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# Cast Off expansion plan by rapid improvement through Optimization tool design, Tool Parameters and using Six Sigma's ECRS Technique

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**Abstract.** Powerful management concepts step-up the quality of the product, time saving in producing the product thereby increase the production rate, improves tools and techniques, work culture, work place and employee motivation and morale. In this paper discussed about the case study of optimizing the tool design, tool parameters to cast off expansion plan according ECRS technique. The proposed designs and optimal tool parameters yielded best results and meet the customer demand without expansion plan. Hence the work yielded huge savings of money (direct and indirect cost), time and improved the motivation and more of employees significantly.

## 1. Introduction

Nowadays, manufacturing and service industries strive to realize the worth of six sigma and design for six sigma with a wider acceptance, growth and investment for the same [1]. The Byrne et al [2] reported that lean Six Sigma initiatives led to product innovations, redesigned processes, and streamlined supplier chain and increase revenue growth by 80%. Jiju Antony [3] conducted opinion survey and concluded that Six Sigma is uniformly applicable for large, medium and small companies. In fact, the responses are results are more rapidly and much more visible in smaller companies than in larger corporations. The literature evident that six sigma approach can be used for improving quality in injection moulding process Vikas Dwivedi et al. [4] , Vikas Tayal and Jitendra Kumar, [7], Rishi Pareek and Jaiprakash Bhamniya, [13] and Bharati et al [5] Explains in small scale jobbing industries Darshak and Desai[9] in metal casting foundry industries (Vijayaram et al (2006), Darshak A and Desai [9] and Gijo et al [4], in rolling mill by Kunal Ganguly [12]. in a manufacturing industry (Mehdiuz Zalan et al. [14]). Simulation based modelling and analysis were used to reduce the manufacturing time (Saravanan and Raju [9] and in specific case of solution to engine-overheating problem by using six sigma approach (Antony et al [6]). Jagdeep Singh and Harwinder Singh [9] discussed important concepts, surveys and case studies in continuous improvement methodology and highlighted future implications. The authors noticed that literature on this classification is limited.



This work is unique by improving productivity through the reduction of machining time by optimizing the tool parameters and tool designs. In this work the six sigma ECRS method was employed.

## 2. The problem statement

The firm is a single source to the world leading automobile manufacturer. The existing capacity of the supplier is 4800 units per month. But the manufacturer increases his demand to 6000 units per month as increases of their customer demand. Hence there is 41% gap to meet the demand.

## 3. Action Plan

It is difficult to move to expansion plan due to the constraints of space, investments, skilled labours and time span. So the theme launched as increase the capacity to 6000 units per month by innovation through leading management techniques and technology. The twelve week schedule prepared to execute the improvement plan. The schedule starts with defining the exact problem (2 weeks), make necessary observation (2 weeks), data analysis must be made within 2 weeks, for action taken 4 weeks, check for consistency for two weeks and standardization to be done within two weeks. The Takt time calculated and presented for the existing and aimed (Table 1).

## 4. Observation

The area of problem identified as flywheel housing line. The product image is shown in Figure 1. The process flow (layout shown in figure 2) with machine code and machining details are as follows. The gravity die casted housings is arrived to machining centre than they are processed in the sequence of: VTL-1 (Facing & Boring), VTL-2 (Facing & Boring), Vmc-1 (Milling, Facing, Drilling, Tapping, Boring, Reaming), Vmc-2 (Milling, Boring, Drilling, Tapping), Vmc-3 (Milling, Drilling, Tapping), Hmc (Milling, Drilling, Tapping), Vmc-4 (Milling, Drilling, Tapping), De-burring, Washing, Drying and Packing. The major operations are seven. The average man machine time for ISX fly wheel housing were observed at various operations and shown in Figure 3 a (Existing). The high cycle time were found at Vmc stations. The tool wise cycle time also observed and presented such cycle time at Vmc 1 in Table 2. By brainstorming the cause and effects for the high cycle time at VMC stations were recorded and shown in Figure 4. And validation such diagram was done with management was presented in Figure 5. The value added and non value added times in seconds at Vmc were observed and for sample such times details at Vmc -1 are furnished in Figure 6.

