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DAR ALMANDUMAH
الرواد في قواعد المعلومات العربية

العنوان:	STUDY OF THE BEHAVIOUR AND MECHANISM OF SLURRY
المؤلف الرئيسي:	البخيتي، محمد احمد حمود علي
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ملخص البحث

دراسة سلوك وآلية التآكل الناتج عن سريان سائل به عوالق صلبة

في هذا البحث أجريت سلسله منهاجية من التجارب على التآكل الناتج عن سريان سائل به عوالق صلبة بغرض دراسة تأثير مختلف العوامل على سلوك وآليات التآكل لمواد طرية ومواد قصيفة هذه العوامل تشمل كل من زاوية التصادم وسرعة التصادم وتركيز الحبيبات الصلبة وخصائص تلك الحبيبات (الحجم والشكل والصلادة) وصلادة المادة المعرضة للتآكل وكذلك بنيتها الدقيقة. لاجراء هذه التجارب تم تصميم وتصنيع جهاز الاختبار ثم أجريت عليه سلسلة من التجارب لاختبار كفاءة وتكرارية ومعولية ذلك الجهاز باستخدام تقنية تعجيل ومشاهدة التآكل لطبقة طلاء مرشوشة على عينات من الصلب.

وقد أجريت التجارب المعملية على مادتين مختلفتين تستخدمان في صناعة أجزاء الماكينات وهما الحديد المنخفض الكربون (AISI 1017 steel) وحديد الزهر الابيض عالي الكروم وباستخدام ثلاثة أنواع مختلفة من الحبيبات الصلبة الصادمة وهي الرمل وكربيد السليكون والألومينا والسائل الحامل لهذة الحبيبات هو الماء. تم استخدام المجهر الالكتروني الماسح والمجهر الضوئي ومحلل الصورة وجهاز قياس الصلادة وميزان إلكتروني حساس (حساسيته 0.1 مجم) في تحديد آليات التآكل وسلوكه.

بالفحص الدقيق والتحليل للصور المجهرية لأسطح العينات التى حدث بها تآكل أتضح أن آليات التآكل للحديد المنخفض الكربون هي آلية الحرث وآلية القطع الدقيق وآلية الثّلمة بشفاه مبثوقة وكذلك آلية الكلال. بينما في حالة حديد الزهر عالي الكروم فإن آلية التآكل تعتمد على تركيب البنّية الدقيقة، ففي حالة الأرضية الطرية تكون آليات التآكل مشابهة تماما" لما هو عليه في الحديد المنخفض الكربون بينما للجزء الآخر من البنّية وهي الكاربيدات الصلبة فإن آلية التآكل هي التشّرخ والتكسّر الإجمالي. وقد لوحظ اعتماد آليات التآكل على ظروف الاختبار فعند دراسة تأثير أحد العوامل على آليات التآكل وجد أن آلية واحدة أو أكثر تلعب الدور الرئيسي في ازالة المادة من سطح التآكل بينما الآليات الأخرى

تكون ذات تأثير مهمل. وقد وجد أن تحديد آليات التآكل ساعد كثيرا في تفسير تأثير العوامل المختلفة على معدل التآكل المستقر.

تأثير زاوية التصادم على آليات التآكل للحديد منخفض الكربون أمكن تقسيمه إلى ثلاث مناطق هي منطقة الزوايا الصغيرة والتى تكون فيها الزاوية أقل من 20° ومنطقة الزوايا المتوسطة والمحصورة ما بين 20° و 70° ومنطقة الزوايا الكبيرة وتكون لزوايا أكبر من 70°. هذا التقسيم أو المناطق الثلاث متعلق بالمركبة المماسية والمركبة العمودية لقوة التصادم. ففي المنطقة الأولى كانت آليات التآكل المسيطرة هي آلية الحرث الضحل وتدحرج الحبيبات على السطح والتى نتج عنها معدلات تآكل صغيرة. في المنطقة الثانية لعب فيها آلية القطع الدقيق وآلية الحرث العميق الدور الرئيسي مما أدي إلى أعلى معدل تآكل أما في المنطقة الثالثة تكون فيها آلية الثّلمات المحاطة بشفاه مما أدى إلى إنخفاض معدل التآكل.

