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The following corrections are to be entered in the Problem sections of several chapters.
The correct versions of the passages to be changed are put in brackets and underlined [ ].

P.6.3. *Flow through round channel.*

In a way analogous to Figs 6.11, 6.12, 6.13 write a Matlab computer program and produce plots of velocity distribution and of strain rate distribution for a) Newtonian fluid with viscosity 100 Pas at strain rate of 3,000/sec and b) Non-Newtonian fluid with viscosity characterized by parameters K=12,198 and n=0.4, see [Eqs. (6.39), (6.40) and (6.47)] for flow in a round channel with R=2mm, length L=50mm and pressure drop ΔP= 30 MPa. Plot *u* and *gammadot* versus +- *r*.

P.7.4 A milling operation is being performed similar to the one shown in Fig. 7.30. The feed/tooth c = 0.2 mm, [$\sigma = 30^o$] and the start and end angles are $\phi_s = 30°$, and $\phi_e = 160°$.

a) Determine the [mean] chip thickness [h_m] .

b) Indicate in a graph of h vs. ϕ, the variation of h on one tooth over two revolutions of the cutter.

P.7.5 Graphically express the variation of torque in an end mill. In a graph of torque vs. angle ϕ, plot the torque of three subsequent teeth and find the maximum total torque on the end mill. The cutter has 8 straight teeth and a diameter of 100 mm. The workpiece engages the cutter from $\phi_s = 45°$ to $\phi_e = 150°$, and the axial depth of cut a_a = 20 mm.[Chip load is c = 0.2 mm.] Assume a specific force of $K_s = 2000$ N/mm^2.

P.7.6 A 4 fluted end mill of 40 mm diameter is performing an up-milling operation as shown in Fig. 7.29a), into a workpiece of 1035 steel. The axial depth of cut a_a = 20 mm and the radial depth of cut a_r = 25 mm. The cutting velocity v = 45 m/min, with a feed [per] tooth of [c] = 0.25 mm.

Determine:

a) Spindle speed n (rev/min).

b) Feed rate f (mm/min).

c) Metal removal rate Q (cm^3/min).

d) [Mean] chip thickness [h_m] (mm).

e) Specific power K_s [W/(cm^3/ min)], from Table 7.1.

f) Power P (kW).

P.7.7 A face milling operation is being performed similar to that of Fig. 7.30. A 300 mm diameter cutter with 16 teeth is cutting a 200 mm wide strip of 1035 material, which is centrally located under the cutter axis. The operating parameters are: a_a = 5 mm, v = 150 m/min, and c = 0.25 mm.

Determine:

a) Spindle speed n (rev/min).
b) Feed rate f (mm/min).
c) Metal removal rate Q (cm^3/min).
d) [Mean] chip thickness [h_m] (mm).
e) Specific power K_s (W/cm^3/sec).
f) Power P (kW).

P.8.10. Investigate machining Ti alloys with a high rake angle, thin chips and high cutting speed. Refer to Fig. P.8.10.

a) Take the case of Example 8.4 with v = 0.5 m/sec, h_1 = 0.2 mm, $\alpha = 0^0$, $\beta = 22^0$, $\phi = 23^0$, b = 10 mm as reference a).

In order to properly include the effect of change of the rake angle and the corresponding changes of the shear angle ϕ and of the length L_c of the shear plane the cutting force F will be derived from the shearing force F_s which itself is obtained from the shear flow stress τ_s :

$$F_s = \tau_s L_s b$$

From this the value of the friction force F_f is further derived. Refer to Fig.8.8 and Eq.(8.13).

b) First change the rake angle to $\alpha = 12^0$. This will affect also the other angles of the cut in the way that has been discussed and expressed in Eq.(8.13). Assume [friction angle $\mu = 22^0$; this results in $\beta = 10^o$ and $\phi = 35^o$] . Assume $L_c = 4h_1$.

c) Add the next change, h_1 = 0.05 mm.

d) Now, see if you could afford to triple the speed to v = 1.5 mm/sec and still keep the peak temperature within acceptable limits. Plot $T_{1,k}$ (1,KK) versus x for all the four cases in one plot.

P.8.12. Power, MRR, cost in a turning operation. Refer to Fig. P.8.11.

