
MECHANICAL ENGINEERING DESIGN

Fourth Edition

Joseph Edward Shigley

Professor Emeritus

The University of Michigan

Larry D. Mitchell

Professor of Mechanical Engineering

Virginia Polytechnic Institute and State University

McGraw-Hill Book Company

*New York St. Louis San Francisco Auckland Bogotá Hamburg
Johannesburg London Madrid Mexico Montreal New Delhi
Panama Paris São Paulo Singapore Sydney Tokyo Toronto*

MECHANICAL ENGINEERING DESIGN

Copyright © 1983, 1977, 1972, 1963 by McGraw-Hill, Inc. All rights reserved. Printed in the United States of America. Except as permitted under the United States Copyright Act of 1976, no part of this publication may be reproduced or distributed in any form or by any means, or stored in a data base or retrieval system, without the prior written permission of the publisher.

7890 HALHAL 89876

ISBN 0-07-056888-X

*This book was set in Palatino by Santype-Byrd.
The editors were Rodger H. Klas and Madelaine Eichberg;
the designer was Robin Hessel;
the production supervisor was Dominick Petrellese.
New drawings were done by J & R Services, Inc.*

Library of Congress Cataloging in Publication Data

Shigley, Joseph Edward.

Mechanical engineering design.

(McGraw-Hill series in mechanical engineering)

Includes index.

I. Machinery—Design. I. Mitchell, Larry D.

II. Title.

TJ230.S5 1983 621.8'15 82-10044

ISBN 0-07-056888-X

C

Pa

1

1-1

1-3

1-5

1-7

1-1

1-1

Qu

2

2-1

2-4

Su

2-9

2-1

Be

2-1

2-1

dition. There then occurs a point corresponding to equal cost which is called the *breakeven point*.

As an example, consider a situation in which a certain part can be manufactured at the rate of 25 parts per hour on an automatic screw machine or 10 parts per hour on a hand screw machine. Let us suppose, too, that the setup time for the automatic is 3 h and that the labor cost for either machine is \$20 per h, including overhead. Figure 1-2 is a graph of the cost versus production by the two methods. The breakeven point corresponds to 50 parts. If the desired production is greater than 50 parts, the automatic machine should be used.

Cost Estimates

There are many ways of obtaining relative cost figures so that two or more designs can be roughly compared. A certain amount of judgment may be required in some instances. For example, we can compare the relative value of two automobiles by comparing the dollar cost per pound of weight. Another way to compare the cost of one design with another is simply to count the number of parts. The design having the smallest number of parts is likely to cost less. Many other cost estimators can be used, depending upon the application, such as area, volume, horsepower, torque, capacity, speed, and various performance ratios.

Value Engineering

A method of evaluating several proposed designs using a systematic approach called *value analysis*, or *value engineering*, is often very useful and may even point the way to new design approaches. In this method* *value* is defined as a numerical ratio, the ratio of the *function*, or *performance*, to the *cost*.

As an elementary introduction to the methods of value analysis let us analyze the ball bearing of Fig. 1-3. The analysis is carried out in tabular form and is illustrated by Table 1-1. Since only bearing manufacturers have access to actual costs, the analysis which follows is a hypothetical situation. The steps proceed from left to right across the table. These are:

- 1 Name of part
- 2 Brief summary or summary of function
- 3 Estimate of percent of total performance contributed by this function
- 4 Cost of part
- 5 Percent of total cost
- 6 Value, the ratio of percent performance to percent cost

The reasoning behind this form of analysis is easily explained. As we shall learn in Chap. 11, the outer and inner rings provide raceways for the balls. Also,

* See D. Henry Edel, Jr., *Introduction to Creative Design*, Prentice-Hall, Englewood Cliffs, N.J., 1967, pp. 111-119.