## 5. Solution procedure

The productivity can be increased by reducing man timer and/ or machining time. This paper and scope of this work is to reduce machining time (Figure 7). The following wastes in process were identified.

1. Over production due to high over all rejection – 8%
2. More time for Rework & salvaging rejected parts
3. Manual time high due to De-burring
4. Unwanted axis movement for Tool changing
5. Tool change time high
6. More number of tools used for operations
7. Roughing & Finishing operation doing separately
8. Low cutting parameter used.

ECRS Methodology followed in machine to eliminate Waste

E - Eliminate non value adding time (Tool changing time, axes movement, indexing)

C - Combine operation (Combination cutting tools)

R - Reduce value adding time (Optimize parameters)

S - Simplify operation (Programming – Multiple to single pass)

According ECRS the following steps were executed.

- Step 1: Air cutting time optimization
- Step 2: Tool change time optimization
- Step 3: Process parameter optimization with existing tool
- Step 4: Process parameter improvement with New tool
- Step 5: Balancing of machining cycle time
- Step 6: Loading and unloading time optimization
- Step 7: Combine tools wherever possible

### 5.1 Cycle Time Reduction at $V_{mc}$ -1

1. Action Taken – 1: Increasing face Milling Cutter diameter  
For quick machining operation the face milling cutter size is increased from  $\text{Ø}80$  mm to  $\text{Ø}100$  (Figure 8) and reduced machining time from 92 seconds to 66 seconds.
2. Action Taken – 2: Increase number of tooth  
The feed per tooth is increased by increasing the number of tooth (from two to four). In the new cutter the diametrical and depth variance were introduced(Figure 9). The machining time was reduced from 42 seconds to 17 seconds in that operation.
3. Action Taken – 3: Introducing KAIZER Finish Boring Bar  
By use of KAIZER Finish Boring Bar the 59 seconds cycle time was saved.(Figure 10)
4. Action Taken – 4: Combined  $\text{Ø}7.3$  Drill and Inspection Hole Boring Bar  
The  $\text{Ø}7.3$  Drill and Inspection Hole Boring Bar were combined (Figure 11) to reduce the tool change time. by this improvement the cycle time saved only seconds.  
The computerized quality checking were carried out (Figure 12) and found the process in control and capable sustainably.

### 5.2 Cycle Time Reduction at $V_{mc}$ -2

1. Action Taken – 5: Increasing Bore Cutter diameter  
For quick machining operation the Bore Cutter diameter is increased from  $\text{Ø}20$  mm to  $\text{Ø}80$  (Figure 13) and reduced machining time from 69 seconds to 53 seconds.
2. Action Taken – 6: Combining Facing And Chamfer Cutter  
In the existing operations separate cutters were used for facing and chamfering operations. Now the facing and chamfer cutters were combined with 16mm XEKT insert (Figure 14) to reduce machining time. Accordingly the combined tool reduced from 25 second to 9 seconds.
3. Action Taken – 7: Tool Modification  
The  $\text{Ø}25$  End Mill with Interpolation to  $\text{Ø}197$  Boring Bar (Figure 15) and hence the time reduced from 35 second to 9 seconds.  
The computerized quality checking were carried out (Figure 16) and found the process in control and capable sustainably.



