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# Study on wheel safety guard for stationary grinding machine

A. Yui, M. Sato, H. Yamada, T. Kitajima and N.Ogasawara[1)]

[1]*National Defence Academy, Japan*

*yu@nda.ac.jp*

**Abstract**
Safety of grinding machines should have higher priority than the machine performance (e.g.: machining precision and/or efficiency). When a rotating grinding wheel spontaneously fractures and the fragments collide with the wheel safety guard, the guard should be thick enough to protect the machine operators and tool instrumentation from the projectiles. Therefore, a safety standard must be established based on reliable technical data. In this paper, the maximum kinetic energy of projectile, based on the kinetic energy under the given peripheral wheel speed and mass, is calculated. The projectile's kinetic energy at penetration is absorbed by the deformation of the wheel safety guard and the disassociation of the abrasive product itself. The collision mechanism of highly stiff projectiles has been examined and published. However, few papers have been published regarding brittle projectiles, such as abrasive products, which easily disassociated. Since the scattered fragment size is not predictable, estimation of actual fragment kinematic energy is impossible. Therefore, the authors estimated the largest size and the highest speed of fragment collisions to the wheel safety guard. Collision experiments were carried out using a prototype experimental apparatus consisting of a launcher, a projectile and a target wall in order to build a correlation between collision energy and a safe thickness of the target wall (wheel safety guard).

Key words: grinding machine, wheel safety guard, abrasive product, collision, penetration

## 1. Introduction

Safety of machine tool operators should be the highest priority in production engineering. When a rotating grinding wheel spontaneously fractures and the fragments collide with a wheel safety guard, the guard should be thick enough to protect the machine operators and machine tool instrumentation from the fragments. This paper investigates necessary wheel safety guard thickness for each wheel peripheral speed and fragment mass, and gives information to the working group of the ISO committee to establish an international standard for wheel safety guards [1].

When a projectile, a fragment of the grinding wheel, collides with a wheel safety guard, the kinematic energy of the projectile is absorbed by the safety guard and projectile itself. In cases where the projectile passed through the safety guard, the energy is divided into the kinematic energy of the projectile as well. The authors built a prototype experimental apparatus consisting of a launcher, a projectile and a target wall, then investigated the minimum thicknesses of a wheel safety guard that could withstand the collision.

## 2. Estimation of kinetic energy of projectile

Kinematic energy of a rotating grinding wheel, $E$, is calculated by equation (1).

$$E = \frac{1}{4} m_w (1-Q) v_s^{\,2} \tag{1}$$

Where, $m_w$ is the mass of the abrasive product; grinding wheel, $v_s$ is the peripheral speed of the abrasive product at center of gravity and $Q$ is the ratio of bore diameter and outside diameter of the abrasive product.

The maximum transferred energy of a projectile, $E_{trans}$, can be calculated by equation (2).

$$E_{trans} = 0.015 \cdot m_p \cdot v_p^{\,2} \tag{2}$$

where, $m_p$ and $v_p$ are the mass and velocity of the projectile, respectively. The energy is at its maximum when the abrasive product was broken under $\alpha = 134$ degrees as shown in Fig.1, which is same energy as $E$.

Velocity of the projectile, $V_{trans}$, launched by the launcher, is given by equation (3).

$$V_{trans} = \sqrt{2P\frac{AL}{m_p}} \tag{3}$$

where, $P$ is the gauge pressure of the air tank, $A$ is a cross section of the projectile, and $L$ is launcher length.

## 3. Experimental equipment and conditions

Figure 2 shows the developed prototype collision experimental

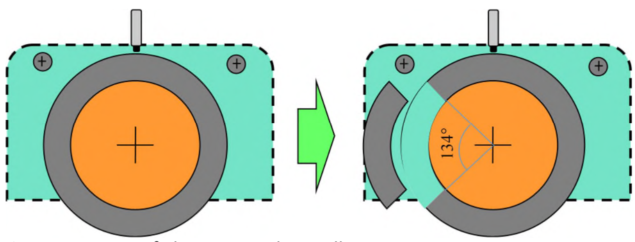


**Figure 1**. Image of abrasive product collision

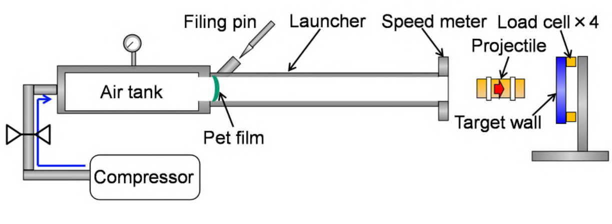


**Figure 2.** Apparatus for collision experiment

equipment apparatus. The maximum projectile speed is 80m/s under air tank garage pressure of 0.5MPa. The projectile is launched by a burst of the pet film of compressed air tank by filing pin. The outside of the projectile is covered by 2 Teflon rings to reduce the friction of the lunched projectile between the inner walls of the launcher. Velocity of the projectile is measured by 2 laser sensors installed at the launcher's exit.

Figure 3 shows effect of the air tank gauge pressure on the launched projectile velocity. The material of the projectile consists of white alumina abrasive product, whose density is 2400kg/m$^3$ with a mass of 3.4kg. The measured projectile velocity is nearly the same as the calculated value, by equation (3). The target wall material as shown in Fig.2 is consistent with wheel safety guard, SS400, which is nearly the same material as 1238 steel. The area of the target wall is 750mm x 750mm and the wall is solidly mounted by friction and additional screw bolts.