بالنسبة لتأثير زاوية التصادم على الحديد الزهر عالي الكروم فامكن تقسيمه الى منطقتين المنطقة الأولى وكانت فيها زاوية التصادم أقل من 45° والثانية لزوايا تصادم أكبر من ذلك. ففي المنطقة الأولى كانت آلية التآكل هي التشكيل اللدّن للأرضية الطرية والتى أدت إلى معدل تآكل منخفض أما في المنطقة الثانية فقد سادها كل من آليتي التشكيل اللدّن للأرضية الطرية وتكسر وتشرخ للكاربيدات في آن واحد مما أدى الى تآكل أعلى ما يمكن عند زاوية تصادم 90° .

ولفحص تأثير خصائص الحبيبات الصلبة أي نوعها وحجمها وشكلها وصلادتها على آليات التآكل ودورها في تطّور التآكل فقد تم توصيف الأنواع الثلاثة من الحبيبات الصلبة (الرمل، كربيد السليكون، والألومينا) بمعرفة معامل "تحديد الشكل" وهو العرض إلى الطول ومعامل الاستدارة ويساوي مربع محيط الحبيبة الى مساحتها. وبناءاً على ذلك وجد أن الانتظام والاستدارة في الشكل لحبيبات الرمل والألومينا تزداد مع زيادة حجمهما بينما تتناقص لحبيبات كاربيد السيليكون. فبالنسبة لتاثير حجم الحبيبات الصلبة وجد أن الأحجام الصغيرة للأنواع الثلاثة من الحبيبات ينتج عنها تأثير واحد وهو تكون ثلمات مصحوبة ببثق للمادة في كل من الحديد المنخفض الكربون والأرضية الطرية لحديد الزهر عالي الكروم. أما بالنسبة لتأثير الأحجام الكبيرة لحبيبات الرمل وكاربيد السليكون على الحديد المنخفض الكربون وعند زاوية تصادم 30° لوحظ أن آليتي الحرث والقطع الدقيق هما المسيطرتان ويزداد دور آلية التآكل بالقطع الدقيق بزيادة درجة تزويّ الحبيبات الصلبة وعدم انتظام شكلها كما هو الحال في حبيبات كاربيد السليكون. كما أن التزّو وحدّية حواف حبيبات كاربيد السيلكون تنتج مسارات تآكل خشنة ومشرشرة مقارنة بمسارات التآكل المستوية والناعمة التي تنتج عن حبيبات

الرمل ذات الشكل المنتظم والمدّور لنفس الحجم. كما أنه شوهد أن الشفاه للثّلمات والمادة المزاحة أمام وعلى جوانب المسار في حالة الحرث تنفصل من سطح التآكل بواسطة آلية الكلال.

أمّا عن تاثير أحجام الحبيبات الكبيرة على حديد الزهر عالي الكروم وعند زاوية تصادم عمودية (90°) حيث يكون التآكل أكبر ما يمكن أتضح أن آليتي التكسّر والتشرّخ يحدثان لطور الكاربيدات الصلبة بالإضافة إلى آلية الثّلمات ذات الشفاه للأرضية الطرية للمعدن معتمدا على شكل الحبيبة. فحبيبات كاربيد السليكون الغير منتظمة الشكل وذات الحواف الحادّة ينتج عنها تكسر إجمالي للكاربيدات الصلبة مع تشرّخ جانبي للكاربيدات أيضا بالإضافة إلى التشوه اللدن للأرضية الطرية مما يؤدي الى تآكل عال في حين أن الحجم المماثل له من حبيبات السليكا والتى لها شكل منتظم ومستدير تعطي تآكلا أقل. واظهرت النتائج أيضا أن صلادة الحبيبات المسببة للتآكل مقارنة بصلادة المعدن لها تأثير جليّ على آلية التآكل.

بالنسبة لسرعة الحبيبات الصادمة ودورها في تطوّر عملية التآكل أتضح أنه مقترن بآليات التآكل والتي تعتمد بدورها على طاقة الحركة لتلك الحبيبات. فللحديد منخفض الكربون وعند زاوية تصادم 30° وجد أن آلية التآكل تتغير من مجرد تكون ثّلمات ذات شفاه عند سرعة تصادم صغيرة (5 m/s) إلى حرث ذو مسار قصير عند السرعة المتوسطة (10 m/s) وحرث ذو مسار طويل للسرعة العالية (15 m/s). أما لحديد الزهر عالي الكروم وزاوية تصادم 90° فاعتماد آلية التآكل على السرعة يكون مرتبط أيضا ببنية المادة الدقيق فلسرعة تصادم صغيرة (5 m/s) تحدث ثلمات فقط في الأرضية الطرية ولسرعة تصادم متوسطة (10 m/s) تزداد الثّلمات في الأرضية الطرية بالاضافة إلى الكسر في الكربيدات. بينما لسرعة تصادم أعلى (15 m/s) يحدث تكسّر وتشرّخ أكثر للكاربيدات بالاضافة الى الثلمات في الأرضية الطرية.

