

Un-Interrupted Dispatching Schedule of RMC

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Abstract: One of the key responsibilities of the RMC batch plant manager is to provide Ready Mixed Concrete (RMC) to construction sites. The manager of the RMC batch plant must create a productive schedule for deploying RMC trucks in order to maximize operations both at the batch plant and on construction sites. The current dispatching schedule is primarily influenced by the preferences of the site and the dispatching manager's past experiences. Check to see if the RMC plant manager sends more and more RMC trucks to the necessary construction site. This may cause a line-up of RMC trucks at one site and keep other sites waiting for RMC truck arrivals, which is referred to as a "interruption." In this research, we try to use evolutionary genetic algorithm optimization to decrease the interruption time.

Key words: GA's applications, Un-interrupted Dispatching, dispatching time of RMC trucks, Optimization of Dispatching schedule.

1. Introduction

One of the most often used building materials in the construction sector is ready-mixed concrete (RMC). RMC is often made in a concrete batch plant, where the raw components for making concrete are measured and combined automatically at the request of the construction sites. For any kind of building, RMC is practical. Comparing RMC to conventionally prepared concrete, there are a number of advantages. The service area of the RMC batch plant is typically constrained by the necessity to pour RMC within 1 to 1.5 hours of the RMC batch plant producing it. As a result, the RMC sector is worried about production and truck dispatching planning. An experienced staff member can manually handle dispatching and scheduling. However, that could result in delays at the construction site. This Paper focuses more on the aspect to reduce such interruptions of construction sites.

2. Factors affecting the dispatching schedule of RMC trucks

2.1 Start Time of Casting (STC):

Generally in India the casting is started in the morning from 7am to 11am. But in some extreme conditions it can be up to 4pm.

2.2 Traveling duration from plant to the job site (GO & BACK):

The distance between the job site and the RMC batch facility, the speed of the RMC vehicle, and the traffic situation all affect how long it takes to travel between them. As a result, it is difficult to estimate the precise time needed to supply RMC to various construction sites. As a general rule, the batch plant manager gives the RMC trucks a higher priority assignment to job sites away from the batch plant to prevent casting discontinuities. Such a strategy, meanwhile, raises the likelihood of interfering with work being done at other job locations with quicker casting times. As a result, when determining the schedule for dispatching RMC trucks, the distance between the RMC factory and the construction site becomes crucial. In practice, the average traveling duration between the batch plant and the construction site can be estimated from the history data or by considering average speed of the RMC truck.

2.3 The operating/casting duration (CD) of RMC at the job site:

The length of time that RMC is required on the job site depends on the nature of the construction operations and the height of delivery (Dumping or Pumping), which may impact the dispatching time between assigning RMC trucks to the same job site. For instance, the dispatching interval between them is shorter the faster the casting duration. The construction process will be interrupted if the RMC trucks are late getting at the job site.

2.4 Number of deliveries/trucks (i.e. Volume of RMC) needed(ND):

The quantity of RMC trucks needed depends on the amount of RMC needed at the building site, the truck's loading capacity, and the volume of traffic on the roads. You see, fewer deliveries are required the bigger the truck capacity. Additionally, the fewer deliveries that are required, the shorter the site's casting time will be.

2.5 Number of trucks available at Batch Plant (C):

The RMC batch plant may need to make more investments if the waiting time at a site lengthens, as will the need for more trucks at the facility. The optimal number of trucks needed for a batch facility is determined by the computer programme created in the MATLAB environment.

2.6 Other Constraints:

The Allowable Buffer Time (ABT), which is the balance time duration after taking into account all of the above-mentioned durations like GO, BACK, and CD, is also to be provided for every site and every delivery since the RMC is to be cast between 1-1.5 hours of its loading. In addition to all of these variables, there are a few crucial variables that must be ignored while creating a manual dispatching schedule.

3. Un-interrupted dispatching schedule of RMC trucks

EXAMPLE 1 (For 03 min mixing duration):

Consider information of dispatching operation listed in Table 1:

Table 1

Site ID	STC	GO	C D	BAC K	ABD	ND
Site 1	8:00 am	30	20	25	30	3
Site 2	8:00 am	25	30	20	20	4
Site 3	8:30 am	40	25	30	15	5

Number of Trucks at Batch Plant : 5 Trucks (C)
 Mixing Duration of Plant : 3 minute (md)
 Max. Capacity of the Truck : 5.5 M³

Where,

- STC** : Start casting time of the construction site (in 24 h format).
- CD** : Casting duration of the construction site (in min).
- GO** : Traveling duration from the batch plant to the construction site (in min).
- BACK** : Traveling duration from the construction site to the batch plant (in min).
- ABD** : The allowable buffer duration of construction site (in min).
- ND** : The number of RMC truck deliveries required for the construction site.
- md** : The mixing duration in min.
- C** : The number of trucks available at Batch Plant.