Table 1 shows experimental conditions and equipment. Velocity of the projectile is set 36-78m/s, mass of the projectile is 3.4kg; constant. Thickness of the target wall is 1-3.2mm.

## 4. Results of collision experiments

Figure 4 shows images of the damaged target wall after the collision experiments under different collision velocities. Thickness of the walls were 2.3mm and the mass of the projectiles were 3.4kg. The two left center photos, from left to right, show the front and back surfaces of damaged wall targets, respectively. The photos on the right show damaged projectiles. Fig. 4(a) shows target walls that were penetrated by the projectile, whose velocity was 77.9m/s. Fig. 4(b) shows a safety guard that could successfully stop the projectile but a crack was propogated on the target wall with projectile velocity being 65.7m/s. Fig. 4(c) shows the target wall which perfectly stopped the projectile but generated plastic deformation on the wall surface under projectile velocity was 41.8m/s.

Figure 5 displays the relationship between target wall thickness and collision energy, obtained by 14 separate collision experiments. The left upper area shows the target wall which was penetrated by the projectile. The lower right area shows the target wall that stopped the projectile and deformed. The yellow colored belt indicates where wall damage may occur. That is, a projectile could be stopped but the target wall generated a crack.

## 4. Conclusions

a prototype experimental apparatus consisting of a launcher, a projectile and a target wall, then investigated the minimum thicknesses of a wheel safety guard that could withstand the collision. A prototype experimental apparatus consisting of a launcher, a projectile and a target wall is constructed; collision experiments using abrasive products were carried out. This resulted in the ability to calculate target wall thickness that is safe from fragmentation. Abrasive product collision can be calculated by kinematic energy of the projectile.


## 5. Acknowledgements

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**References**

[1] ISO/TC 39/SC 10/WG 2 N18


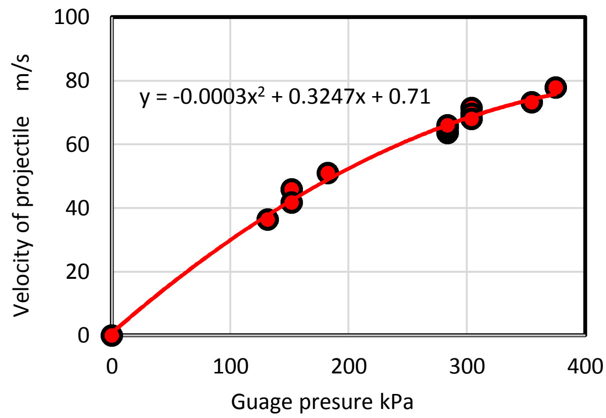


**Figure 3.** Effect of gauge pressure on velocity of projectile

**Table 1** Experimental conditions

| | |
|---|---|
| Gauge pressure of air tank | 0-0.5MPa |
| Lancer length | 6000mm |
| Lancer bore | $\phi$100mm |
| Material of projectile | Abrasive product (WA46O8V) |
| Mass of projectile | 3.4kg |
| Material of target wall | SS400 (1238 steel) |
| Thickness of target wall | 1.0, 1.6, 2.4, 3.2mm |

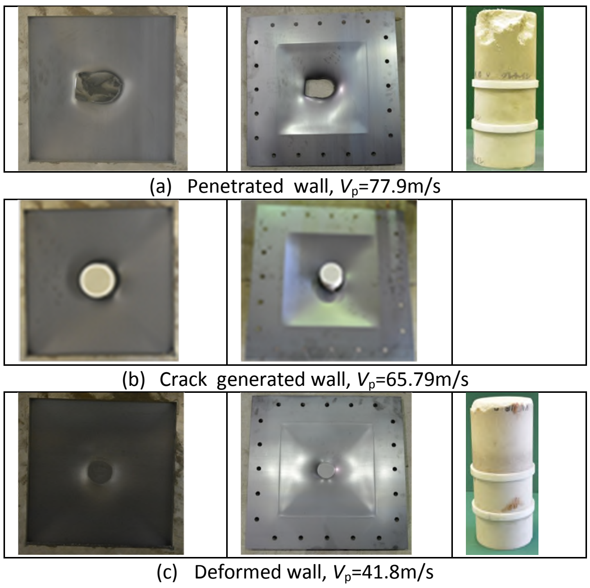


**Figure 4.** Photo of wheel safety guard after collision experiments

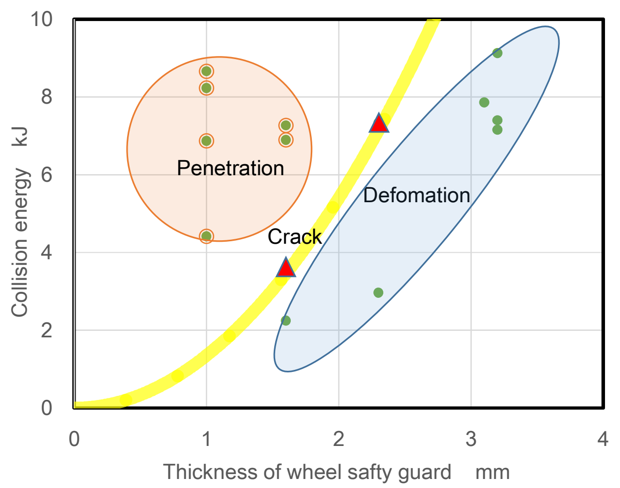


**Figure 5.** Relationship between thicknesses of target wall on collision energy