وتناول البحث أيضا تاثير تركيز الحبيبات الصلبة في السائل على كل من الحديد منخفض الكربون وحديد الزهر عالي الكروم وأتضح أن الفقد في وزن العينة نتيجة التآكل يزداد مع زيادة نسبة التركيز بينما معدل التآكل (الفقد في الوزن/وزن الحبيبات الصادمة) يزداد عند نسب التركيز الصغيرة ثم يتناقص بعد ذلك مع زيادة نسبة التركيز. وبفحص الصور المجهرية الدقيقة لأسطح العينات المتعرضة للتآكل عند نسبتي تركيز هما 1 wt.% و 3 wt.% (وزن الحبيبات الى وزن السائل) أتضح أن آلية التآكل لا تعتمد على نسبة التركيز بينما شدّية التآكل تزداد مع زيادة نسبة التركيز وذلك راجع إلى زيادة عدد الحبيبات الصادمة مما ينتج عنه زيادة في حجم أثر التآكل.

Abstract

In the present work a series of systematic slurry erosion tests were carried out to investigate the effect of different parameters on slurry erosion mechanisms and behaviour for ductile and brittle materials. These parameters include impingement angle, impact velocity, particle concentration, erodent particle characteristics, namely size, shape and hardness as well as target material hardness and microstructure. An apparatus for carrying out slurry erosion experiments was designed and manufactured. A series of accelerated erosion tests using a paint erosion indication technique has been carried out to calibrate and examine the reproducibility, capability and performance of the designed test rig.

The slurry erosion tests were carried out using the designed test rig on two different machinery materials, namely AISI 1017 steel and high-chromium white cast iron; and using three different types of erodent particles, namely silica sand, silicon carbide and alumina. The scanning electron microscopy, computer aided-image analysis technique, optical microscopy and gravimetric and microhardness measurements were utilized to identify the slurry erosion process.

Observations and analysis of the scanning electron microphotographs of specimen surfaces impacted for a short time at different slurry erosion conditions revealed that for 1017 steel the slurry erosion mechanisms are: ploughing, microcutting, indentation with extruded lips and fatigue wear. While, for high-Cr white cast iron the slurry erosion mechanisms are: cracking and gross fracture of the carbide phases as well as ploughing, microcutting and indentation with extruded lips for the ductile matrix. It was found that, in each particular case (test conditions) one or more of these mechanisms play the main role in the metal removal process, while others have a minor effect or not at all. Determination of the erosion mechanisms helped greatly in the interpretation of the effect of the different parameters on the erosion rate in steady-state tests.

Test results showed that, the effect of impingement angle on erosion mechanisms of 1017 steel has three regions. These regions are: region of small impingement angles less than 20°, region of intermediate impingement angles between 20° and 70° and finally region of high impingement angles greater than 70°. These three regions are related to the tangential and normal components of the impacting force. The first region was characterized by shallow long scratches and limited chip formations resulting in small erosion rate. In the second region the formed wear tracks have deep and wide size and large chips were formed in front of the wear tracks, which explain the high erosion rate at intermediate impingement angles (maximum occurred at 45°). The third region was distinguished with relatively deep and elongated indentations with extruded material and small erosion rate. Consequently, it can be said that shallow ploughing and particle rolling were the dominant erosion mechanisms in the first region, microcutting and deep ploughing in the second region while indentations and material extrusion prevailed in the third region. For high-Cr white cast iron the test results showed that, the erosion mechanisms involved both plastic deformation of the ductile matrix and brittle fracture of the carbides. At low impingement angles (up to 45°) observations of microphotographs of the impacted surfaces revealed that, plastic deformation of the ductile matrix was the dominant erosion mechanism and the carbides fracture was negligible which lead to small erosion rate. Whereas, at high impingement angles (greater than 45°) gross fracture and cracking of the carbides in addition to indentation with extruded lips of the ductile matrix were the main erosion mechanisms.

