Supplemental Materials

Table S1. Summary of literature survey

Author's Name	Methodology/Tools used				Type of cost function		Example product			Objective function			APS	AMS	Tolerance allocation model	
	MHM	HM	LMM	OM	DCF	CCF	SA	CA	NA	MC	QC	MT			WC	RSS
Zhang and Wang (1993) [7]	√					√		√		√					√	
Zhang and Wang (1993a) [42]	√					√	√			√			√		√	
Vasseur *et al.* (1997) [1]	√					√	√			√	√					√
Zhang and Wang (1998) [67]	√					√		√		√					√	
Ji *et al.* (2000) [8]	√					√	√			√	√				√	
Carfagni *et al.* (2001) [54]	√					√	√			√					√	
Uttam (2001) [9]	√					√	√			√			√	√	√	
Ming and Mak (2001) [43]	√			√		√	√			√			√		√	
Singh *et al.* (2003) [10]	√					√		√		√			√		√	
Singh e*t al.* (2004) [12]	√					√		√	√	√					√	
Prabhaharan *et al.* (2004) [11]	√					√	√		√	√					√	
Singh *et al.* (2004a) [12]	√					√		√	√	√			√		√	
Singh *et al.* (2005) [65]	√					√		√		√			√		√	
Prabhaharan *et al.* (2005) [62]	√					√	√		√	√					√	
Etienne et al. (2008) [13]	√					√	√			√			√		√	
Wu et al. (2009) [14]	√			√		√			√	√					√	

Kumar et al. (2009) [59]	√					√	√			√			√		√	
Sivakumar et al. (2011) [16]	√					√	√			√			√		√	
Sivasubramanian and Sivakumar (2010) [17]	√					√		√		√		√	√	√	√	
Sampath Kumar et al. (2010) [32]	√					√	√			√	√				√	
Rao (2011) [33]	√					√	√			√	√				√	
Sivakumar et al. (2012) [66]	√					√	√	√		√					√	
Geetha et al. (2013) [38]	√					√		√		√	√	√	√	√	√	
Kim *et al.* (1999) [18]		√				√	√			√			√		√	
Gadallah (2011) [19]		√				√	√			√					√	
Chase *et al.* (1990) [5]			√	√	√	√	√		√	√					√	
Chen (1996) [55]			√			√	√			√					√	
Christopher *et al.* (2003)			√			√		√		√					√	
Cheng and Tsai (2011) [2]			√			√		√		√						√
Cheng and Tsai (2013) [3]			√			√	√			√						√
Liu and Jin (2013) [35]			√			√	√			√	√				√	
Ostwald *et al.* (1997) [31]				√	√		√			√					√	
Loosli (1987) [60]				√		√	√			√			√		√	
Wu *et al.* (1988) [14]				√		√	√			√	√				√	
Lee and Woo (1989) [20]				√		√	√	√	√	√					√	
Dong *et al.* (1990) [57]				√		√		√		√					√	
Nagarwala et al. (1995) [61]				√		√	√			√			√		√	
Feng and Kusiak (1997) [4]				√	√		√			√	√				√	√
Chase (1999) [26]				√	√		√		√	√					√	√
Feng and Kusiak (2000) [21]				√		√	√			√			√		√	
Diplaris and Sfantsikopoulos (2001) [56]				√		√	√			√					√	

Choi *et al.* (2000) [38]	√	√			√	√	√	√	
Chou and Chang (2001) [39]	√	√	√			√	√	√	
Jeang and Chang (2002) [68]	√	√		√		√		√	
Ye and Salustri (2003) [40]	√	√	√			√	√	√	
Rao and Wu (2005) [63]	√	√		√				√	
Savage *et al.* (2005) [64]	√	√		√		√		√	
Huang and Shiau (2006) [69]	√	√		√		√		√	
Gopalakrishnan et al. (2007) [41]	√	√	√			√	√	√	
Li et al. (2008) [44]	√	√		√		√		√	
Janakiraman and Saravanan (2010) [58]	√	√	√			√		√	
Jayaprakash et al. (2012) [6]	√	√	√			√			√
Hung and Chan (2013) [45]	√	√	√	√		√		√	
Barari (2013) [46]	√	√		√		√		√	

MHM – Meta-Heuristic Method; HM – Heuristic Method; LMM – Lagrange's Multiplier Method; OM – Other Methods; DCF – Discrete Cost Function; CCF – Continuous Cost Function; SA – Simple / Linear Assembly; CA – Complex Assembly; NA – Non-linear Assembly; MC – Manufacturing Cost/Tolerance Cost; QC – Quality Cost; MT – Machining Time; APS – Alternative Process Selection; AMS – Alternative Machine Selection; WC – Worst-Case; RSS – Root Sum Square method;

Table S2. Feasibility Matrix for WMA [Geetha et al. (2013)]

