB App for Case 1 with industry logic

Step 2: Check the 'TWT' value as 10.05 minutes. Also the time at which the last truck comes back to the plant 'TBB' value, which is 12:20 PM (shown in Fig. 3, at TBB column and 12th row, seen when tab "View Sequence result" is hit).

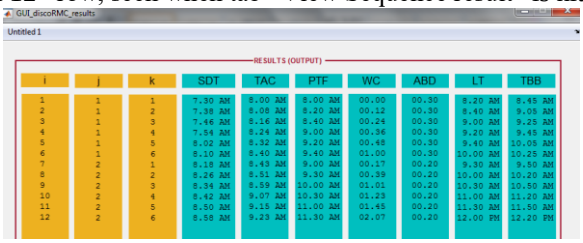


Fig. 3 Simulation Results for case 1 with industry logic

Step 3: The changes in TWT are observed by changing value of 'C' from '12' to '6', till interruptions are '0'. When there is changes in TWT, say, in our case at 'C = 5', see the value for 'TWT = 5:37 minutes' and interruptions '1'.

Step 4: To have optimum number of trucks the App is 'RUN' for 'C = 5' and all other data same, the results appears to be 'TWT = 4:02 minutes' and interruptions '1', refer Fig. 4.

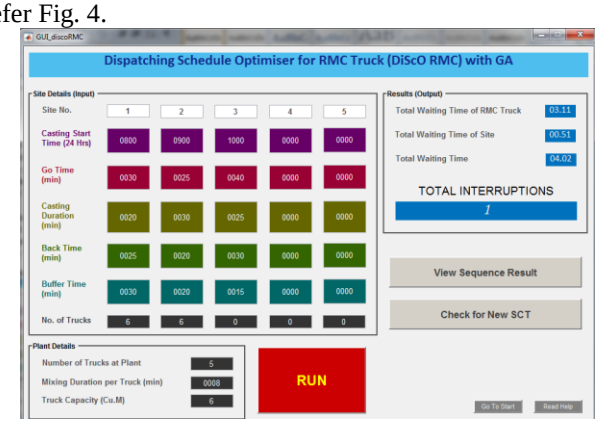


Fig. 4 View of Sequence Result by MATLAB App with GA

Step 5: The flexibility given to the dispatching manager is to make changes in the decision making parameters, through, 'Check for New SCT' tab, make changes in the 'SCT' for new 'TAC' values and 'Calculate for New SCT' the result observed to be 'TWT = 3:58' with same interruptions, refer Fig. 5.

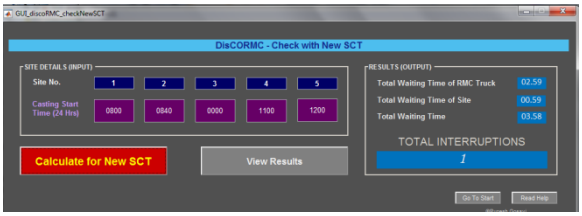


Fig. 5 Results after changes in SCT

The net saving in the 'TWT' was observed to be 1:39 minutes (29.37 %) (from 5:37 to 3:58) where as the net saving in number of RMC trucks 'C' was observed to be '1' from '6' to '5', because as per thumb rule RMC trucks required are '6'.

The same case of dispatching is checked on CP-30 as well as CP-90 for proving efficiency of the model.

Four different cases were generated for checking the efficiency for optimizing number of trucks as follows:

Case 1: for 3 sites and 12 trucks dispatching, *more sites less trucks;*

Case 2: for 2 sites and 12 trucks dispatching, *less sites less truck;*

Case 3: for 5 sites and 18 trucks dispatching, *more sites more trucks;*

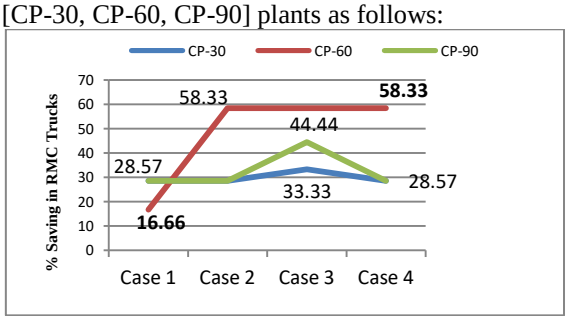
Case 4: for 2 sites and 18 trucks dispatching, *less sites more trucks;*

The results of the cases were listed in Table 2, for saving in number of trucks:

Table 2 Summary of Result for different dispatching conditions showing % saving in RMC trucks

Case No.	No. of Sites to be Delivered	No. of Total Deliveries	Type of Plant with 'md'	No. of Trucks by Thumb Rule	No. of Trucks by MATLAB App	No. RMC trucks saved	% Saving in No. of RMC Trucks
1	3	12	CP-30	7	5	2	28.57
2	2	12		7	5	2	28.57
3	5	18		9	6	3	33.33
4	2	18		7	5	2	28.57
1	3	12	CP-60	6	5	1	**16.66**
2	2	12		12	5	7	**58.33**
3	5	18		12	5	7	58.33
4	2	18		12	5	7	58.33
1	3	12	CP-90	7	5	2	28.57
2	2	12		7	5	2	28.57
3	5	18		9	5	4	44.44
4	2	18		7	5	2	28.57

The graphical representation of the data is observed for all [CP-30, CP-60, CP-90] plants as follows:



From graph we can conclude that in Case 1 better results by CP-90, in Case 2, 3 and 4 better results by CP-60, where as in Case 3 best result were observed by CP-30.

V. CONCLUSION

GA based App to produce optimized dispatching schedule to optimize number of RMC trucks is applied for four different cases, on three different plants and the optimizations is observed, which is in the range of 17 % to 58 %. It shows efficiency of the App by comparing industry logic with developed App, thereby reducing number of trucks required to dispatch RMC from a plant to sites as well as waiting time. It also proves the flexibility and ease with which the App can be used by the dispatching manager. This saving in number of trucks ultimately saves the initial cost of the installation of plant. The research also recommends the selection of type of plant, as CP-30, CP-60, CP-90, for dispatching, depending upon the number of sites and number of deliveries to be handled.

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