The erodent particles, namely silica sand, silicon carbide and alumina were characterized in terms of their area (A), average diameter (d_{ave}), perimeter (P), length (L) and width (W). The aspect ratio (W/L) and the roundness factor ($P^2/4\pi A$) were used as the indicators of particle shape. It was found that the regularity and circularity in shape of silica sand and alumina particles increased with the increase of particle sizes, while decreased for silicon carbide particles. Test results revealed that, with fine erodent particles plastic indentation accompanied by extruded material was the dominant erosion mechanism for 1017 steel and high-Cr white cast iron irrespective of the impingement angle and erodent type or shape. For 1017 steel and at impingement angle of 30°, results showed that ploughing and microcutting were the main erosion mechanisms when the target surface is impacted by coarse SiC and SiO_2 particles. The role of microcutting in the metal removal process increased with the increase of particle angularity and sharpness as in the case of silicon carbide particles. As well as the angularity and sharpness of silicon carbide particles yielded serrated tracks rather than smooth tracks obtained with regular and rounded silica sand particles for the same size. It was also shown that the lips and chips formed due to indentation and ploughing mechanisms were finally detached from the target surface by fatigue. It was also observed that microcracks initiated at many locations on the eroded area such as, chips and lips which were subjected to severe plastic deformation, serrations of ploughing tracks and traces of polishing lines. For high-Cr white cast iron and at normal incidence, test results showed that with impacting by coarse particles, fracture and cracking of the carbides in addition to plastic indentation with lips of the ductile matrix were the main erosion mechanisms depending on the particle shape. The angularity and sharpness of silicon carbide particles yielded severe erosion damage included gross fracture associated with formation of many lateral cracks of the carbides rather than mild erosion damage obtained with regular and rounded silica sand particles for a comparable size. The results also showed that the hardness of erodent particles has a pronounced effect on the material removal mechanism.

Test results showed that the role of the impact velocity in developing erosion damage is related to the variation of the erosion mechanisms which depend upon the kinetic energy of the impacting particles. At low impact velocity (5 m/s) and at impingement angle of 30°, microscopic observations of damaged surfaces of 1017 steel revealed that, indentation with extruded lips was the dominant erosion mechanism. Whereas, at high impact velocity ploughing was the main erosion mechanism. The length of the wear tracks developed by ploughing mechanism depends upon the impact velocity. For high-Cr white cast iron and at normal incidence, test results showed that the erosion mechanism of indentation with extruded lips of the ductile matrix prevailed at low impact velocity (5 m/s). Whereas, at intermediate impact velocity (10 m/s) plastic indentation of the ductile matrix in addition to some fracture of the carbides were the dominant erosion mechanisms. For high impact velocity (15 m/s) fracture and cracking of the carbides besides to indentation of the ductile matrix were the dominant erosion mechanisms.

Test results showed that the weight loss from the surface of the test specimens increases with the increase of solid particle concentration. But the erosion rate (expressed in terms of mass loss per mass of erodent particles) increases at low particle concentration up to 1 wt.%. Then it decreases rapidly attaining nearly steady state behaviour. Observations of scanning electron microphotographs revealed that the erosion mechanisms at particle concentration of 1 wt.% and 3 wt.% are the same. It was also observed that the intensity of erosion damage at particle concentration of 3 wt.% is higher than that for particle concentration of 1 wt.%. This was attributed to repeated multiple impacts which occur at higher particle concentration resulting in large sizes of wear scar.

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Nomenclature

A	μm^2	The projected area of the erodent particle
C	wt. %	The solid particle concentration
d	μm	The mean particle size
d_{ave}	μm	The measured average diameter of the particle
d_{max}	μm	The measured maximum diameter of the particle
d_{min}	μm	The measured minimum diameter of the particle
D	μm	The diameter of rotation of the rotor
E_m	(mg/kg)	Erosion rate
E_r	(mg/mm^2/s)	Another expression of the erosion rate
g	m/s^2	The gravitational acceleration
H_P	kgf/mm^2	Hardness of the erodent particle
H_T	kgf/mm^2	Hardness of the target material
k	----	Constant
K	----	Constant
k_c	MPa(m)$^{0.5}$	Fracture toughness of the target material
l	mm	The total actual length of the test specimen
l_o	mm	The length of the specimen which is not exposed to the falling slurry stream
l_l	mm	The length of the specimen which is exposed to the falling slurry stream
L	mm	The length of the erodent particle
m	---	The particle size exponent
n	---	The impact velocity exponent
N	Hz	The rotational speed of the rotor

