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REDUCTION OF OVERALL MANUFACTURING EXPENSES FOR BOTH SIMPLE AND COMPLEX ASSEMBLIES

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ABSTRACT

The cost reduction of products is always the major concern for manufacturers to compete and survive in the global market. The quality of the product is a major concern during the minimization of the manufacturing cost of the product. The functional quality of the product is a function of the tolerance imparted to the components of the product. Further, tolerance of the component depends on the manufacturing process and the capability of the machine involved in the manufacturing process. The present researchaims at developing a methodology for minimizing the cost of a product without forgoing its functional quality. The proposed methodology describes the step by step procedure of minimizing the manufacturing cost of the assembly by adopting alternate nominal dimension selection and alternate process selection.

Keywords: Quality, Tolerance stack, Assembly, Optimization.

1. Introduction

The present research aims at developing methodology for minimizing the cost of a product without forgoing its functional quality. The proposed methodology describes the step by step procedure of minimizing the Manufacturing cost of the assembly by adopting alternate nominal dimension selection and alternate process selection [1].

The tolerance optimization has been carried out in both cases. The minimization of Total Manufacturing Cost of an assembly (TC_{asy}) has been carried out for both SA and CA to describe the methodology [2], and it can beextendedtoanyotherassembliesandtheresultsarecomparedwiththeexisting cost model functions. Both discrete and continuous cost functions are used to allocate tolerance for both

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linear and non-linear assemblies using non-traditional optimization techniques.[3]

Most of the earlier studies focused [4,5] on the minimization ofobjectiveslikeassemblytoleranceandmanufacturingcostwithoutconsidering the alternate nominal dimension selection. The present work differs from the earlier works in the manner that the alternate nominal dimension and process selection is carried out in very close decimal ranges instead of discrete values [5-8]. The alternate manufacturing processes and nominal dimensions are selected without affecting the critical dimensions of the assembly during the cost minimization process of an assembly.[9,10]

The minimization of $T\ C_{asy}$ is carried out by selecting the optimalvaluesofnominaldimensionsfromthealternateprocessesalongwithtolerance synthesis [11]. The problem is tobe considered as a multi-objective optimization problem as two different objectives such as alternate nominal dimension selection and tolerance allocation of each component, which are considered for an assembly [12]. As the number of components is increasing and the tolerance range is to be divided into fine intervals, the task of optimization will increase exponentially and hence it turns out to be Non-Polynomial Hard (NP-hard)Problems [13].The minimization of manufacturing cost isobtainedusingLagrangeMultiplier(LM)method,evolutionaryalgorithmssuchasGenetic Algorithm (GA), Artificial Bee Colony (ABC) algorithm and Teacher Learner Based Optimization (TLBO) algorithm. The effectiveness of various algorithms has been compared [14,15].

2. Objectives

The proposed research with regard to the minimization of the total manufacturing cost of an assembly (TC_{asy}) is carried out in two major stages. In Stage-I, the modelling and analysis of optimum tolerance synthesis of Simple Assemblies are performed using LM and GA methods with alternate nominal dimension selection. The minimization has been carried out with and without T_{QL}.

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In Stage–II, the Complex Assembly (CA) with multiple components have been considered for minimization of TC_{asy} using various optimization algorithms. The alternate nominal dimension and process election have been employed during the minimization process. The optimization algorithms such as LM, GA, ABC and TLBO algorithms Deb(1995, 2001) have been used, and the results are compared. The various major stages and sub-stages have been described in detail in Chapter 3.

3. Research Methodology

The proposed research with regard to minimization of the total manufacturing cost of an assembly (TCasy) is carried out in two major stages. The first one is devoted to SA and the next one is concerned about CA. The various major stages and sub stages have been illustrated as work-flow diagram

