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Research paper

Implementation of MCDM model in lean manufacturing using grey relational analysis in automotive industry

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Abstract

The present economic situation shows the consistent demand for profitable solutions that allow business organizations to gain better advantage. Due to this reason, many organizations search for methodologies that allow them to improve their products and services improve their processes, reduce costs, and improve the profit and customer satisfaction. This has been implemented through lean techniques in their managerial and production methods. As we know Lean production system mainly emphasizes on the waste elimination, using simple and visual techniques. This paper is an attempt to optimize process layout and waste expulsion for automotive powertrain in a leading automo-tive company by using lean manufacturing techniques. In this paper, the existing process in place for machining of cam shaft is analysed and process layout is optimized to reduce cycle time and lead time. In order to reduce the cycle time, the process parameters such a speed, feed and depth of cut are optimized for increased material removal rate (MRR) and decreased surface roughness (RA) by using Grey Relational Analysis (GRA) technique. As MRR is inversely related to cycle time, optimization of parameters for higher MRR reduces the cycle time. Grey Relational Analysis is done by using Design Xpert software.

Keywords: *Lean; Mcdm; GRA; Lead Time; Cycle Time*

1. Introduction

Lean manufacturing is nothing but elimination of unnecessary waste and maximum utilisation of available resources. Lean manufacturing practices have found acceptance in many manufacturing operations [6] over more and more traditional mass production techniques. Lean production systems implementation through mathematical models is also justified [8].This paper is based on [1] analyzing the existing process in place for machining of cam shaft. [2] Suggest feasible solutions for the concerns that are existing and potential problems that may arise from the results of the analysis. [3] To optimize the process layout to reduce lead time, cycle time and WIP. [4] To reduce wastes involved in processing [5] and working conditions [7]. In this paper we are optimizing the steps involved in cam shaft machining. In this, the cam is machined in three cells consisting of six operations. They are (a) Marking and Painting (b) Centring, Facing, Drilling, Tapping and reaming (c) Journal turning, thrust face machining (d) Dowel pin pressing (e) Journal oil hole drilling, sensor plate mounting turning (f) Cam and journal grinding. GRA analysis is carried out in journal turning operation.

2. Optimization of process

Multiple-criteria decision-making (MCDM) is a branch of operation research that explicitly considers multiple criteria in decision-making environments. In real life we come across multiple conflicting criteria for making decisions. Organizing complex problems well and considering multiple criteria explicitly lead to better decisions. Lot of advances in this field has taken place. Different approaches and methods are implemented by unique decision-making software, have been developed from politics and business to the environment and energy. The grey system theory initiated by Deng (1982) is widely applied to various fields. It is proven to be useful for dealing with incomplete and uncertain information. Grey relational analysis (GRA) is grey system theory, and is suitable for solving problems with complicated interrelationships between multiple factors and variables. GRA is used in solving MCDM problems, such as the hiring decision, power distribution systems, the inspection of IC marking process, the modelling of QFD, the detection of silicon wafer slicing defects, etc. GRA solves MADM problems by merging performance attribute values being considered for every alternative. This reduces to a single attribute decision making problem. Therefore, alternatives with multiple attributes can be compared easily after the GRA process.

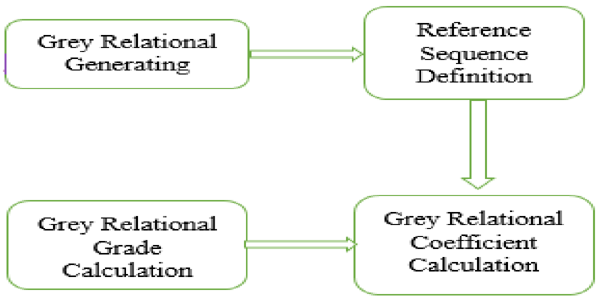

Fig 1: Procedure in GRA.