P	μm	The perimeter of the projected area of the erodent particle
Q	ml/min.	The flow rate of the slurry stream
s	mm	The distance between the orifice and the specimen surface
t	min.	The erosion test time
v	m/s	The resultant impact velocity
v_o	m/s	The velocity of the falling slurry stream at the exiting orifice
v_l	m/s	The vertical velocity of the falling slurry stream at the specimen surface
v_2	m/s	The horizontal linear velocity
w	----	The relative hardness exponent
W	mm	The width of the erodent particle
x	mm	The projected horizontal length of the specimen
y	mm	The projected vertical length of the specimen
z	----	Constant
ΔW	mg	The mass loss
θ	degree	The impingement angle
θ_o	degree	The mounting angle
α	degree	The rake angle

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STUDY OF THE BEHAVIOUR AND MECHANISM OF SLURRY EROSION

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الله

بسم الله الرحمن الرحيم

« قالوا سبحانك لا علم لنا إلا ماعلمتنا
إنك أنت العليم الحكيم »

صدق الله العظيم

To Whom I love Especially:
My Parents
My Wife
My Children:
(Osama, Nada, Islam and Karam)

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Abstract

In the present work a series of systematic slurry erosion tests were carried out to investigate the effect of different parameters on slurry erosion mechanisms and behaviour for ductile and brittle materials. These parameters include impingement angle, impact velocity, particle concentration, erodent particle characteristics, namely size, shape and hardness as well as target material hardness and microstructure. An apparatus for carrying out slurry erosion experiments was designed and manufactured. A series of accelerated erosion tests using a paint erosion indication technique has been carried out to calibrate and examine the reproducibility, capability and performance of the designed test rig.

The slurry erosion tests were carried out using the designed test rig on two different machinery materials, namely AISI 1017 steel and high-chromium white cast iron; and using three different types of erodent particles, namely silica sand, silicon carbide and alumina. The scanning electron microscopy, computer aided-image analysis technique, optical microscopy and gravimetric and microhardness measurements were utilized to identify the slurry erosion process.

Observations and analysis of the scanning electron microphotographs of specimen surfaces impacted for a short time at different slurry erosion conditions revealed that for 1017 steel the slurry erosion mechanisms are: ploughing, microcutting, indentation with extruded lips and fatigue wear. While, for high-Cr white cast iron the slurry erosion mechanisms are: cracking and gross fracture of the carbide phases as well as ploughing, microcutting and indentation with extruded lips for the ductile matrix. It was found that, in each particular case (test conditions) one or more of these mechanisms play the main role in the metal removal process, while others have a minor effect or not at all. Determination of the erosion mechanisms helped greatly in the interpretation of the effect of the different parameters on the erosion rate in steady-state tests.

Test results showed that, the effect of impingement angle on erosion mechanisms of 1017 steel has three regions. These regions are: region of small impingement angles less than 20°, region of intermediate impingement angles between 20° and 70° and finally region of high impingement angles greater than 70°. These three regions are related to the tangential and normal components of the impacting force. The first region was characterized by shallow long scratches and limited chip formations resulting in small erosion rate. In the second region the formed wear tracks have deep and wide size and large chips were formed in front of the wear tracks, which explain the high erosion rate at intermediate impingement angles (maximum occurred at 45°). The third region was distinguished with relatively deep and elongated indentations with extruded material and small erosion rate. Consequently, it can be said that shallow ploughing and particle rolling were the dominant erosion mechanisms in the first region, microcutting and deep ploughing in the second region while indentations and material extrusion prevailed in the third region. For high-Cr white cast iron the test results showed that, the erosion mechanisms involved both plastic deformation of the ductile matrix and brittle fracture of the carbides. At low impingement angles (up to 45°) observations of microphotographs of the impacted surfaces revealed that, plastic deformation of the ductile matrix was the dominant erosion mechanism and the carbides fracture was negligible which lead to small erosion rate. Whereas, at high impingement angles (greater than 45°) gross fracture and cracking of the carbides in addition to indentation with extruded lips of the ductile matrix were the main erosion mechanisms.