		Process numbers				
		P1	*P2*	*P3*	*P4*	*P5*
Operation numbers	*O1*	1	1	0	1	0
	O2	1	0	1	0	1
	O3	0	1	0	1	0
	O4	0	0	1	0	1
	O5	1	0	0	1	0
	O6	0	1	0	0	1
	O7	0	0	1	1	0
	O8	1	1	0	0	0
Machine numbers	*M1*	1	0	1	0	1
	M2	0	1	0	1	1
	M3	1	1	1	1	0
	M4	0	0	1	0	1

Table S3. Cost and Time Function Constants for WMA [Geetha et al. (2013)]

		Process number				
		P1	P2	P3	P4	P5
Cost function constant	*a*	1.4	1.5	0.9	2.5	1.9
	b	0.24	0.22	0.18	0.23	0.15
Time function constant	*X1*	2	5	3	4.5	3
	Y1	0.4	0.2	0.8	0.5	0.2
Process capability limits in mm	t_{min}	0.01	0.03	0.02	0.03	0.009
	t_{max}	0.08	0.09	0.07	0.13	0.1
Cost and Time manipulating Factor Machine Numbers	*M1*	0.8	0	0.85	0	1.08
	M2	0	0.85	0	1.11	1.01
	M3	1.15	1	0.9	0.95	0
	M4	0	0	1.02	0	0.8

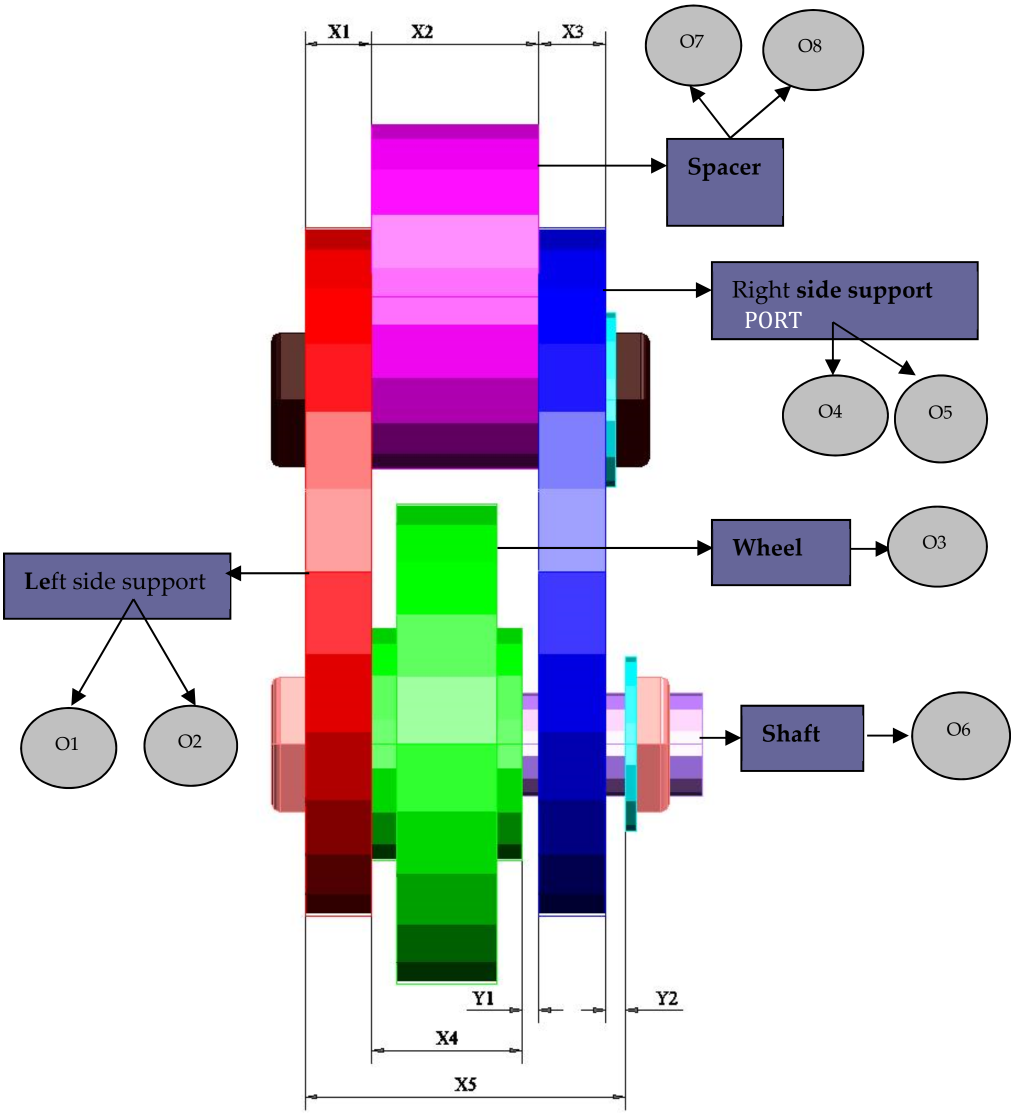

Figure S1: Wheel Mounting Assembly (WMA) [Geetha et al. (2013)]

