On the Area Coverage of Grit Blasting

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Reprinted from the Research Reports of the Faculty of Engineering, Meiji University, Japan.

1. INTRODUCTION

Full coverage, i.e., completely covered with dent, is a base of grit blasting. Now a days, area coverage is usually calculated by next formula, \( C = 1 - (1 - C)^n \) [1]. Although this formula means that full coverage didn't reach, but we know that full coverage is easily reached on ordinary process.

The purpose of this paper is to obtain the relation between blasting conditions and area coverage including full coverage. Grit blasting was performed for plain carbon steel (0.45%C) under several conditions. Measured factors are area coverage and full coverage.

2. FORMER THEORY

Now, area coverage may be calculated with the next equation by SAE:

\[
C_n = 1 - (1 - C)^n
\]  

(1)

This equation does not lead full coverage till infinite time as shown in Fig. 1, and not found to be suitable for calculating area coverage and full coverage. For this 98% coverage is used conventionally as full coverage. Namely, this equation contains basic contradictions in practice.

3. EXPERIMENTAL PROCEDURE

Blasting conditions, equipment, grit and work material are shown in Table 1. Treatments of data on dent and coverage are as follows:

1. Diameter of dent was determined from mean values calculating from long and short diameters of 20 dents.
2. Area coverage was determined from the ratio of total area of dent on blasted surface from photo enlarged six times.

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Centrifugal type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grit</td>
<td>Material: cast steel</td>
</tr>
<tr>
<td>Diameter</td>
<td>0.55 - 3.7 mm</td>
</tr>
<tr>
<td>Velocity</td>
<td>17 - 35 m/s</td>
</tr>
<tr>
<td>Blasting time</td>
<td>T: full coverage time</td>
</tr>
<tr>
<td>Impact angle</td>
<td>Normal to the blasting surface</td>
</tr>
<tr>
<td>Specimen</td>
<td>Carbon steel (0.45%C) 180 HV</td>
</tr>
<tr>
<td>Size</td>
<td>25 x 25 x 11.5 mm</td>
</tr>
</tbody>
</table>

4. RESULTS

4.1 Area Coverage

The relations between area coverage and blasting time are shown in Fig. 2, and the increasing ratio of area coverage is divided into the 1st and 2nd term. There are very few overlapped dents in the 1st term, and most of all dents are overlapped partially in the 2nd term.

Factors which affect area coverage are area of one dent and number of dent. The former is determined by mean diameter of dent (d), and the latter is determined by the density of dent of unit area of specimen.

As shown in Fig. 3 the relation between the mean diameter of dent and grit size and velocity can be linear on the logarithmic coordinate, and the formula is:

\[
d = k_d D_g V^{1/2}
\]  

(2)

Therefore, mean diameter is in proportion to grit size and square root of grit velocity.

With the same procedure, density of dent has been found to be in proportion to the sectional area of lead pipe and in inverse proportion to the cube of grit size as shown in Fig. 4.
Figure 3. Relation between mean diameter of dent and grit size (a) and grit velocity (b).

Figure 4. Relation between density of dent and grit size (a) and diameter of lead pipe (b).

Figure 5. Relation between initial area coverage and grit size (a) and velocity (b).

Figure 6. Coefficient $k_c$ and exponent $m$ in equation (5) [(a) 1st term and (b) 2nd term].

Figure 7. Relation among full coverage time, diameter of lead pipe (a), grit size (b) and velocity (c).

Figure 8. Relation between full coverage and hardness of work material.
Therefore, the formula on the number of dent per unit time and unit area of specimen N is as follows:

\[ N = k_s \cdot D_b \cdot D_c \]  
(3)

Total area of dent per unit time and unit area of specimen Q is the product area of one dent \((S_d)\) and N in eq. (3). Therefore, the next equation as obtained:

\[ Q = S_d \cdot N, \quad \text{where} \quad S_d = \pi \cdot d^2 / 4, \]
\[ = k_0 \cdot D_b \cdot D_c \cdot V \]  
(4)

Because initial area coverage \(C_1\) is defined by \((A \cdot Q)/A\), where A is blasting area, and \(C_1\) is equal to \(Q\). Namely, \(Q\) is the maximum value of area coverage per unit time. The relation between initial area coverage and grit size and velocity are shown in Figure 5 on logarithmic coordinate, and from this results, the equation (4) is confirmed.

As shown in Figure 2, the relation between area coverage \((C)\) and total dent area per unit time \((Q)\), blasting time \((T)\) can be expressed in the following equation:

\[ C = k_c \cdot Q \cdot T^m \]  
(5)

Here, coefficient \(k_c\) means the overlapping ratio of dent and exponent \(m\) means the blasting efficiency. Figure 6 shows the relation between initial area coverage and \(k_c\), \(m\) in 1st and 2nd terms. Exponent \(m\) is 0.6 - 1.0 in the 1st term, and 0.6 - 0.11 in the 2nd term.

4.2 Full Coverage Time

The influences of diameter of the lead pipe, grit size and velocity on full coverage time are shown in Figure 7. From these, the relation is as follows:

\[ T_f = k_r \cdot D_b \cdot D_g \cdot V^v \]  
(6)

The influence of the hardness of work material on full coverage time is shown in Figure 8, full coverage time is in proportion to the square root of the hardness.

5. CONCLUSIONS

The increasing ratio of area coverage is clearly separate into two terms (the 1st and the 2nd) at 85% coverage. Area coverage is affected by factors such as the number of dent per unit time on unit work area, and total dent area per unit time.

Area coverage can be expressed the next formula:

\[ C = k_c \cdot Q \cdot T^m \]

Here \(C\): area coverage  
\(k_c\): material constant  
\(Q\): total dent area  
\(T\): blasting time  
\(m\): exponent (0.6 - 1.0 in the 1st, 0.06 - 0.11 in the 2nd)

Full coverage will be reached in a few minutes, and the relations among full coverage time \((T_f)\) and diameter of lead pipe \((D_b)\), grit size \((D_g)\), grit velocity \((V)\) are shown as the next equation:

\[ T_f = k_r \cdot D_b \cdot D_g \cdot V^v \]

Where \(k_r\): work material constant involved hardness.

6. REFERENCE