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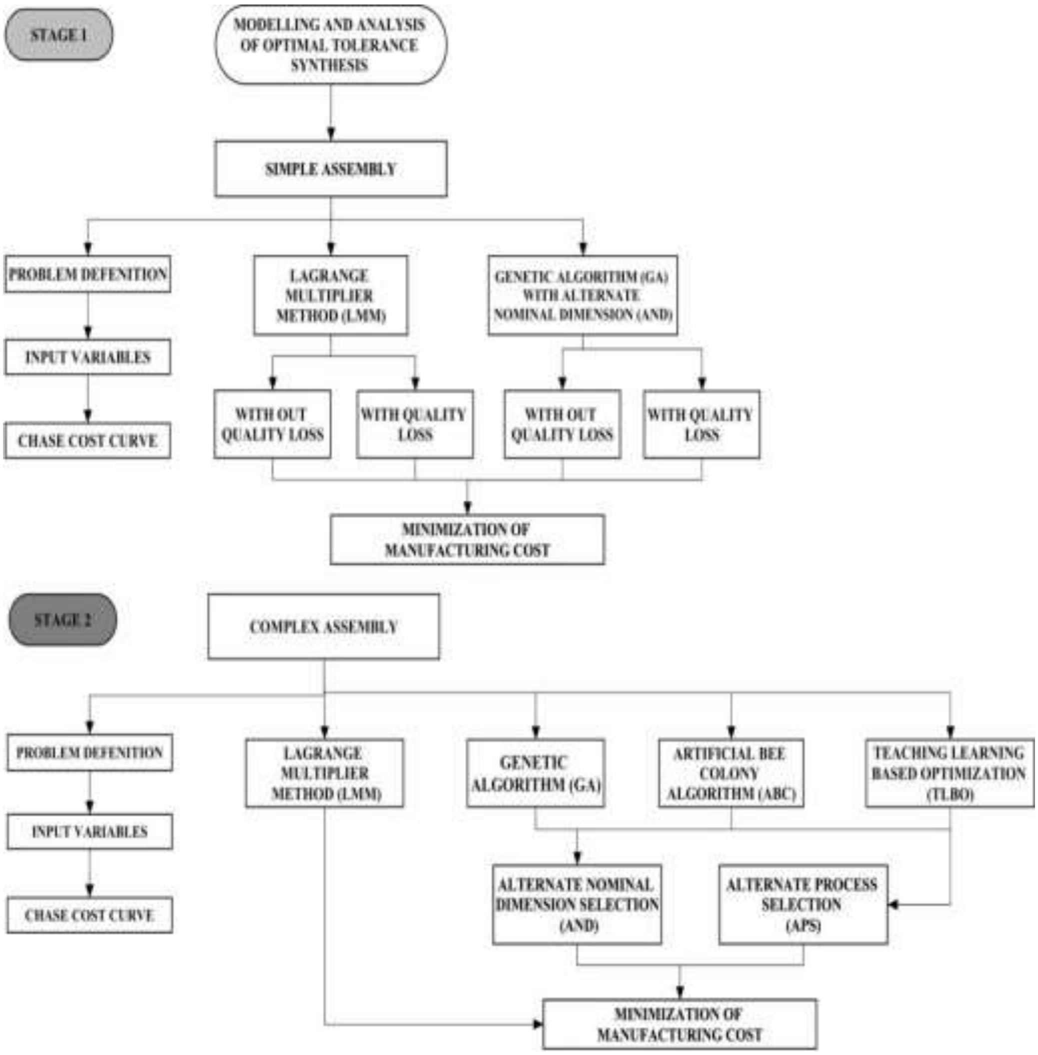

Fig 1. Methodology schematic diagram

3. METHOD

LM method has been applied to optimize the tolerances of components and assembly together in view of minimizing the manufacturing cost. In LM method, the process tolerance allocation is made in a single step. The mathematical model of L Mmethod (Chase *et al.* 1990) that consists of a function for estimating the manufacturing cost and the assembly tolerance constraint with constant ‘λ’.

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4. Minimization of total manufacturing cost of complex assembly using TLBO algorithm

The present study enumerates the systematic procedure for minimization of TC_{asy} in the environment of any assemblies consisting number of components. The alternate manufacturing processes and nominal dimensions are selected without affecting the critical dimensions of the assembly during the cost minimization process of an assembly.

The present work differs from the earlier work in the aspect of alternate process and selection of alternate nominal dimension for the sub components by maintaining the critical tolerances as a constraint. It is considered as the novelty of the present work in minimization of the total manufacturing cost of an assembly.