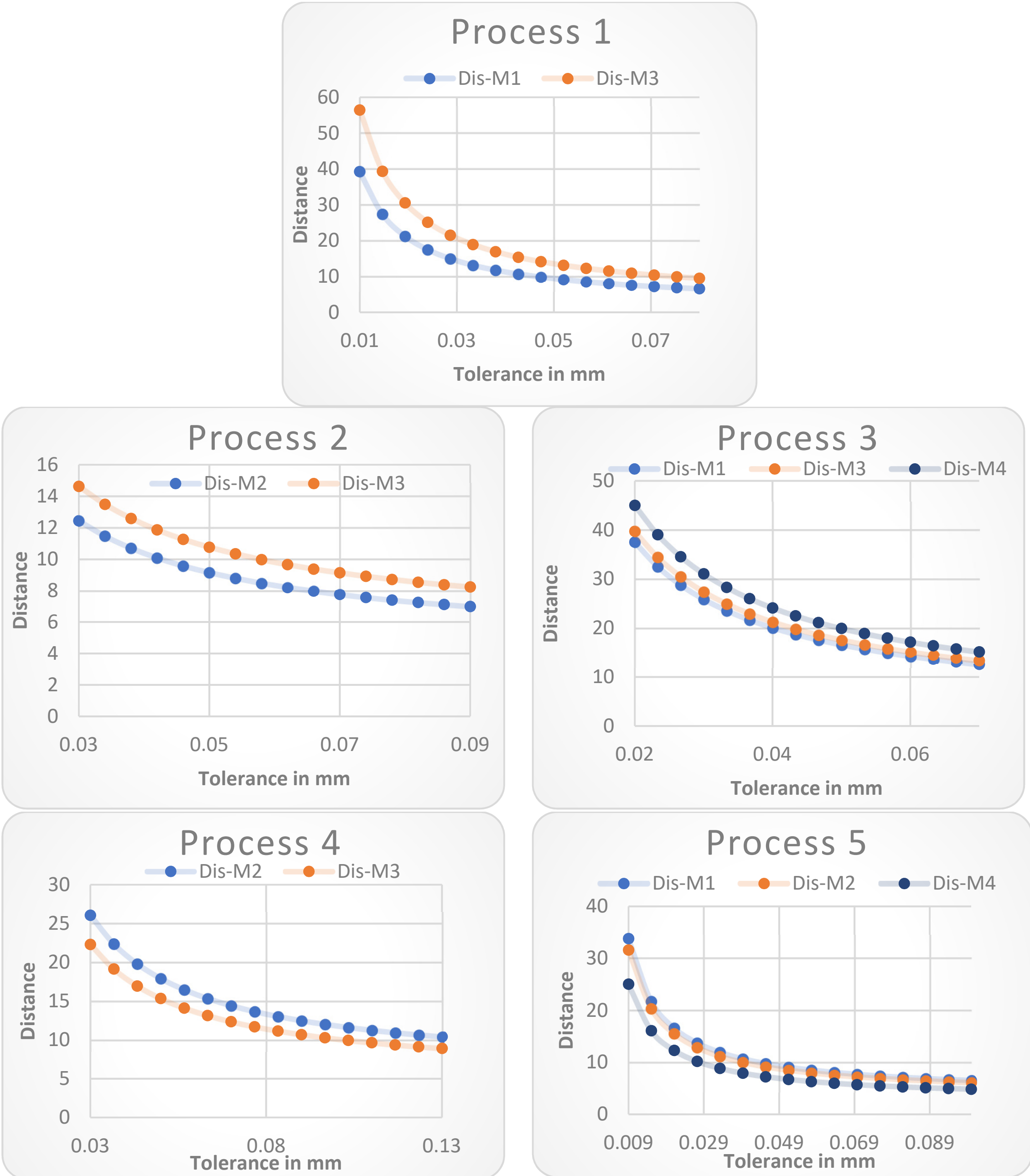

Figure S2: Selection of best machine for process number 1 to 5 to manufacture WMA