Mean diameter d_m = 75mm, length L = 200 mm, depth of cut a = 5 mm, feed per revolution f_r = 0.25 mm. Specific force K_s = 2000 N/mm^2, cutting speed v = 150 m/min. Tool life eq. $v^3 f_r^2 T = 8 \times 10^6$ (v(m/min), f_r (mm), T(min) $C_{tool\ edge}$ = \$4.0, $t_{tool\ change}$ = 8 min, machine rate r = \$0.4/[min] . Determine the power consumed (kW), machining time t_m , cost per part C/p.

P.8.13. Optimum speeds, feeds, cost. Use Fig. P.8.11.

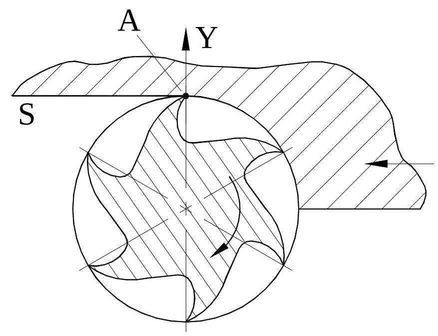
A single tool single pass turning operation has a tool life equation:$v^{3.5} f_r^{2.5} T = 15.24 \times 10^6$; v (m/min), f_r (mm), T (min). The rate for using the machine is r_m = 0.5/min, the tool changing time is t_{tch} = 5 min, and the cost per tool edge is C_{te} = \$2.50, d=80 mm, L = 400 mm.

a) The feed rate is limited by the maximum permissible cutting force of $F_{t,\ max}$ = 2516 N. If the cutting force is determined by $F_t = 1400[\ b f_r^{0.85}\ ]$ and b = 5 mm, what is the maximum feed rate?

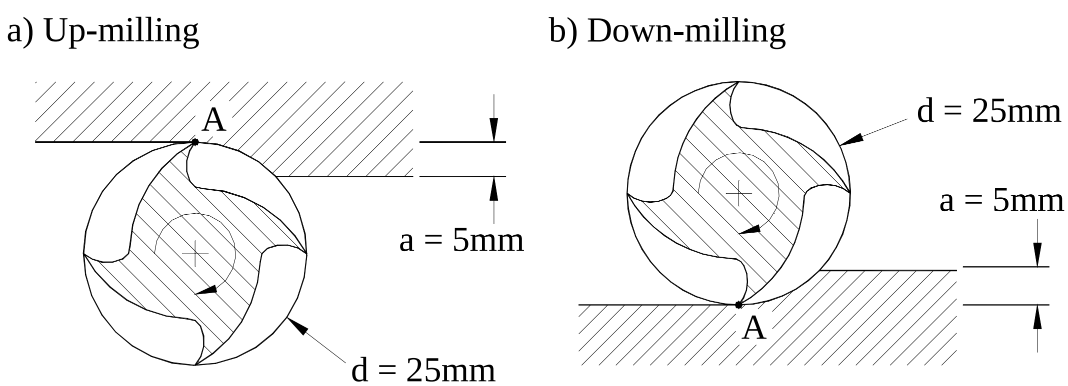
b) Express the machining time t_m as a function of v and determine the optimum cutting speed v_{opt} m/min).

c) What is the corresponding machining time t_m and the minimum cost per part C_p?

Replace Fig. P9.5. As shown here the letter A has been added.



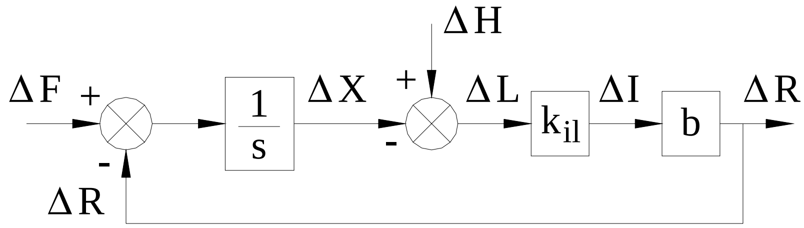
Replace Fig. P.9.7. As shown here the number of teeth on the cutter should be 4, not 6.



