ABSTRACT—Paper presents the experimental confirmation of a vibration and stability model of a thermally stressed rotating disk. Attention is directed to the rotating-disk convective-heat-transfer problem. Measured temperature distributions are used in the computation of the theoretical characteristic frequency spectrum which is then verified by the experimental frequency spectrum. The theoretical characteristic spectrum is shown to be effective in predicting the likelihood of a critical speed instability of the thermally stressed rotating disk. Optimal control of disk operation using this model is proposed.
tion of the critical speed from the rotation speed, is
directly determinable from the disk spectrum. Con-
sequently, this suggests a potential method for on-line
evaluation and control of the saw-disk transverse
stability.

In nearly all applications, thermal effects are un-
avoidable and often cause significant stability varia-
tions. Difficulties in determining the rotating-disk
temperature distribution have hampered efforts to in-
clude thermal effects in the stability analysis. Theo-
retical papers\textsuperscript{8-11} have been published which use heat-
transfer data from the literature\textsuperscript{13,14} to explore the
thermal-stability problem. However, geometric-simi-
larity problems exist between the type of disk used
here, which has a large central collar, and those used
in the heat-transfer coefficient measurements, which
are flat. Applicability of these heat-transfer results
will be discussed herein. The present work com-
pares the measured characteristic frequencies of a
thermally stressed rotating disk with theoretical com-
putations which use the measured temperature. For
the most part, the experimental support of the theory
is excellent and continued effort toward on-line sta-
bility control based on the critical-speed theory is
encouraged.

**Disk Properties**

The four disk specimens examined are character-
ized by the following properties:

<table>
<thead>
<tr>
<th>Property</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material</td>
<td>Cr-Mo steel</td>
</tr>
<tr>
<td>Thickness</td>
<td>1.02 mm (uniform)</td>
</tr>
<tr>
<td>Free peripheral diameter</td>
<td>407.4 mm</td>
</tr>
<tr>
<td>Central clamp diameter</td>
<td>203.2 mm</td>
</tr>
<tr>
<td>Young's modulus</td>
<td>$20.7 \times 10^4$ MPa (assumed)</td>
</tr>
<tr>
<td>Poisson's ratio</td>
<td>0.3 (assumed)</td>
</tr>
<tr>
<td>Hardness (HRC)</td>
<td>55</td>
</tr>
</tbody>
</table>

Two specimens were identical uniform disks, the
third contained four 25.4-mm-long radial-edge slots,
and the fourth contained four 50.8-mm-long edge
slots. The narrow radial slots were spaced at 90-deg
intervals terminating at the periphery.

**Heat-transfer Analysis**

The heat-transfer analysis had three principal ob-
jectives: (1) measurement of the disk-temperature
distribution for use as input data in the characteristic
frequency computation, (2) evaluation of published
convective-heat-transfer coefficients for the disk of
interest here, (3) examination of the potential for
theoretical computation of the temperature distribu-
tion using the measured temperature at specific
points.

The apparatus for temperature measurement is il-
lustrated in Fig. 1. An infrared thermometer with a
focus spot size of 3.8-mm diameter was used to sweep
the disk temperature at a rate of 0.9 mm/s. A tem-
perature-resistant black paint, 5.1 $\mu$m thick, covered