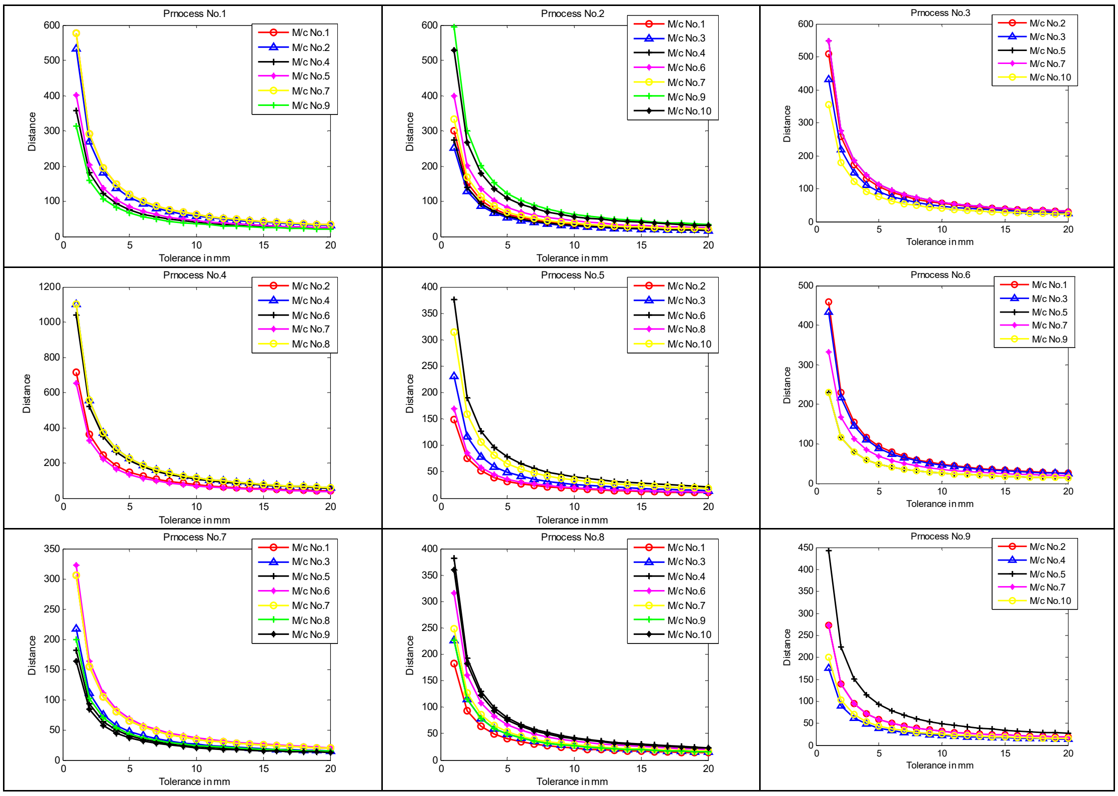

Figure S3: Selection of best machine for process number 1 to 9 to manufacture KJA

<u>Pseudocode of Whale Optimization Algorithm with Univariate search method</u>

Initialize no. of Whales' position as tolerance of each sub-stage/operation (t_{ij}, where i =1,2,..nw and j=1,2,..no)
While ($it < nitr$)
For each whale i=1 to nw
Determine the assembly tolerance (t_{ay}) using equations (19) and (21)
Check t_{ay} within the specified tolerance value t_y
For each operation j=1 to no
For each alternative process of operation k=1 to $npo(j)$
Calculate TC_{ijk} and MT_{ijk} using equations (2) and (3)
Calculate dis_{ejk} using equation (13)
End
Select the process corresponding to minimum value of dis_{ijk}
as bp_i=j, its TC_{ij} as bTC_i and MT_{ij} as bMT_i
End
Compute C and T using equations (22) and (23)
Calculate fitness function F_i using equation (13)
Calculate machine engage time (met) and check with machine available time (amt)
End
Sort F_i in ascending order and store the first whale's fitness value as F_{it}, position as $X_{it.}$ and save its corresponding bp, bTC, bMT, C, T and F
Using the sorted data, assign $X_{p.} = X_{1.}$
Compute $a = 2 - it * (\frac{2}{nitr})$ and $a2 = -1 + it * (\frac{-1}{nitr})$
For each whale
Update the position using
*A=2*a*rand()-a and G= 2*rand() and l=(a2-1)*rand()+1 and p=rand()*
If $p < 0.5$

If $abs(A)$ >=1
$D_{i.}=abs(G*X_{r.}-X_{i.})$ *and* $X_{i.} = X_{r.}-A*D_{i.}$
If $abs(A)$ <1
$D_{i.}=abs(G*X_{p.}-X_{i.})$ *and* $X_{i.} = X_{p.}-A*D_{i.}$
If p >= 0.5
$D_{i.}=abs(X_{p.}-X_{i.})$ *and* $X_{i.} = X_{p.}+D_{i.}*Exp^{b*l}*cos(2\pi l)$
Check $X_{i.}$ within bounds
End
End
Sort F_{it} in ascending order and display the first data's position as the optimal allocated tolerance, bP as the best process, *bTC* and *bMT* as minimum tolerance cost and machining time of each operation and *C, T* as optimum manufacturing cost and machining time.