Fundamentals of Tool Design

Fifth Edition

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Abbreviations

3D	three-dimensional
3DP	three-dimensional printing

A

AC	alternating current
A	ampere
AFM	abrasive flow machining
AGD	American Gage Design
AISI	American Iron and Steel Institute
AJM	abrasive-jet machining
AMSA	American Metal Stamping Association
AMT	Association for Manufacturing Technology
ANSI	American National Standards Institute
ASCII	American standard code for information interchange
ASM	American Society for Metals
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials

B

Bhn	Brinell hardness number

C

C	Celsius
CAD	computer-aided design
CAM	computer-aided manufacturing
CAMI	Coated Abrasive Manufacturers' Institute
CAT	computer-aided tomography
CBD	chronic beryllium disease (berylliosis)
CBN	cubic boron nitride
CCD	charged couple device
CE	concurrent engineering
CFR	Code of Federal Regulations
CIM	computer-integrated manufacturing
CGA	circle grid analysis
CHM	chemical machining
cm	centimeter
CMM	coordinate measuring machine
CNC	computer numerical control

D

dB	decibel
DC	direct current
DCC	direct computer control
DFM	design for manufacturability
dia.	diameter
DOE	design of experiments
DOF	depth of field
DSCP	direct-shell production casting
DXF	drawing exchange format

E

EBM	electron beam machining
ECM	electrochemical machining
EDM	electrical discharge machining
EH&S	environmental, health, and safety
ELP	electropolishing
EPA	Environmental Protection Agency
Eq.	equation

F

F	Fahrenheit
FDM	fused deposition modeling
fig.	figure
FIM	full indicator movement
FLD	forming limit diagram
FMS	flexible manufacturing system
FOV	field of view
ft	foot/feet
ft^3/min	cubic feet per minute

G

g	gram
gal	gallon
GD&T	geometric dimensioning and tolerancing
GMAW	gas metal-arc welding

H

hp	horsepower
hr	hour
HSS	high-speed steel
Hz	hertz

I

IC	integrated circuit
ID	inside diameter
IGES	initial graphics exchange specification
in.	inch
ipm	inches per minute
ipr	inches per revolution
ISO	International Organization for Standardization

J

J	joule
JIT	just-in-time

K

kg	kilogram
kHz	kilohertz
km	kilometer
kN	kilo Newton
kPa	kilo Pascal
ksi	1,000 pounds per square inch
kW	kilowatt

L

lb	pound
lbf	pound force
LBM	laser beam machining
LED	light-emitting diode
LMC	least material condition
LVDT	linear variable displacement transformer

M

m	meter
μin.	microinch
μm	micrometer
mg	milligram
mi	mile
MIL	military specification
min	minute
mm	millimeter
MMC	maximum material condition
MN	mega Newton
MPa	mega Pascal
ms	millisecond
MSCMM	multi-sensor coordinate measuring machine

N

N	Newton
NC, N/C	numerical control
Nd:YAG	neodymium: yttrium aluminum garnet
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
NIST	National Institute for Standards and Technology
nm	nanometer
N/m	Newton/meter
NSMPA	National Screw Machine Products Association
NTIS	National Technical Information Service

O

OBI	open-back inclinable (press)
OBS	open-back stationary (press)
OD	outside diameter

OHD	overhead drive
ohm	unit of electrical resistance
OSHA	Occupational Safety and Health Administration
oz	ounce

P

PAM	plasma-arc machining
PCBN	polycrystalline cubic boron nitride
PCD	polycrystalline diamond
PCM	photochemical machining
PH	precipitation hardening
ppm	parts per million
psi	pounds per square inch
PWB	printed wiring board

Q

qt	quart

R

R	radius
Ra	roughness average
RCRA	Resource Conservation and Recovery Act
rev	revolution
RFS	regardless of feature size
R_{max}	maximum roughness depth
RMS	root mean square
rpm	revolutions per minute
RP&M	rapid prototyping and manufacturing

S

s, sec.	second
SAE	Society of Automotive Engineers
sfm, sfpm	surface feet per minute
sfpm	surface feet per minute
SiC	silicon carbide
SLS	selective laser sintering
SME	Society of Manufacturing Engineers
SPC	statistical process control
SPM	strokes per minute
STEP	standard for the exchange of product
STL	stereolithography

T

TEM	thermal energy method
TiC	titanium carbide
TiN	titanium nitride
TP	true position

U

U.K.	United Kingdom
UL	Underwriters' Laboratories
U.S.	United States
USM	ultrasonic machining
UV	ultraviolet

V

V	volt

W

W	watt
WAM	waterjet abrasive machining
WBTC	Worldwide Burr Technology Committee
WJM	waterjet machining

Y

yd	yard
yr	year

MATH SYMBOLS

$\sim$	about equal to
$^\circ$	degree
/	divided by or per
$>$	greater than
$\geq$	greater than or equal to
α	Greek alpha
β	Greek beta
Δ	Greek delta
ϵ	Greek epsilon
γ	Greek gamma
λ	Greek lambda
μ	Greek mu
Ω	Greek omega
ϕ	Greek phi

π Greek pi
σ Greek sigma
θ Greek theta
ϑ Greek theta (lower case)
$<$ less than
$\leq$ less than or equal to
$-$ minus
% percent
$+$ plus
$\pm$ plus or minus
$\times$ times

Preface

The field of tool design is one of the most diverse areas of manufacturing engineering. From simple cutting tools and workholders to complex cutting dies, computer software applications, and rapid prototyping/manufacturing technology, the field of tool design has evolved into an individual discipline requiring imagination and innovation to solve today's complex tooling conundrums.

In larger facilities, the tool designer often has a specific area of concentration. In smaller shops, the designer may have complete design responsibility along with supervising and directing the toolroom. In either case, today's tool designers must be familiar with all aspects of tool design to perform their responsibilities effectively.

This book, the *Fundamentals of Tool Design*, is a means to that end. For the Society of Manufacturing Engineers, this book is a touchstone—it brings to ground the SME mission of gathering and sharing information. For those who reviewed chapters, it was a positive experience to share the insight acquired throughout their careers and an opportunity to smooth the road a little for those coming after them. For those who will read this book, whether in a classroom or on a shop floor, it might be considered an educational autobahn, the confluence of myriad roads and avenues, entrances, and exits that leads one to the wellspring of knowledge, and what is a better destination than that?

David Spitler

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