**Figure 1.** Fly wheel Housing

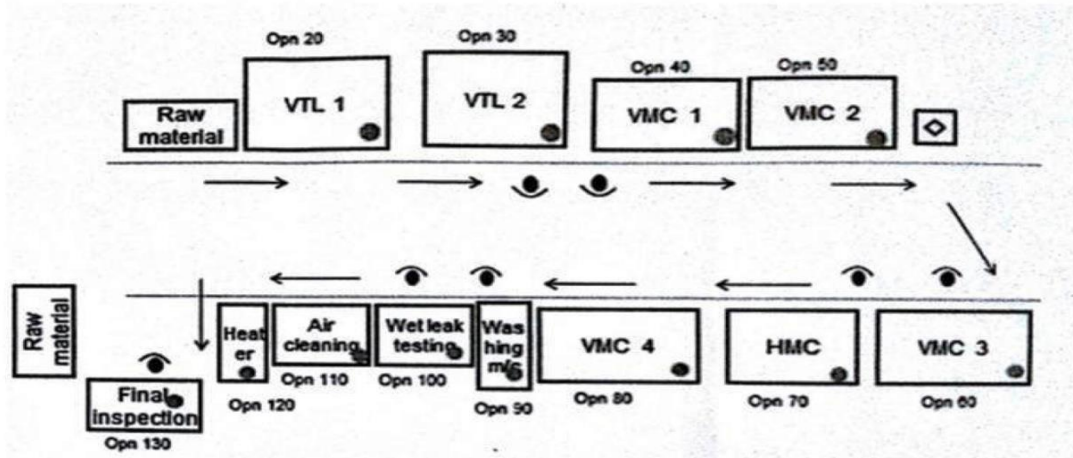


Figure 2. Machining Cell layout

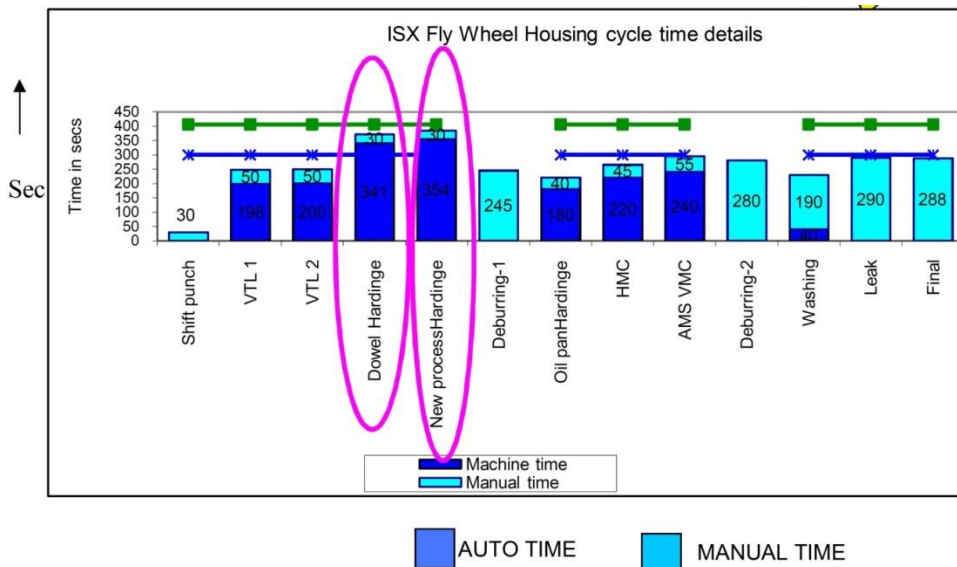


Figure 3a. The average man machine time for ISX fly wheel housing (Existing)