For optimizing process parameters, we formulated a set of 3 values of each of the parameters namely cutting speed (N), Feed Rate (f) and Depth of Cut (t). As already mentioned, the cam shaft journal turning operation has the maximum cycle time among all the five machines in the machining cell of the cam shaft layout. Because of higher cycle time, the machines following the journal turning machine are idle for a longer time as the machining line is not balanced. In order to balance the line to reduce the machine wait time, the process parameters can be optimized.

Table 1: Existing Process Parameters

Speed (N) (rpm)	Feed Rate (f) (mm/min)	Depth of Cut (t) (mm)
700	0.35	0.3

3. Calculations for optimizing process parameters

The machining time is inversely related to the material removal rate (MRR) of the operation and hence, the optimization is done for maximum MRR without much increase in surface roughness (RA). The material removal rate and machining time are calculated using the equations.

$$MRR=\pi\times(Do+Di)\times N\times f\times t/2 \quad (1)$$

$$T=L\times n/N\times f\times 60 \quad (2)$$

Where n = Number of passes of cutting tool.

The surface roughness is calculated using surface measurement machine. By using this surface measurement machine set up, the surface roughness of high accuracy can be obtained easily. This accuracy helps us to obtain better results at the end of the Grey relational analysis calculation and to obtain most accurate Grey relational coefficient.

Fig 2: Surface Roughness Measurement Setup.

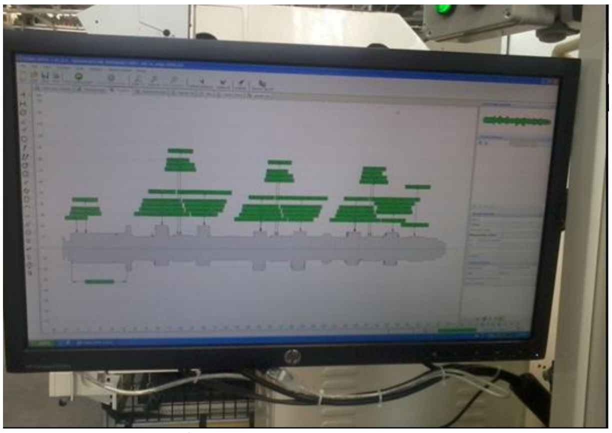

Fig 3: Surface Roughness Measurement Display.

4. Taguchi method

Taguchi method is a statistical method developed by Japanese Engineer Genichi Taguchi used to investigate the effect of different parameters affecting the average and variance of a process performance characteristic that define the outcome of the product. The methods overcome the defects of the factorial method in which all combination must be tested. They have different orthogonal array to organize the parameter and the level at which they must be performed. Since we have to study the effect of all the parameters with minimum possible number of experiments this Taguchi method is applied. At first, a proper orthogonal array must be selected based on the number of parameters.

Table 2: Assignment Levels of Process Parameters

Level	Speed (N) (rpm)	Feed (f) (mm/min)	Depth of Cut (t) (mm)
1	500	0.25	0.2
2	700	0.35	0.3
3	900	0.45	0.4

Since we have [3] variables and three values for each variable, L9 orthogonal array is selected.

Table 3: Assignment Levels of Process Parameters

Speed (N) (rpm)	Feed (f) (mm/min)	Depth of Cut (t) (mm)	Material Removal Rate (mm^3 /min)	Surface Roughness (RA) (µm)
500	0.25	0.3	53.969	0.034
500	0.35	0.4	100.742	0.031
500	0.45	0.5	161.906	0.027
700	0.25	0.4	100.742	0.036
700	0.35	0.5	176.298	0.039
700	0.45	0.3	136.001	0.041
900	0.25	0.5	161.906	0.034
900	0.35	0.3	136.001	0.037
900	0.45	0.4	233.145	0.037

5. Calculation of gr generation, gr grade and gr coefficient

Table 4: Taguchi Method and Calculation

Material Removal Rate (mm^3 /min)	Surface Roughness (RA) (µm)	Grey Relational Generating	
		Material Removal Rate (mm3 /min)	Surface Roughness (RA) (µm)
53.969	0.034	0.00	0.500
100.742	0.031	0.26	0.714
161.906	0.027	0.60	1.000
100.742	0.036	0.26	0.357
176.298	0.039	0.29	0.143
136.001	0.041	0.46	0.000
161.906	0.034	0.60	0.500
136.001	0.037	0.46	0.286
233.145	0.037	1.00	0.286