Step 3.1: Fill all the above data in the “RMC_truck” program made in MATLAB and determine the ideal departing time of each RMC truck. The ideal departing time of each RMC truck, shown in Table 2, is determined by using Equations (1) and (2).

Table 2 Earliest departing times of RMC trucks:

FDT min[08:00 – 00:30, 08:00 – 00:25, 08:30 – 00:40] = 07:30

I	1	2	3	4	5	6	7	8	9	10	11	12
IDT	07:30	07:33	07:36	07:39	07:42	07:45	07:48	07:51	07:54	07:57	08:00	08:03

$$FDT = \min (STC-GO)_i, i = 1 \text{ to } m \quad \dots\dots(1)$$

$$IDT_i = FDT + (i-1)* md, i = 1 \text{ to } N \quad \dots\dots(2)$$

$$n = \sum_{i=1}^m k_i$$

Where,

- FDT** is the departing time of the first dispatched truck,
- IDT** is the ideal departing time of the dispatched truck,
- i** is the dispatched order of the truck,
- m** is the number of construction sites that request RMC deliveries,
- k** is the required RMC deliveries of the construction site,
- n** is the total number of the RMC deliveries for all construction sites.

Step 3.2: Step 1 will help you identify when each RMC truck should leave. The batch facility can only hold five trucks, therefore it's probable that it won't be able to supply RMC given that none of these vehicles have returned. According to the dispatching sequence established by the GA, only the departure time of the first five sent RMC trucks from the batch plant is known, and the departure time for the other trucks is derived by knowing the back time of any of these vehicles. [Table 3](#) shows an example of the dispatching sequence generated by the GA. The calculations starts with the first dispatched RMC truck which departs from the batch plant at 07:30 Hrs. [Table 4](#) records the process of the simulation according to Eqs. (3)–(11) and ([Table 4](#)) also shows the simulated result according to the dispatching sequence and simulation process.

IF $i \leq n$, Number of Trucks at Batch Plant,
 $SDT(i) = IDT(i) \dots\dots\dots(3)$

else
 $SDT(i) = mnm + md,$
 (mnm = Minimum of TBB) $\dots\dots\dots(4)$

$TAC(i) = SDT(i) + GO(Ix(i)) \dots\dots\dots(5)$

IF $t(i) == 1$
 $PTF(i) = SCT(Ix(i)) \dots\dots\dots(6)$

else
 $PTF(i) = LT(Ix(i)-1)$

$WC(i) = -TAC(i) + PTF(i) \dots\dots\dots(7)$

If $WC(i) > 0$
 $LT(i) = PTF(i) + CD(Ix(i)) \dots\dots\dots(8)$

Else
 $LT(i) = PTF(i) + CD(Ix(i)) + WC(i) \dots\dots\dots(9)$

$TBB(i) = LT(i) + BACK(Ix(i)) \dots\dots\dots(10)$

$TWT = \text{Sum of } WC(i) \dots\dots\dots(11)$

Table 3 Dispatching sequence generated by GA for 1st Generation:

j	2	3	2	1	3	1	3	3	1	2	3	2
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Table 4 Result of the dispatched sequence:

Number of Trucks Available at batch plant are :5

i	1	2	3	4	5	6	7	8	9	10	11	12
j	2	3	2	1	3	1	3	3	1	2	3	2
k	1	1	2	1	2	2	3	4	3	3	5	4

SDT	07.30	07.33	07.36	07.39	07.42	08.53	08.57	09.23	09.28	09.53	10.11	10.35
TAC	07.55	08.13	08.01	08.09	08.22	09.23	09.37	10.03	09.58	10.18	10.51	11.00
PTF	08.00	08.30	08.30	08.00	08.55	08.29	09.20	10.02	09.43	09.00	10.28	10.48

