Guidelines for Product Improvement:

Usage of all fragile parts’ DBCs on a product

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Organization : TRI Osaka  1988～

< Research >
  • Optimal cushioning design method  
  • Test method for shock fragility of products  
  • AFS (Accumulated Fatigue Spectrum)  
    & Vibration Test method by AFS ( K2-Fatigue by IMV )

< Consultancy >
  • Packaging (Transportation)  
  • Shock & Vibration  etc.

< Test & Evaluation >
  • Vibration  
  • Drop  
  • Compression strength  
  • Shock fragility of product  
  • Cushioning material  etc.
This plan was selected as a national project, “Feasibility Study of Standardization” last year.

- A new test procedure has been put together.
- We visited CPRTC at Tianjin (Director Li Hua etc.) and Jinan Univ. at Zhuhai (Prof. Zhi-Wei Wang etc.).

We would like to contribute a new idea to shock test standard all over the world.

- Both cost-cut and high quality will be realized.
Explanation of DBC
(Damage Boundary Curve)

- Non-damage
- Damage

Input Shock Pulse

A

t
Shock Analytical Model by R. E. Newton

Specimen

Part D (ex. a frame)
Part C (ex. a power unit)
Part B (ex. a chip computer)
Part A (ex. a front panel)

The most fragile part

Product
GB/T 15099, ASTM D 3332, JIS Z 0119  (Dr. R.E.Newton)

Critical Velocity
Shock Test
Method A

Damage Boundary

Critical Acceleration
Shock Test
Method B

Velocity Change

DBC and Test Method of Shock Fragility

\[ \Delta V_c \]

\[ \Delta \frac{V_c}{2} \]

\[ A_c \]

\[ V \]

\[ T \]
GB/T 15099, ASTM D 3332, JIS Z 0119

(Dr. R.E. Newton)
Shock test for packaging design

World

China  GB/T 15099-94

America  ASTM D 3332

EU

Japan  JIS Z 0119

New procedure

DBCs for all fragile parts

Guideline for product improvement
If this result is used in packaging design, ....

An accident may happen due to lack of cushioning.

Velocity Change \( \Delta V \)

Drop Height

Acceleration \( A \)

Velocity Change

\[
\text{Acceleration } A = \frac{\Delta V}{\Delta t} = \frac{500 \text{ m/s}^2}{11 \text{ ms}}
\]

\[
\text{Drop Height}
\]

\[
\text{DBC (ASTM D 3332, JIS Z 0119 2002)}
\]

\[
\text{Ac} = 500 \text{ m/s}^2 \quad \Box \quad 250 \text{ m/s}^2
\]

Over-Packaging

\[
\text{Shock Test by Product Designer & Shock Test by Package Designer (IEC 68-2-27, ASTM D 3332, JIS Z 0119) }
\]
Result of Shock Test for a Video-player

A hook of a gear comes off.

Legs of a coupler break.

A front panel breaks.

Stoppers of a front frame come off.
The most fragile part

Product
Shock Test by **Product Designer** & Shock Test by **Package Designer**

(IEC 68-2-27, ASTM D 3332, JIS Z 0119)
A shock test result of a certain product

<table>
<thead>
<tr>
<th>Test No.</th>
<th>Accele. m/s²</th>
<th>V m/s</th>
<th>T ms</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1930</td>
<td>2.31</td>
<td>2.01</td>
<td>No damage</td>
</tr>
<tr>
<td>2</td>
<td>2110</td>
<td>2.49</td>
<td>1.98</td>
<td>No damage</td>
</tr>
<tr>
<td>3</td>
<td>2660</td>
<td>2.90</td>
<td>1.94</td>
<td>Part A was deformed.</td>
</tr>
<tr>
<td>4</td>
<td>2790</td>
<td>3.14</td>
<td>1.59</td>
<td>Part B was deformed.</td>
</tr>
<tr>
<td>5</td>
<td>3360</td>
<td>3.41</td>
<td>1.50</td>
<td>No damage except for A &amp; B.</td>
</tr>
</tbody>
</table>
A shock test result of a certain product

<table>
<thead>
<tr>
<th>Test No.</th>
<th>Accele. m/s²</th>
<th>△V m/s</th>
<th>△T ms</th>
<th>Observations</th>
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<td>1</td>
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<td>2.31</td>
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<td>2</td>
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<td>2.49</td>
<td>1.98</td>
<td>No damage</td>
</tr>
<tr>
<td>3</td>
<td>2660</td>
<td>2.90</td>
<td>1.94</td>
<td>Part A was deformed.</td>
</tr>
<tr>
<td>4</td>
<td>2790</td>
<td>3.14</td>
<td>1.59</td>
<td>Part B was deformed.</td>
</tr>
<tr>
<td>5</td>
<td>3360</td>
<td>3.41</td>
<td>1.50</td>
<td>No damage except for A &amp; B</td>
</tr>
<tr>
<td>6</td>
<td>228</td>
<td>7.41</td>
<td>32.9</td>
<td>No damage</td>
</tr>
<tr>
<td>7</td>
<td>279</td>
<td>7.20</td>
<td>26.1</td>
<td>No damage</td>
</tr>
<tr>
<td>8</td>
<td>323</td>
<td>7.12</td>
<td>22.3</td>
<td>Part C was deformed.</td>
</tr>
<tr>
<td>9</td>
<td>376</td>
<td>6.88</td>
<td>18.4</td>
<td>Part A &amp; B was deformed.</td>
</tr>
<tr>
<td>10</td>
<td>419</td>
<td>6.93</td>
<td>16.8</td>
<td>No damage except for A,C &amp; D</td>
</tr>
</tbody>
</table>
Velocity change (m/s)