Conclusion

The minimization of the total manufacturing cost of assemblies (TC_{asy}) is carried out with to lerance of components and critical clearance of the SA and CA assemblies as constraints. The Chase cost tolerance model has been employed for determining the cost of the assembly at different tolerance levels. The LM method and the algorithms such as GA, ABC and TLBO have been employed by incorporating alternate nominal dimension and process selections. The proposed methods are described with the aidof numerical illustrations for better understanding and implementation.

It is strongly expected that the proposed methods will be highly useful to the manufacturing sectors to minimize the manufacturing cost of products.

References

1. Srinivasan V (2007) Computational metrology for the design and manufacture of product geometry: a classification and synthesis. J ComputInfSciEng 7(1):3–9. https://doi.org/10.1115/1. 2424246.
2. Goetz S, Hartung J, Schleich B, Wartzack S (2019) Robustness evaluation of product concepts based on function structures. Proc Des SocIntConfEng Des 1(1):3521–3530. https://doi.org/10.1017/dsi.2019.359.
3. Eifler T, Ebro M, Howard TJ (2013) A classification of the industrial relevance of robust design methods. In: InternationalConference on Engineering Design, ICED13, Seoul, pp 427–436.
4. Balamurugan C, Saravanan A, Dinesh Babu P, Jagan P, RangaS, Narasimman S (2017) Concurrent optimal allocation ofgeometric and process tolerances based on the present worth ofquality loss using evolutionary optimisation techniques. Res EngDes 28(2):185–202. https://doi.org/10.1007/s00163-016-0230-7.
5. Wang Y, Li L, Hartman NW, Sutherland JW (2019) Allocation ofassembly tolerances to minimize costs. CIRP Ann 68(1):13–16.https://doi.org/10.1016/j.cirp.2019.04.027.
6. Sivakumar K, Balamurugan C, Ramabalan S (2012) Evolutionarymulti-objective concurrent maximisation ofprocess tolerances. Int J Prod Res 50(12):3172–3191.https://doi.org/10.1080/00207543.2010.550637.
7. Vignesh Kumar D, Ravindran D, Siva Kumar M, Islam MN(2016) Optimum tolerance synthesis of simple assemblies withnominal dimension selection using genetic algorithm. ProcInstMechEng Part C J MechEngSci 230(19):3488–3508.https://doi.org/10.1177/0954406215613366.
8. Walter MSJ, Wartzack S (2013) Statistical tolerance-costoptimizationof systems in motion taking into account differentkinds of deviations. In: Abramovici M, Stark R (eds) Smartproduct engineering. Lecture Notes in Production Engineering.Springer, Berlin, pp 705–714. https://doi.org/10.1007/978-3- 642-30817-8 69.

9. Sivakumar K, Balamurugan C, Ramabalan S (2011) Concurrentmulti-objective tolerance allocation of mechanicalassemblies considering alternative manufacturing processselection. Int J AdvManufTechnol 53(5-8):711–732.https://doi.org/10.1007/s00170-010-2871-4.
10. Siddique N, Adeli H (2015) Nature inspired computing: anoverview and some future directions. CognitComput 7(6):706–714. https://doi.org/10.1007/s12559-015-9370-8.
11. Zeng W, Rao Y, Wang P (2017) An effective strategyfor improving the precision and computational efficiency ofstatistical tolerance optimization. Int J AdvManufTechnol 92(5-8):1933–1944. https://doi.org/10.1007/s00170-017-0256-7.
12. Shringi D, Purohit K (2013) Simultaneous optimization oftolerances for prismatic part assembly in different stack upconditions. Int J Mining. MetallMechEng 1(2):183–186.
13. NurRosyidi C, Murtisari R, Ahmad Jauhari W (2017) A concurrentoptimization model for supplier selection with fuzzy qualityloss. J IndEngManag 10(1):98–110. https://doi.org/10.3926/jiem.800.
14. Hoffenson S, Dagman A, S¨oderberg R (2013b) A multi-objectivetolerance optimization approach for economic, ecological, andsocial sustainability. In: Nee A, Song B, Ong SK (eds) Reengineeringmanufacturing for sustainability. Springer, Singapore,pp 729–734. https://doi.org/10.1007/978-981-4451-48- 2 119.
15. Hoffenson S, Dagman A, S¨oderberg R (2014) Tolerance optimization considering economic and environmental sustainability. JEng Des 25(10-12):367–390. https://doi.org/10.1080/09544828.2014.994481.