WC 00.05 00.17 00.29 00.09 00.33 00.54 00.17 00.01 00.15 01.18 00.23 00.12

LT	08.30	08.55	09.00	08.29	09.20	09.43	10.02	10.28	10.18	10.48	11.16	11.30
TBB	08.50	09.25	09.20	08.54	09.50	10.08	10.32	10.58	10.43	11.08	11.46	11.50

Total Time for the RMC truck is waiting is = 01.24

Total Time for the site is waiting is = 03.29

Number of interruptions are :4

Where,

- SDT** is the simulated departing time of dispatched truck,
- TAC** is the time that dispatched truck arrives at construction site,
- PTF** is the start casting time of the construction site,
- WC** is the duration that dispatched truck waits at the construction site,
- WC** is the duration that construction site waits for the arrival of the truck,
- LT** is the time that the RMC truck leaves construction site,
- TBB** is the time that the RMC truck back to the batch plant,
- i** is the dispatching order of the RMC trucks,
- j** is the dispatched sequence to the site number,
- k** is the order of the RMC truck arrives at the respective construction site,
- C** is the number of the RMC trucks that the batch plant owns.

Step 3.3: Determine the fitness value using Eq. (12) and (13). From the [Table 5](#), the total duration that RMC trucks wait at construction sites and total duration that construction sites wait for the arrival of RMC trucks are 84 and 209 min, respectively. The interruption of casting concrete occurs when the duration that the construction site waits for the arrival of the RMC truck is longer than the allowable buffer duration. As shown in [Table 5](#), the number of interruptions marked with under lines, are 4. Since the interruptions of casting concrete should be avoided as far as possible, the penalty value is calculated by Eq. (12).

$$P = (\text{Number of interruption}) \times 60 \times 24 \dots\dots(12)$$

The fitness value (FV) of a dispatched schedule is defined as $FV = P + TWC$, where TWC is the total duration that RMC trucks wait at the construction sites. In this example, the fitness value of the dispatched schedule is equal to 5844 ($= 4 \times 60 \times 24 + 84$).

$$FV = (\text{Number of interruption}) \times 60 \times 24 \dots\dots(13)$$

And then obtain a final dispatching order (as shown in [Table 5](#)) of RMC trucks by using the GA tool in MATLAB. At the same time it will generate the graph of “Fitness value X Number of Generations” (Refer Fig. 1 & 2). For which we have to select the number of generations, limits of the variables and number of variable (total number of trucks to be delivered).

Step 3.4: This dispatching order (as shown in the [Table 5](#)) is to be copied in the “Result” program in MATLAB. Run this program which will generate the results in the “Output” file, as shown in the [Table 6](#).

Table 5 Final Dispatching sequence generated by GA:

J	1	2	3	2	3	2	3	3	2	3	1	1
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Table 6 Results of dispatched sequence generated by MATLAB Program :

Number of Trucks Available at batch plant are :5

i	1	2	3	4	5	6	7	8	9	10	11	12
j	1	2	3	2	3	2	3	3	2	3	1	1
k	1	1	1	2	2	3	3	4	4	5	2	3

SDT 07.30 07.33 07.36 07.39 07.42 08.48 08.53 09.23 09.28 09.53 10.06 10.31
TAC 08.00 07.58 08.16 08.04 08.22 09.13 09.33 10.03 09.53 10.33 10.36 11.01
PTF 08.00 08.00 08.30 08.30 08.55 09.00 09.20 09.58 09.43 10.28 08.20 10.56

WC 00.00 00.02 00.14 00.26 00.33 00.13 00.13 00.05 00.10 00.05 02.16 00.05

LT 08.20 08.30 08.55 09.00 09.20 09.43 09.58 10.28 10.23 10.58 10.56 11.21
TBB 08.45 08.50 09.25 09.20 09.50 10.03 10.28 10.58 10.43 11.28 11.21 11.46

Total Time for the RMC truck is waiting is = 01.15
Total Time for the site is waiting is = 03.07

Number of interruptions are :1

Step 3.5: The **Table 6** gives the scope to shift the casting time of any of the sites (e.g. Site 2 & 3 in our case), so as to reduce the number of interruption, shown by underline as 1. Now if the casting time of Site 2 & 3 is made as per **Table 7** the number of interruptions can be reduced to zero refer final output in **Table 10**. Also Refer the out-puts generated as per the RMC Dispatching Managers logic from a Batch Plant in Pune, Maharashtra, India, as shown in the **Table 8 & Table 9**.