Acceleration (m/s²)

Result of Shock Test (DBC)
ASTM D 3332, JIS Z 0119

- Part A breaks.
- Part B breaks.
- No damage except for Part A and Part B

No damage except for Part A, Part C, and Part D

Part A and Part D break.
Part C breaks.
No damage
No damage
ASTM D 3332

Result of Shock Test (DBC)

ASTM D 3332, JIS Z 0119

<table>
<thead>
<tr>
<th>Velocity change (m/s)</th>
<th>Acceleration (m/s²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part A breaks.</td>
<td>No damage</td>
</tr>
<tr>
<td>Part B breaks.</td>
<td>No damage</td>
</tr>
<tr>
<td>Part A breaks.</td>
<td>No damage except for Part A, Part C, and Part D</td>
</tr>
<tr>
<td>Part C breaks.</td>
<td>No damage except for Part A, Part C, and Part D</td>
</tr>
<tr>
<td>Part A and Part D break.</td>
<td>No damage</td>
</tr>
<tr>
<td>Part C breaks.</td>
<td>No damage</td>
</tr>
<tr>
<td>No damage</td>
<td>No damage</td>
</tr>
<tr>
<td>No damage</td>
<td>No damage</td>
</tr>
<tr>
<td>No damage</td>
<td>No damage</td>
</tr>
</tbody>
</table>
New Procedure

Result of Shock Test (DBC)
ASTM D 3332, JIS Z 0119

No damage (Part C and Part D)
No damage (Part B)
Part C breaks.
Part A and Part D break.
Part A breaks.
No damage
No damage
No damage

Velocity change (m/s)

Acceleration (m/s²)
## New Procedure

The chart illustrates the drop height experiment results with drop heights of 19cm, 25.5cm, and 35cm calculated at ε = 0.3.
If Part A is refined, ...

Drop Height: 19cm, 25.5cm, 35cm

calculated at e=0.3
If Part A is refined, ⋯

ex. 1 When the max drop height is 30cm, Ac will be improved from $323 \text{ m/s}^2$ to $419 \text{ m/s}^2$.

ex. 2 When the max drop height is 40cm, Ac will not be improved.
If Part A and Part B are refined, ⋯

Drop Height: 19cm, 25.5cm, 35cm

Calculated at e=0.3
If Part A and Part B are refined, 

ex. 1 When the max drop height is 30cm, Ac will be improved from **323 m/s²**.

Very Effective

ex. 2 When the max drop height is 40cm, Ac will not be improved.

Meaningless
If Part C is refined, •••

Drop Height: 19cm, 25.5cm, 35cm calculated at e=0.3
If Part C is refined, 

---

ex. 1  When the max drop height is 30cm, Ac will not be improved.

Effective

ex. 2  When the max drop height is 40cm, Ac will be improved from 279 □ 323 m/s².

Meaningless
--- The point ---

By this new test procedure, product designers can get a guideline of part’s improvement.

Ex.

H=30cm  □  “Refine Part A.”
or “Refine Part A and B.”

H=40cm  □  “No need to refine”
or “Refine Part C.”
Result of Shock Test for a Video-player

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A front panel breaks.

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A shock test result of a certain product

<table>
<thead>
<tr>
<th>Test No.</th>
<th>A m/s²</th>
<th>V m/s</th>
<th>T ms</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1180</td>
<td>1.42</td>
<td>2.10</td>
<td>No damage</td>
</tr>
<tr>
<td>2</td>
<td>1800</td>
<td>2.01</td>
<td>1.95</td>
<td>No damage</td>
</tr>
<tr>
<td>3</td>
<td>2280</td>
<td>2.89</td>
<td>2.10</td>
<td>No damage</td>
</tr>
<tr>
<td>4</td>
<td>2940</td>
<td>4.09</td>
<td>2.45</td>
<td>No damage</td>
</tr>
<tr>
<td>5</td>
<td>4100</td>
<td>4.96</td>
<td>2.05</td>
<td>Gear, Coupler, Panel, Frame</td>
</tr>
<tr>
<td>6</td>
<td>199</td>
<td>5.51</td>
<td>28.2</td>
<td>No damage</td>
</tr>
<tr>
<td>7</td>
<td>389</td>
<td>5.48</td>
<td>14.5</td>
<td>No damage</td>
</tr>
<tr>
<td>8</td>
<td>596</td>
<td>5.39</td>
<td>9.55</td>
<td>No damage</td>
</tr>
<tr>
<td>9</td>
<td>772</td>
<td>5.52</td>
<td>7.56</td>
<td>Gear, Coupler</td>
</tr>
<tr>
<td>10</td>
<td>951</td>
<td>5.38</td>
<td>6.16</td>
<td>No damage except for the above</td>
</tr>
</tbody>
</table>
Thank you very much for your kind attention.