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Study on protection performance of grinding wheel safety guard against the soft and brittle abrasive projectile

Akinori Yui[1], Takuya Fukui[1] and Takayuki Kitajima[1]

[1]*Mechanical Systems Engineering, National Defense Academy, Japan*

Email: yui@nda.ac.jp

Abstract
Industrial standard for grinding wheel safety guard thickness should be defined to the protect machine operators and/or cost reduction of the grinding machines. Therefore, the authors built up a projectile launching system and made collision experiments for structural carbon steel and stainless steel guards using hard and brittle abrasive products for the projectile with hardness grade H and O. The collided wheel guard damage can be classified into 3 patterns: plastic defamation, crack generation, and penetration. The borderline between plastic defamation and penetration is proportion to the square of the wheel guard thickness. In this paper, the projectile made of soft and brittle abrasive product with hardness grade E is added as the projectile and investigates the effect of projectile hardness on the borderline. In the case of soft and brittle abrasive projectile, E, kinematic energy of the projectile is spent for the projectile fracture. As the result, the wheel guard made of structural carbon steel is damaged less compared with harder grade abrasive products; O, under same kinematic energy.

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

1. Introduction

Safety of grinding machine should have higher priority to protect machine operators. When a highly rotating grinding wheel spontaneously fractures and the fragments collide with the grinding wheel safety guard, the guard should be thick enough to protect the machine operators and machine tool from the projectiles.

Therefore, the authors built up an experimental apparatus to confirm the safety of grinding wheel guards as shown in Fig.1 and Table 1[1)]. Collision experiments of structural carbon steel and stainless steel guards were carried out using hard projectiles with grade O[2)]. Features of collided wheel guard damages can be classified into 3 patterns: plastic defamation, crack generation and penetration. The border between plastic deformation and penetration defined as "borderline". The borderline under different cover thickness is proportional to the square of the wheel cover thickness as shown in Fig.2. In the equation, k=4847 and k=1387 is the borderline coefficient of stainless steel and structural carbon steel, respectively. k is affected by the shearing force of wheel safety guards.

Although many technical papers using hard and/or ductile projectiles have been published, experimental results using soft and/or brittle materials are not published yet. Therefore, the projectile made of E and O grade abrasive products is used for the projectiles and colliding mechanism to the structural carbon steel guard is investigated.

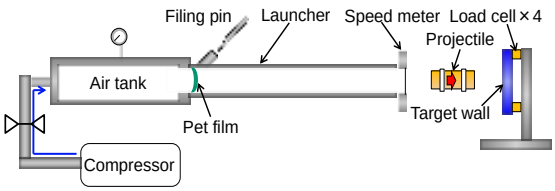
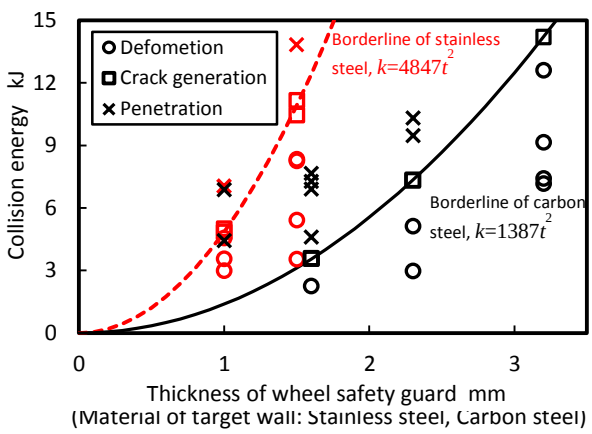


Fig.1 Apparatus for collision experiment.

Table 1. Specification of experimental equipment.

Material of projectile	Abrasive product : WA46O8V, WA46E8V
Mass of projectile/kg	3.4, 2.8
Material of target wall	Structural carbon steel Stainless steel
Thickness of target wall/mm	1.0-3.2
Kinematic energy of projectile/kJ	0-15
Projectile speed/m·s^{-1}	0-91



2. Experimental results under soft projectile E

Figure 3 and Table 2 shows projectiles which are made from different hardness grade abrasive products. In case of harder abrasive products, O, the projectile head portion will not so fragmented, on the other hand, head portion of softer abrasive products; E is fragmented. Measured length of projectile, E after the collision experiments is 30% shortened compared with O grade projectile.