Table 7 Optimum Solution can be decided by changing the times from the results generated:

Changes are made in the **Table 1** for Start Casting Time:

Site ID/m	STC	GO	CD	BAC K	ABD	ND/k
Site 1	8:00 am	30	20	25	30	3
Site 2	8:15 am	25	30	20	20	4
Site 3	9:45 am	40	25	30	15	5

Number of Trucks at Batch Plant : 5 Trucks (c)
Mixing Duration at Plant : 3 minute (md)
Max. Capacity of the Truck : 5.5 M³

Table 8 Solution generated as per Batch Plant managers logic without changes in Casting Time:

Number of Trucks Available at batch plant are :5

i	1	2	3	4	5	6	7	8	9	10	11	12
j	1	1	1	2	2	2	3	3	3	2	3	3
k	1	2	3	1	2	3	1	2	3	4	4	5

SDT 07.30 07.33 07.36 07.39 07.42 08.48 08.57 09.08 09.27 09.28 10.06 10.35
TAC 08.00 08.03 08.06 08.04 08.07 09.13 09.37 09.48 10.07 09.53 10.46 11.15
PTF 08.00 08.20 08.40 08.00 08.34 09.04 08.30 10.02 10.27 09.43 10.52 11.17

WC 00.00 00.17 00.34 00.04 00.27 00.09 01.07 00.14 00.20 00.10 00.06 00.02

LT 08.20 08.40 09.00 08.34 09.04 09.43 10.02 10.27 10.52 10.23 11.17 11.42
TBB 08.45 09.05 09.25 08.54 09.24 10.03 10.32 10.57 11.22 10.43 11.47 12.12

Total Time for the RMC truck is waiting is = 02.00
Total Time for the site is waiting is = 01.30

Total Time of waiting is = 03.30

Number of interruptions are :1

Table 9 Solution generated as per Batch Plant managers logic with changes in Casting Time:

Number of Trucks Available at batch plant are :5

i	1	2	3	4	5	6	7	8	9	10	11	12
j	1	1	1	2	2	2	3	3	3	2	3	3
k	1	2	3	1	2	3	1	2	3	4	4	5

SDT 07.30 07.33 07.36 07.39 07.42 08.48 09.08 09.28 09.38 10.08 10.46 11.11
 TAC 08.00 08.03 08.06 08.04 08.07 09.13 09.48 10.08 10.18 10.33 11.26 11.51
 PTF 08.00 08.20 08.40 08.15 08.45 09.15 09.45 10.13 10.38 09.45 11.03 11.51

WC 00.00 00.17 00.34 00.11 00.38 00.02 00.03 00.05 00.20 00.48 00.23 00.00

LT 08.20 08.40 09.00 08.45 09.15 09.45 10.13 10.38 11.03 11.03 11.51 12.16
 TBB 08.45 09.05 09.25 09.05 09.35 10.05 10.43 11.08 11.33 11.23 12.21 12.46

Total Time for the RMC truck is waiting is = 02.07
 Total Time for which Truck is waiting = 01.14
Total Time of waiting = 03.21

Number of interruptions are :2

Table 10 Final Optimum solution generated by MATLAB Program with changes in Casting Time:

Number of Trucks Available at batch plant are :5

i	1	2	3	4	5	6	7	8	9	10	11	12
j	1	2	1	1	2	3	2	3	2	3	3	3
k	1	1	2	3	2	1	3	2	4	3	4	5

SDT 07.30 07.33 07.36 07.39 07.42 08.48 08.53 09.08 09.23 09.28 10.11 10.28
 TAC 08.00 07.58 08.06 08.09 08.07 09.28 09.18 09.48 09.48 10.08 10.51 11.08
 PTF 08.00 08.00 08.20 08.40 08.30 09.30 09.00 09.55 09.48 10.20 10.45 11.16

WC 00.00 00.02 00.14 00.31 00.23 00.02 00.18 00.07 00.00 00.12 00.06 00.08

LT 08.20 08.30 08.40 09.00 09.00 09.55 09.48 10.20 10.18 10.45 11.16 11.41
 TBB 08.45 08.50 09.05 09.25 09.20 10.25 10.08 10.50 10.38 11.15 11.46 12.11

Total Time for the RMC truck is waiting is = 01.39
 Total Time for the site is waiting is = 00.24
Total Time of waiting is = 02.03

Number of interruptions are :0

The Example 1 with a site conditions mentioned in journal paper, which is giving the expected results of not only the un-interrupted dispatching schedule but also compares the result with the real life practical situation of a batch plant. The results generated by our MATLAB program is not only giving the un-interrupted dispatching schedule, but also reducing the Total waiting time (from 03:21 Hrs to 02:03 Hrs), by giving scope to the manager to reschedule/change the Start casting time (SCT) of the sites.