The erodent particles, namely silica sand, silicon carbide and alumina were characterized in terms of their area (A), average diameter (d_{ave}), perimeter (P), length (L) and width (W). The aspect ratio (W/L) and the roundness factor ($P^2/4\pi A$) were used as the indicators of particle shape. It was found that the regularity and circularity in shape of silica sand and alumina particles increased with the increase of particle sizes, while decreased for silicon carbide particles. Test results revealed that, with fine erodent particles plastic indentation accompanied by extruded material was the dominant erosion mechanism for 1017 steel and high-Cr white cast iron irrespective of the impingement angle and erodent type or shape. For 1017 steel and at impingement angle of 30°, results showed that ploughing and microcutting were the main erosion mechanisms when the target surface is impacted by coarse SiC and SiO_2 particles. The role of microcutting in the metal removal process increased with the increase of particle angularity and sharpness as in the case of silicon carbide particles. As well as the angularity and sharpness of silicon carbide particles yielded serrated tracks rather than smooth tracks obtained with regular and rounded silica sand particles for the same size. It was also shown that the lips and chips formed due to indentation and ploughing mechanisms were finally detached from the target surface by fatigue. It was also observed that microcracks initiated at many locations on the eroded area such as, chips and lips which were subjected to severe plastic deformation, serrations of ploughing tracks and traces of polishing lines. For high-Cr white cast iron and at normal incidence, test results showed that with impacting by coarse particles, fracture and cracking of the carbides in addition to plastic indentation with lips of the ductile matrix were the main erosion mechanisms depending on the particle shape. The angularity and sharpness of silicon carbide particles yielded severe erosion damage included gross fracture associated with formation of many lateral cracks of the carbides rather than mild erosion damage obtained with regular and rounded silica sand particles for a comparable size. The results also showed that the hardness of erodent particles has a pronounced effect on the material removal mechanism.

Test results showed that the role of the impact velocity in developing erosion damage is related to the variation of the erosion mechanisms which depend upon the kinetic energy of the impacting particles. At low impact velocity (5 m/s) and at impingement angle of 30°, microscopic observations of damaged surfaces of 1017 steel revealed that, indentation with extruded lips was the dominant erosion mechanism. Whereas, at high impact velocity ploughing was the main erosion mechanism. The length of the wear tracks developed by ploughing mechanism depends upon the impact velocity. For high-Cr white cast iron and at normal incidence, test results showed that the erosion mechanism of indentation with extruded lips of the ductile matrix prevailed at low impact velocity (5 m/s). Whereas, at intermediate impact velocity (10 m/s) plastic indentation of the ductile matrix in addition to some fracture of the carbides were the dominant erosion mechanisms. For high impact velocity (15 m/s) fracture and cracking of the carbides besides to indentation of the ductile matrix were the dominant erosion mechanisms.

Test results showed that the weight loss from the surface of the test specimens increases with the increase of solid particle concentration. But the erosion rate (expressed in terms of mass loss per mass of erodent particles) increases at low particle concentration up to 1 wt.%. Then it decreases rapidly attaining nearly steady state behaviour. Observations of scanning electron microphotographs revealed that the erosion mechanisms at particle concentration of 1 wt.% and 3 wt.% are the same. It was also observed that the intensity of erosion damage at particle concentration of 3 wt.% is higher than that for particle concentration of 1 wt.%. This was attributed to repeated multiple impacts which occur at higher particle concentration resulting in large sizes of wear scar.

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Nomenclature

A	μm^2	The projected area of the erodent particle
C	wt. %	The solid particle concentration
d	μm	The mean particle size
d_{ave}	μm	The measured average diameter of the particle
d_{max}	μm	The measured maximum diameter of the particle
d_{min}	μm	The measured minimum diameter of the particle
D	μm	The diameter of rotation of the rotor
E_m	(mg/kg)	Erosion rate
E_r	(mg/mm^2/s)	Another expression of the erosion rate
g	m/s^2	The gravitational acceleration
H_P	kgf/mm^2	Hardness of the erodent particle
H_T	kgf/mm^2	Hardness of the target material
k	----	Constant
K	----	Constant
k_c	MPa(m)$^{0.5}$	Fracture toughness of the target material
l	mm	The total actual length of the test specimen
l_o	mm	The length of the specimen which is not exposed to the falling slurry stream
l_l	mm	The length of the specimen which is exposed to the falling slurry stream
L	mm	The length of the erodent particle
m	---	The particle size exponent
n	---	The impact velocity exponent
N	Hz	The rotational speed of the rotor

العنوان: STUDY OF THE BEHAVIOUR AND MECHANISM OF SLURRY

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STUDY OF THE BEHAVIOUR AND MECHANISM OF SLURRY EROSION

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