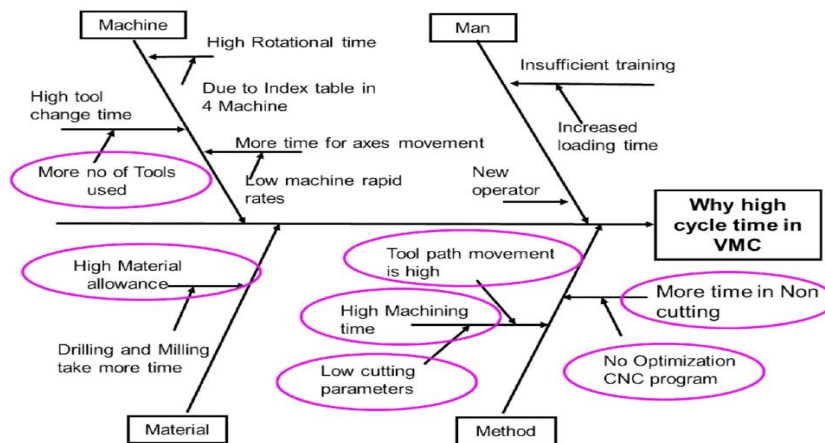
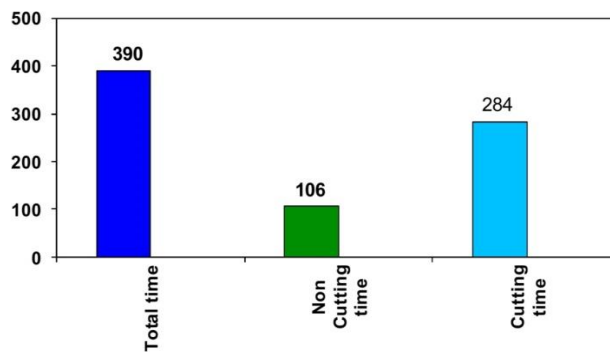


Figure 4. Fishbone diagram or Ishikawa diagram for high cycle time

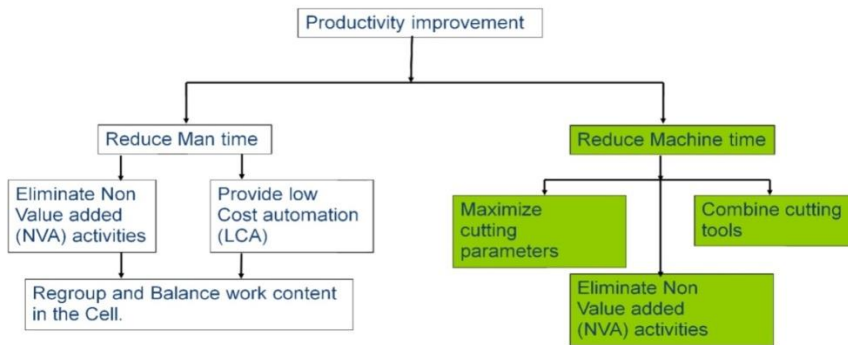
Sl. No.	OPTIONS	Productivity	Quality	Cost	Delivery	Morale	Safety
1	Establish Sub Contract machining for Isx flywheel housing			✗	✗		
2	Add additional machines for de-bottlenecking			✗			
3	Work 24 X 7 to compensate for the Quantity	✗	✗	✗		✗	
4	Revisit the cell for the capacity enhancement	✓	✓	✓	✓	✓	✓