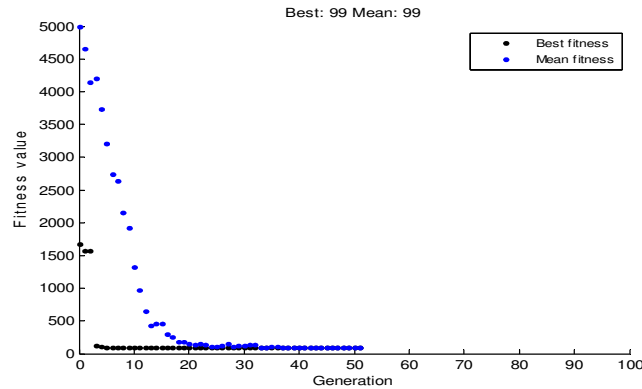


Fig. 1 Result of example 1

EXAMPLE 2 (For 20 min. mixing time):

Consider a site situation with following data:

Site ID	STC	GO	CD	BAC K	ABD	ND/k
Site 1	8:00 am	30	20	25	30	3
Site 2	8:00 am	25	30	20	20	4
Site 3	8:30 am	40	25	30	15	5

Number of Trucks at Batch Plant : 05 Trucks (c)
 Mixing Duration at Plant : 20 minute (md)
 Max. Capacity of the Truck : 6 M³

Table 5 Final dispatching order generated by GA:

j 1 2 1 2 1 2 3 2 3 3 3 3

Step 6 Results from GA for the Scheduled Casting time:

Number of Trucks Available at batch plant are :5

i 1 2 3 4 5 6 7 8 9 10 11 12
 j 1 2 1 2 1 2 3 2 3 3 3 3
 k 1 1 2 2 3 3 1 4 2 3 4 5

SDT 07.30 07.50 08.10 08.30 08.50 09.05 09.25 09.45 10.05 10.25 10.40 11.20
 TAC 08.00 08.15 08.40 08.55 09.20 09.30 10.05 10.10 10.45 11.05 11.20 12.00
 PTF 08.00 08.00 08.20 08.45 09.00 09.25 08.30 10.00 10.30 11.10 11.35 12.00

WC 00.00 00.15 00.20 00.10 00.20 00.05 **01.35** 00.10 00.15 00.05 00.15 00.00

LT 08.20 08.45 09.00 09.25 09.40 10.00 10.30 10.40 11.10 11.35 12.00 12.25
 TBB 08.45 09.05 09.25 09.45 10.05 10.20 11.00 11.00 11.40 12.05 12.30 12.55

Total Time of RMC truck is waiting = 00.20
 Total Time for the site is waiting = 03.10
Total Time of waiting = 03.30

Number of interruptions are :1

Table 7 Corrections/alteration made in Casting time for site 2 & 3:

Site	STC	GO	CD	BAC	ABD	ND/k
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ID/m				K		
Site 1	8:00 am	30	20	25	30	3
Site 2	9.00 am	25	30	20	20	4
Site 3	10.00 am	40	25	30	15	5

Table 8 Results by Managers logic without changes in the Casting time:

Number of Trucks Available at batch plant are :5

i 1 2 3 4 5 6 7 8 9 10 11 12
 j 1 1 1 2 2 2 3 3 3 2 3 3
 k 1 2 3 1 2 3 1 2 3 4 4 5

SDT 07.30 07.50 08.10 08.30 08.50 09.05 09.25 09.45 10.05 10.35 11.05 11.20
 TAC 08.00 08.20 08.40 08.55 09.15 09.30 10.05 10.25 10.45 11.00 11.45 12.00
 PTF 08.00 08.20 08.40 08.00 09.25 09.55 08.30 10.30 10.55 10.25 11.20 12.10

WC 00.00 00.00 00.00 00.55 00.10 00.25 01.35 00.05 00.10 00.35 00.25 00.10

LT 08.20 08.40 09.00 09.25 09.55 10.25 10.30 10.55 11.20 11.30 12.10 12.35
 TBB 08.45 09.05 09.25 09.45 10.15 10.45 11.00 11.25 11.50 11.50 12.40 13.05