3. Compressive strength of abrasive projectiles

Figure 4 shows the experimental equipment for strain-stress experiments for the projectile, Instron 5500R. Compression force is given to the specimen, abrasive product though the jig made of hardened steel. Fig. 5 shows measured strain-stress curve of the abrasive products which are used for projectiles. Allowable compressive stress of O grade abrasive product is the highest, 138MPa; and E is the lowest, 17MPa.

4. Effect of projectile hardness on collision mechanism of wall thickness of steel abrasive product guards.

Figure 6 shows the effects of projectile hardness on borderline of structural carbon steel. The red dotted curve shows borderline of O grade abrasive products and the black line shows borderline of E grade. Borderline under soft projectile is larger compared with the hard projectile. The coefficient of collision energy under O and E grade abrasive product is 1387 and 4367, respectively.

The reason for this is that kinematic energy of the projectile is consumed for fracture of the projectile itself under soft projectile such as E. As a result, the wheel guard damage under same kinematic energy is less compared with the hard projectile materials, O grade abrasive products.

Hence the measured tensile strength of the structural carbon steel is 500-600MPa, the borderline is given by the calculation. The thickness of the wheel safety guard for E grade abrasive product projectile can be 3 times thinner than O grade abrasive product.

5. Conclusions

The following conclusions were obtained under the collision experiments using different grade abrasive product on steel wall.

[1] Softer abrasive projectile results in smaller damage on target structural carbon steel guard under same kinematic energy.

[2] Thickness of the wheel safety guard for E grade abrasive product projectile can be 3 times thinner than O grade abrasive product.

Acknowledgments

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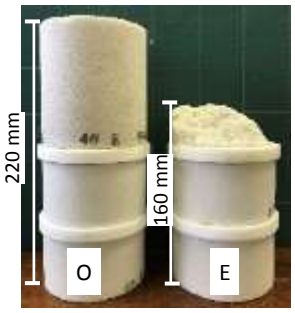

Fig.3 Collide abrasive products.

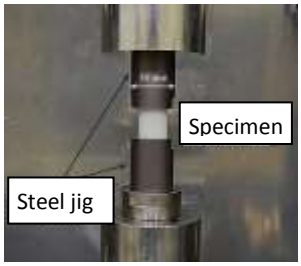

Fig.4 Equipment for Strain-Stress experiment (Instron 5500R).

Table 2 Result of collision experiments.

Projectile hardness grade	O	E
Guard damage	Deformation	Deformation
Thickness of guard /mm	3.2	1.6
Projectile speed m/s	66.0	68.9
Collision energy /J	7405	6649

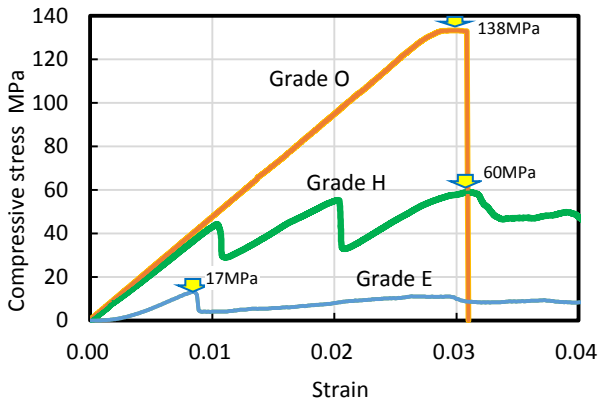

Fig.5 Strain-Stress experiment of abrasive product.

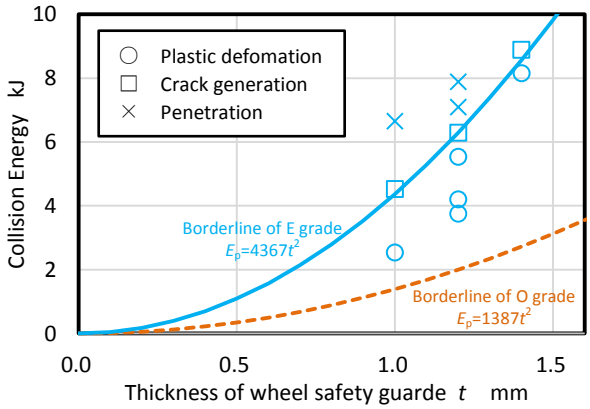

Fig.6 Effect of projectile hardness grade; E and O on borderline of structural carbon steel.
(Projectile: WA46E8V, WA46O8V)

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