✓ Scope available     
 ✗ No scope to improvement

**Figure 5.** Validation of Ishikawa diagram for high cycle time



**Figure 6.** The value added and non value added at Vmc -1



**Figure 7.** Methodology



Figure 8. Action Taken – 1

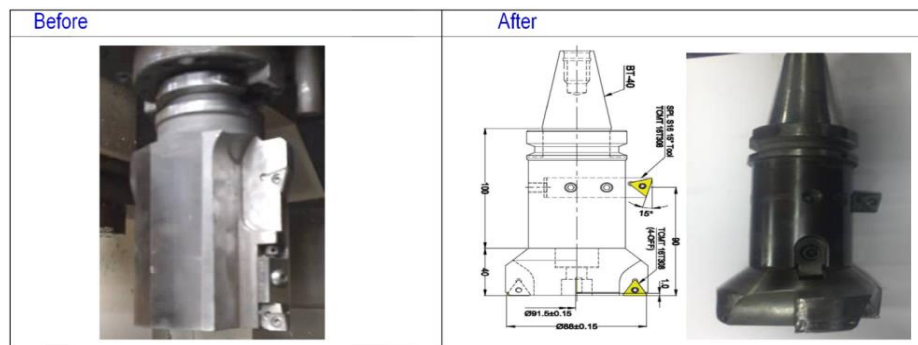


Figure 9. Action Taken – 2



Figure 10. Action Taken – 3

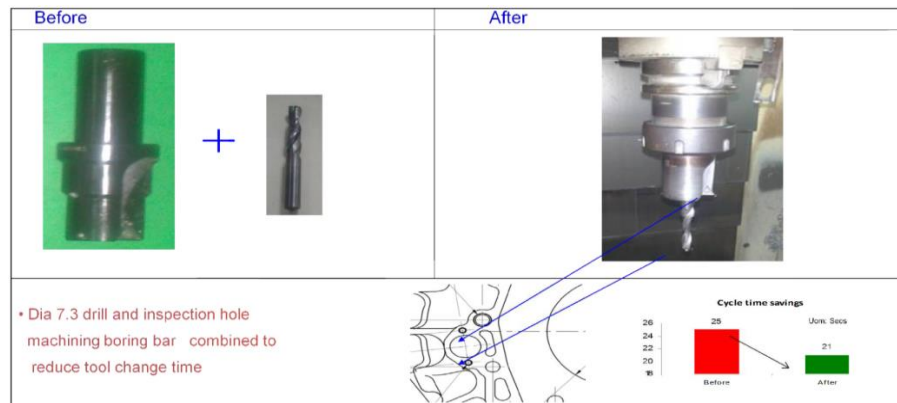


Figure 11. Action Taken – 4

Data Capturing and Data Analysis Screen							
Readings		Charts		Control Charts		Dashboard	
Machine	Part	Parameter	Process Status	Cp	Cpk		
08 96 04	3103584	STARTEK MOTOR POSITION		- NA -	22.52		
08 96 04	3103584	STR. MTR. MTG HOLE POSITION		- NA -	9.54		
08 96 04	3103584	DOWEL DIA DATUM B HARDINCE		4.49	3.24		
08 96 04	3103584	MOUNTING HOLE DIA - B		11.92	11.26		
08 96 04	3103584	MOUNTING HOLE DIA C		15.89	15.09		
08 96 04	3103584	STR. MTR. DIA - HAR		10.58	9.86		
08 96 04	3103584	DOWEL DIA DATUM C HARDINCE		5.8	4.24		

■ In Control & Capable   
 ■ Not in Control but Capable   
 ■ In Control but Not Capable   
 ■ Not in Control & Not Capable   
 No of Parameters 7   
 < > Close