P.9.14. *Chatter in milling.* Modify the case illustrated in Fig.9.64. Instead of slotting, assume:
(a) Up-milling with radial immersion a/d = [0.25]
(b) Down milling with a/d = [0.25]
[Number of teeth is m = 4].
Comment for the correction: now go over to paragraph 2:
2. Modify the program listed in Fig. 9.65 to accommodate the different radial immersions [and the fact that only one tooth is cutting at atime. and run simulations for $b = 0.5\ b_{lim}$ and $b = 1.8\ b_{lim}$. Use spindle speed N = 3,000 rpm and M = 2560 computation steps.] Plot x, y, F_x, F_y .

P.10.6., line 4 of the task specification, the SDM system parameters are [k = 2.5 e 7 N/m]; the letter M is replaced by m (meters).

Replace Fig. P.11.1. As shown here the letter k_a is replaced by k_{il} .



P.11.11. *Finite Difference computation of a thermal field of a weld.*

This task is analogous to Example 11.11. The size of the field is different as is also the way of presenting the results.

The size of the field is given by i =1:20, j =1:150. The transformed independent variable T has the dimension n = 1:3000. It is Δx = 3 mm, Δy = 3 mm, g = 4.5 mm. The arc is in location n = 2001. The welded material is steel with parameters k = 43 (N/sec.^{o}C),[α = 12 (mm^2 /sec)], ρc = 3.7(N/^{o}C mm^2).

a) The starting parameters are power input P = 800 W, welding speed v = 2 mm/sec. Calculate the final temperature T_f. Write the computer program to compute the 3000 values of T and plot a graph of temperature profiles along lines parallel with the weld line: those in rows i = 1, 2, 3, 10, 20. Use errmax = 2 ^{o}C. Determine the number of iterations k. Read the maximum temperature T_{2001} . Plot all five lines in one graph, versus distance x.

b) [Change] input P so as to obtain T_{2001} = 1490 ^{o}C, with the same welding speed and obtain new plots. What is the value of the new P ?

c) Increase the speed to v = 4 mm/sec and run the computation with the original value of P. Obtain new plots, read maximum temperature T_{2001} .

Attach the three graphs.

P.11.12. *Residual stresses, see Fig. P. 11.12.*

Carry out an exercise like those in Sec 11.9 but assume different gradients of temperature in the direction away from the weld line as shown in the models at a) and b). Use yield strength Y = 300 N/mm^2 and, for simplicity keep it constant, independent of temperature, thermal expansion coefficients α = 1e-5 /C and modulus of elasticity [E = 2e5 N/mm^2].

Plot graphs like those in Fig. 11.105 and determine temperatures T_1 and T_2 at which first the middle bar and then the outer bar become plastic. Determine the residual stresses σ_m, σ_i, σ_o.

There are also corrections for the text of the book:

Page 116, Table 3.1, Pig iron compositions. The heading of the last column should be C instead of Fe.

Page 56, Eq. (2.12) should read: $Y = \sigma_i + k' D^{-0.5}$ *the exponent is negative.*

Page 656, Eq.(10.43) should be $t_o = \pi / \omega_d$, *x is replaced by π.*

Page 813, the equation that follows Eq. (11.80) and the words modifying and acknowledging that $\Delta x = \Delta y$
should read

$$(T_{i-1,j} + T_{i+1,j} + T_{i,j-1} + T_{i,j+1} - 4\, T_{i,j}) + P/gk = (T_{i-1,j} - T_{i,j})\, \Delta x v / \alpha$$

the signs of the subscript of the second term and of the fifth term in the parentheses of the left hand side are to be changed.

Page 814, the top line, in the expression $B = \Delta xv/\alpha$ *,the capital letter B replaces b.*

Page 846, the paragraph between Eq. (12.15) and Eq (12.16), the value of *c* is 4.18 Nm/(g^oC) and not 418.

In Eq. (12.17), in the denominator instead of $R\ e^{0.25}$ it should be written $Re^{0.25}$.

marked at the $t = 0$ axis in the graph and show the three deflection components that determine the error of location of the machined surface. The surface S_A is "overcut" by 2.375 mm. ▲

EXAMPLE 9.8 Slotting with a Two-Fluted Cutter, Nonresonant Conditions ▼

Assume the same natural frequency of the system, $f_n = 310$ Hz, and the spindle speed $n = 8400$ rpm $= 140$ rev/sec; the tooth frequency is $f_t = 280$ Hz; the periodic force is exciting the system below resonance.