Table 5: Grey Relational Generation

Grey Relational Coefficient		Grey Relational Grade
Material Removal Rate (mm^3/min)	Surface Roughness (RA) (µm)	
0.333	0.500	0.417
0.404	0.636	0.520
0.557	1.000	0.779
0.404	0.438	0.421
0.413	0.368	0.391
0.480	0.333	0.407
0.557	0.500	0.529
0.480	0.412	0.446
1.000	0.412	0.706

6. results and discussion

Table 6: Grey Relational Coefficient and Grey Relational Grade

Source	Degree of free-dom	Sequence sum of squares	Contribution (%)
Speed	2	0.032373	22.92
Feed	2	0.052591	37.24
Depth of cut	2	0.049347	34.95
Error	2	0.006877	4.89
Total	8	0.141188	100

From the table 6, we can clearly see that the material removal rate and the surface roughness are influenced by the feed rate and depth of cut.

Table 7: Analysis of Variance for GRA

Level	Speed	Feed	Depth of Cut
1	0.5717	0.4552	0.4230
2	0.4391	0.4853	0.5488
3	0.5601	0.6303	0.5991
Δ	0.1327	0.1751	0.1761
Rank	3	2	1

From the table 8, we can see that the optimal level of performance can be achieved at the speed of 500 rpm, feed of 0.45 mm/min and depth of cut of 0.5 mm.

7. Conclusion

Table 8: Response Table

Speed (N) (rp)	Feed (f) (mm/min)	Depth of Cut (t) (mm)	RA µm	MRR (mm3 /min)	Total Machin-ing Time(T) (s)
700	0.35	0.3	0.039	105.779	81.63
500	0.45	0.5	0.027	161.906	53.33

By optimizing the process parameters, we have reduced the machining time of the journal turning operation with a better surface roughness. So we suggest using these machining parameters for performing the journal turning operation.
In this work, the basics of lean manufacturing were studied and the various tools and their usages were understood.

References

[1] Gurumurthy, A. and Kodaly, R., 2011 'Design of lean manufacturing systems using value stream mapping with simulation: A case study', Journal of Manufacturing Technology Management, Vol. 22 Issue 4, pp.444 - 473.

[2] Goriwondo WM, Mhlanga S, Marecha A. Use of the value stream mapping tool for waste reduction in manufacturing case study for bread manufacturing in Zimbabwe. Proceedings of international Conference on Industrial Engineering and Operations Management 2011.

[3] VijayaRamnath B., Elanchezhian C. and Kesavan R., "A multi attribute decision making method for selection of optimal assembly line", Management Science Letters, Vol.1, pp.65-72, 2011.

[4] VijayaRamnath B., Elanchezhian C. and Kesavan R., "Application of analytical hierarchy process to select Lean-Kitting assembly for an engine assembly", AIMS International Journal of Management, Vol.4, No.2, pp.119-133, 2010.

[5] Singh, B., Garg, S. K., Sharma, S. K., & Grewal, C. 2010. Lean implementation and its benefits to production industry. International Journal of Lean 6 Sigma, 1, 157–168.

[6] William, M. G., Mhlanga, S. and Marecha, A., 2011 'Use of the value stream mapping tool for waste reduction in Manufacturing. Case study for bread manufacturing in Zimbabwe.' Proceedings of International Conference on Industrial Engineering and Operations Management, Kuala Lumpur, Malaysia, pp 236.

[7] Saurin, T.A., Ferreira, C.F., 2009. The impacts of lean production on working conditions: A case study of a harvester assembly line in Brazil.

[8] K. Venkataraman, VijayaRamnath & and Kannappan. S., "Comparative analysis of AHP and ANP model for lean production system justification", Applied mechanics and materials, Vol.591, pp.197-201, 2014.