Total Time for the RMC truck is waiting is = 01.00

Total Time for the site is waiting is = 03.30

Total Time of waiting is = 04.30

Number of interruptions are :4

Table 9 Results by Managers logic with changes in Casting time:

Number of Trucks Available at batch plant are :5

i 1 2 3 4 5 6 7 8 9 10 11 12
 j 1 1 1 2 2 2 3 3 3 2 3 3
 k 1 2 3 1 2 3 1 2 3 4 4 5

SDT 07.30 07.50 08.10 08.30 08.50 09.05 09.25 09.45 10.10 10.40 11.10 11.20
 TAC 08.00 08.20 08.40 08.55 09.15 09.30 10.05 10.25 10.50 11.05 11.50 12.00
 PTF 08.00 08.20 08.40 09.00 09.30 10.00 10.00 10.30 10.55 10.30 11.20 12.15

WC 00.00 00.00 00.00 00.05 00.15 00.30 00.05 00.05 00.05 00.35 00.30 00.15

LT 08.20 08.40 09.00 09.30 10.00 10.30 10.30 10.55 11.20 11.35 12.15 12.40
 TBB 08.45 09.05 09.25 09.50 10.20 10.50 11.00 11.25 11.50 11.55 12.45 13.10

Total Time for the RMC truck is waiting is = 01.15

Total Time for the site is waiting is = 01.10

Total Time of waiting is = 02.25

Number of interruptions are :2

Table 10 Final Optimum solution generated by MATLAB after the changes in Casting Time:

Number of Trucks Available at batch plant are :5

i 1 2 3 4 5 6 7 8 9 10 11 12
 j 1 1 2 1 2 2 3 3 2 3 3 3
 k 1 2 1 3 2 3 1 2 4 3 4 5

SDT 07.30 07.50 08.10 08.30 08.50 09.05 09.25 10.05 10.10 10.40 11.10 11.20
 TAC 08.00 08.20 08.35 09.00 09.15 09.30 10.05 10.45 10.35 11.20 11.50 12.00
 PTF 08.00 08.20 09.00 08.40 09.30 10.00 10.00 10.30 10.30 11.10 11.45 12.15

WC 00.00 00.00 00.25 00.20 00.15 00.30 00.05 00.15 00.05 00.10 00.05 00.15

LT 08.20 08.40 09.30 09.20 10.00 10.30 10.30 11.10 11.05 11.45 12.15 12.40

TBB 08.45 09.05 09.50 09.45 10.20 10.50 11.00 11.40 11.25 12.15 12.45 13.10

Total Time for the RMC truck is waiting is = 01.25

Total Time for the site is waiting is = 01.00

Total Time of waiting is = 02.25

Number of interruptions are :0

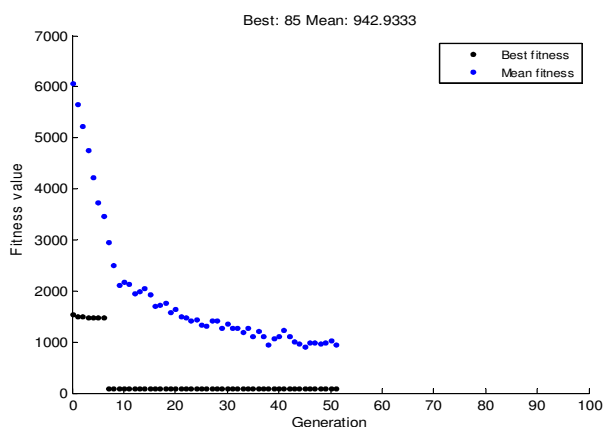


Fig. 2 Result of example 2

Conclusion

The output of the program is as per the desired value, that the “interruptions” have been reduced to ZERO by reducing waiting time also. The manager of the batch plant must rapidly decide on a dispatching timetable that fulfills the needs of several building sites. However, finishing such an operation is a time-consuming effort that largely depends on the batch plant manager's experience. The method and computer programme for dispatching RMC vehicles in a methodical way are presented in this work. Results demonstrate that the batch plant manager can quickly generate an effective, flexible, and uninterrupted dispatching schedule by implementing the proposed RMC dispatching computer programme in a MATLAB environment using GA. In addition, the batch plant manager can reduce the waiting time of the site/truck by giving options for rescheduling the Start Casting Time STC of sites.

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