Axial depth of cut $b = 10$ mm

Specific force $K_s = 1000$ N/mm

Chip load $c = 0.1$ mm

Stiffness on the tool $k = 1000$ N/mm

The components of the cutting force F_y are expressed in the same way as in Example 9.7, except for the frequency:

$F_{y1} = -500 \cos (2\pi \times 280\, t)$ N

$F_{y2} = -150 \sin (2\pi \times 280\, t)$ N

DC = 500 N

and the force graph is the same as Fig. 9.38a except for the time scale.

The phase shift of the vibration behind the forces is obtained using Eq (9.41):

$$\phi = \text{atan2}\left(\frac{-2\zeta p}{1 - p^2}\right)$$

where $p = f_t/f_n$. Thus

$$p = \frac{280}{310} = 0.9032 \qquad \phi = -38.11°$$

and the ratio of the vibration amplitude A to the force amplitude is obtained from Eq (9.42) as

$$\frac{A}{F} = \frac{1/k}{\sqrt{(1 - p^2)^2 + 4\zeta^2 p^2}} = 0.00427$$

Thus we obtain $A_1 = 2.135$ mm, and $A_2 = 0.64$ mm.

The forces and vibration components are shown in Fig. 9.39, where they are represented by rotating vectors, the projection of which onto the real axis determines the instantaneous values. At time $t = 0$ a positive cosine function is on the positive real axis, and a positive sine function is on the negative imaginary axis. Thus, F_1 (negative cosine) is on the negative real axis, and Y_1 is 38.11° lagging behind it. F_2 (negative sine) is on the positive imaginary axis, and Y_2 is lagging behind by 38.11°. The projections of Y_1 and Y_2 on the real axis determine the displacements y_1 and y_2 at $t = 0$:

$$y_1 = -2.135 \cos 38.11° = -1.68$$

$$y_2 = 0.64 \sin 38.11° = +0.395$$

and the error δ is obtained as

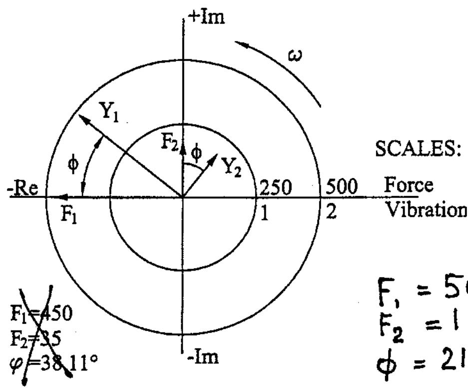


Figure 9.39
Milling forces and vibrations and error of surface location. Slotting with a two-fluted cutter. Forces and vibrations as rotating vectors in Example 9.8 *at nonresonant conditions.* Both the amplitudes and phase shifts of the vibrations depend on the ratio of force frequency over the natural frequency.

$F_1 = 500$
$F_2 = 150$
$\phi = 21.42°$

(2.127) (0.409) (−1.218)

$$\delta = 0.5 - 1.68 + 0.395 = -0.785 \text{ mm}$$

which is the amount by which the surface is "undercut."

The next example is such that it can best be solved by writing and running a computer simulation program because the force function is strongly nonharmonic. ▲

EXAMPLE 9.9 Up-Milling with a Four-Fluted Cutter with Straight Teeth: Only One Tooth in Cut; Forces and Deflections ▼

This is not a slotting case; the cutter engagement angle is less than 90°: The parameters of the case follow:

Axial depth of cut $b = 10$ mm
Chip load $c = 0.1$ mm
Stiffness on cutter $k = 4 \times 10^6$ N/m
Mass $m = 0.88$ kg
Damping coefficient $c = 150$ N/(m/sec)
Spindle speed $n = 5000$ rpm
Cutter diameter $d = 20$ mm
Radial depth of cut $a = 3$ mm
Number of teeth $m = 4$
Specific force $K_s = 750$ N/mm^2
$\phi_s = 0°$, $\phi_e = 45.57°$; see Fig. 9.40

Determine the following:

$$\text{Natural frequency:} \quad f_n = \frac{1}{2\pi}\sqrt{\frac{k}{m}} = 0.159\sqrt{4.54 \times 10^6} = 339 \text{ Hz}$$

$$\text{Tooth frequency:} \, f_t = \frac{4n}{60} = 333.33 \text{ Hz}$$