Figure 12. The online report of computerized quality checking at Vmc-1

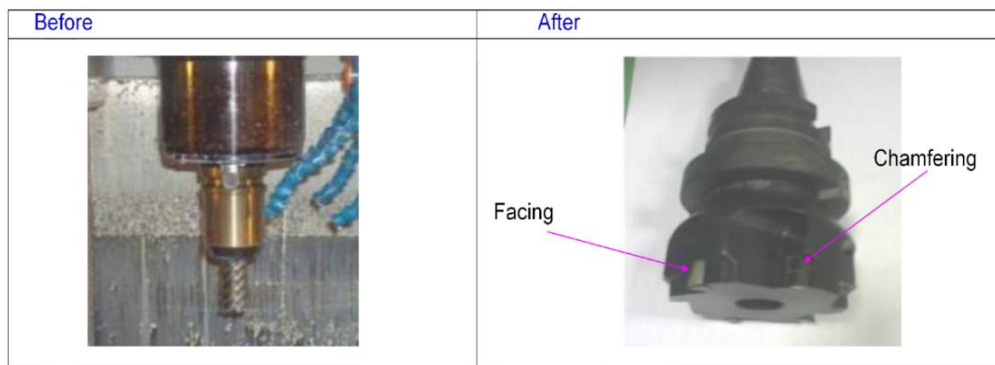


Figure 13. Action Taken – 5

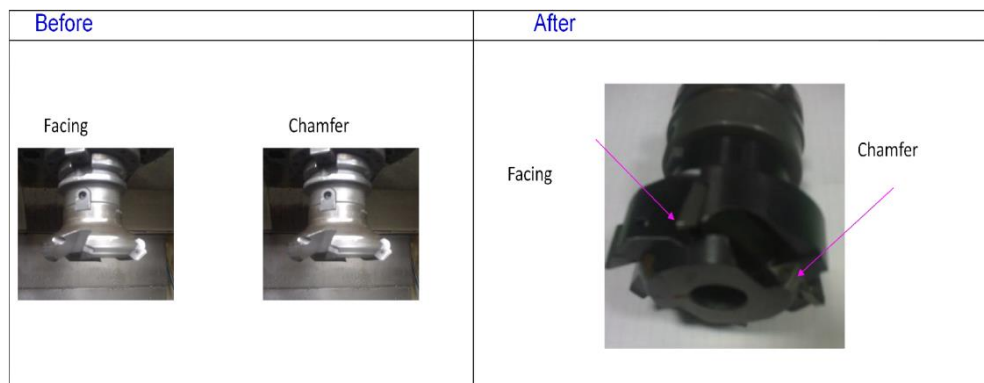


Figure 14. Action Taken – 6



**Figure 15.** Action Taken – 7**Table 1.** Existing and Target.

Description	Existing	Target
Available time in a month(Sec)	1944000	1944000
Average monthly demand(nos.)	4000	6000
Takt time(sec)	486	320
Hourly output (nos.)	10	12
Part price (Rs.)	3500	3500
No. of Operators/day	24	21
Sales/Employee/year (Rs.L)	70	120
Improvement (%)		71

**Table 2.** Tool wise cycle time VMC-1

Tool No.	Description of Operation	Tool indexing	Time in Seconds	
			Auto time	Total time
1	Face milling		92	92
2	13.8 x 3 drilling	4	13	17
3	13.8 x 3 ball nose drilling	4	5	9
4	5/8 x 11 Unc tap x 3	4	14	18
5	Starter motor rough	4	38	42
6	Starter motor finish	4	23	27
7	Dia 7.3 drill	4	7	11
8	Inspection hole machining	4	6	10
9	Dia 18.25 drill		60	60
10	Dowel finishing x 2	4	11	15
11	R38 end mill	4	36	40
	Loading/Unloading			30
	Cycle time		371	

## 6. Results and Discussion

The improvement project was carried out realized the improvement. They are as follows:

- The average man machine time for ISX fly wheel housing were observed at various operations and shown in Figure 3 b (Final).
- The Takt time was reduced from 486 seconds to 320 seconds,
- The units per hour improved from 10 units to 12 units.
- Scrap reduced from 0.5 tons per day to 0.26 tons per day.
- The dispatch from 2606 units to 5184 units (Figure 17)

The Tangible Savings includes

- The Average sales increase per month is 6000 Units,
- The Average Sales increase per month is 0.23 Cr ,
- The Average sales increased as 2.7 Cr per year
- Incremental contribution (38%) - 1.026 Cr. and
- Expansion plan not executed. That is Cost Saving for Creating another cell for Fuel filter housing in particularly minimum investment of 2 Vmc machines with the cost of 136 lacs apart from this labour, operation and maintenance expenditures etc.

The intangible savings includes

- The Machine utilization improved,
- The quality ensured by improved Process capability for critical characteristics.
- The Power Consumption reduced.
- The employee morale and motivation improved.

## 7. Conclusion

The drastic improvement through engineering approach with latest management technique was discussed with case study. The objective of this publication is, one can get clear idea and make a try to make an attempt for drastic improvement before suggest the expansion plan. In this case study the target was achieved without expansion strategy. Hence huge amount of cost savings, profit were realized. The business stability ensured. The scrap rate reduced nearly 50%.

Here the takt time target achieved by introducing Modified tools and optimized the cutting process parameter. The Improved the process flow (line balancing) in the cell was ensured. The Quality and its reliability were significantly improved. Customer satisfaction as well as employee morale were improved.

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