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LIST OF ABBREVIATIONS AND SYMBOLS

Abbreviation/Symbol	Description
a_e	Radial depth of cut
AECM	Active energy consumption of the machine tool
AMGA	Archive based micro-genetic algorithm
AMOPSO	Adaptive multi-objective particle swarm optimization
ANN	Artificial neural network
a_p	Axial depth of cut
APCM	Active power consumption of the machine tool
ATR	Activity-Therblig relationship
C/O	Change over time
C/T	Cycle time
$C_{coolant}$	Coolant cost
$c_{coolant}$	Coolant price per liter
CE	Carbon emissions
CEC	Comprehensive energy consumption
CE_{chip}	Carbon emissions caused by the chips treatment
$CE_{coolant}$	Carbon emission caused by coolant
CE_{elec}	Carbon emission caused by electricity
CEF_{chip}	Carbon emission factor for chip processing
$CEF_{coolant}$	Carbon emission factor of coolant production
$CEF_{coolant\text{-}dis}$	Carbon emission factors of coolant disposal
CEF_{elec}	Carbon emission factor due to electricity production
$CEF_{material}$	Carbon emission factor of raw material production
CEF_{tool}	Carbon emission factor of the cutting tool
C_{elec}	Electricity cost
$CE_{material}$	Carbon emission caused by raw material production
CE_{tool}	Carbon emission caused by cutting tool
CEU	Comprehensive energy utilization
C_L	Labor cost
C_{MT}	Machine tool depreciation cost
CNC	Computer numeric control
Com-MGGP	Complexity based multi-gene genetic programming
C_p	Production cost
CSEC	Cutting specific energy consumption

Abbreviation/Symbol	Description
CSM	Current state map
C_{tool}	Cutting tool cost
$EC_{process}$	Energy consumption during machining process
E_i	Energy consumed by activity *i*
E_j	Energy consumed by Therblig *j*
f	Feed rate
FRP	fiber reinforced plastic
FSM	Future state map
f_z	Feed rate per tooth
GA	Genetic algorithm
HBMO	honey-bee mating optimization
HMM	Hidden markov model
k	Specific cutting energy of material
MEC	Machine energy consumption
MOBSA	Multi objective backtracking search algorithm
MOO	Multi objective optimization
MOPSO	Multi objective particle swarm optimization
MQL	Minimum quantity lubrication
MQL	Minimum quantity lubrication
MRR	Material removal rate
NC	Numeric control
NLP	Nonlinear programing
NNVAA	Necessary non-value-added activity
NSGA	Non-dominated sorting genetic algorithm
NVAA	Non-value-added activity
NVAT	Non-value-added Therbligs
OEC	Operator energy consumption
P(t)	Power drawn by machine tool at time *t*
$P_{air\text{-}cut}$	Air cutting power
PF	Power factor
p_{ij}	Power of j^{th} Therblig in i^{th} activity
PSO	Particle swarm optimization
PT	Processing time
R_a	Surface roughness
RPM	Rotation per minute

Abbreviation/Symbol	Description
RSM	Response surface methodology
S/N	Signal to noise ratio
SA	Simulated annealing
SCE	Specific cutting energy
SEC	Specific energy consumption
s_{ij}	Execution state of j^{th} Therblig in i^{th} activity
SOO	Single objective optimization
SQP	Sequential quadratic programming
STEP-NC	Standard for exchange of product model data-numerical control
t_c	Cutting time
T_c	Cutting temperature
$T_{coolant}$	Coolant replacement time
TEC	Total energy consumption
t_i	Duration of i^{th} activity
TP	Therblig power
TT	Therblig time
T_{tool}	Cutting tool life
TVSM	Therblig-based value stream map
U	Energy utilization ratio
UM	Machine specific energy
U_{nc}	Net specific cutting energy
UNVAA	Unnecessary non-value-added activities
V	Cutting speed
VAA	Value-added activity
V_{ad}	Volume of additional cutting fluid used before replacement
VAT	Value-added Therbligs
v_c	Cutting speed
$V_{coolant}$	Total volume of coolant used before replacement
V_{in}	Volume of cutting fluid used initially
VMC	Vertical milling center
VSM	Value stream map
W_{chip}	Weight of chips produced
W_{tool}	Weight of cutting tool
α	Concentration of the coolant

Abbreviation/Symbol	Description
η_A	Energy efficiency at the activity level
η_T	Energy efficiency at Therblig level
η_{time}	Time efficiency
E_{sb}	Total standby energy
E_{st}	Total starting energy
E_u	Total idling energy
E_c	Total cutting energy
E_a	Additional load loss
ρ	Density of workpiece material