OXIDATION BEHAVIOR OF NUCLEAR GRAPHITE(IG110) WITH SURFACE ROUGHNESS

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Abstract

Graphite is suitable materials as a moderator, reflector, and supporter of a nuclear reactor because of high tolerance to the high temperature and neutron irradiations. Because graphite is so weak to the oxidation, its oxidation study is essentially demanded for the operation and design of the nuclear reactor. This work focuses on the effect of the surface oxidation of graphite according to the surface treatment. With thermogravimeter (TG), oxidation characteristics of the isotropic graphite are measured at the three temperature areas, and oxidation ratio and amounts are estimated as changing the surface roughness. Furthermore, the polished graphite surface produced from the surface treatment is investigated with the Raman spectroscopic study. Oxidation behaviors of the surface are also evaluated as elimination the polished layer by washing with strong sonication

1. Introduction

The interest regarding the hydrogen production nuclear reactor construction which it prepares whole world in depletion of the fossil materials is coming to be high. The hydrogen production which uses the nuclear reactor vapor in high temperature and then disjointing it leads 800℃ where the existing nuclear reactor occurs in the method which produces the hydrogen the temperature near higher 1000℃ it demands and the atomic reactor of the form which is various against with a high temperature gas cooling reaction is becoming discussion. Consequently hereupon it is suitable and the research against the atomic reactor of new concept is advanced and also the research against the atomic reactor use material is advanced. The material which is used with in high temperature gas cooling reaction the material which is stabilized in high temperature physical properties and the neutron is demanded and the graphite the atomic reactor inside and the considerable quantity this use to the support body back is forecast with the material which corresponds hereupon.

The graphite nuclear fission hour the ability which it subsists in the neutron which occurs compares in the others material and it excels very and restricts the moderator, very in the center support body back atomic reactor multi region inside the atomic reactor.1 where it is an effective material) and the high temperature burglars and ten enemy qualities are the rainwater with the reflector which and the neutron to hit a reaction velocity the internal furnace graphite authorizaton it is used. But the graphite from 450℃ the oxidation happens from in air and very it has the weak point which is weak in oxidation and hazard the graphite reconsideration oxidation relation test and measurement which stand data certainly must be secured the immediacy plan and a movable stability guarantee of the atomic reactor. The oxidation of the graphite happens in reaction and surface reaction and other reaction back multi form at the gas and me oxidation of place most becomes the correspondence in surface reaction of the graphite. The Kawakami, the H. according to the back the graphite follows in temperature territory and chemical regime near 600, 700~900℃ in-pore with mass transfer above chemical near the regime and 1000℃ controlled regime it is divided and it is reporting and that the oxidation happens, oxidation of chemical regime the graphite block the oxidation of the surface and the inside happens simultaneously and from in-pore chemical regime oxidation the vicinity of the surface happens liveliness oxidation the inside than and the mass transfer controlled regime is reporting that the oxidation of most happens from the surface. Graphite oxidation principal becomes the correspondence in the temperature territory where the graphite is exposed in mobility of the atomic reactor relation of immediacy result directness of the atomic reactor and there is and graphite shift life decisive hour becomes the consideration factor which is important. Effect it goes mad to the shift life of the graphite and also different factor. graphites which are a contraction of the graphite which it follows in neutron investigation over expansion quality start and it receives the neutron and it contracts, they expand again, it starts. The graphite expands, when it starts, in the atomic reactor structure body stress there is a possibility producer of occurring crack in the atomic reactor whole the mortar and it expands point of view at life of the graphite which will be busy doing nothing to decide, it is shifting.

The graphite which is used consequently in the atomic reactor orthodoxy does very in six prisim forms where the most load and removal are convenient and is becoming processing. The research which it sees the graphite block the graphite which hazard is processed orthodoxy one load to sleep graphite block the surface condition what kind of effect should have gone mad to a graphite oxidation in the atomic reactor, it evaluates and it does. The surface decisive condition which leads the surface luminous intensity which it follows in surface polishing against the isotropy graphite IG-110 of the Japanese snipe carbon company which is used in the atomic reactor and a raman analysis it observation, the effect where the surface condition goes mad to an oxidation speed and oxidation principal it evaluated. And ultrasonic cleaning process it led and polishing layer removal of the surface the recovery of the surface damage layer which leads and it observed it followed hereupon and the effect which goes mad to an oxidation it evaluated.

2. Experiments

The Book of Psalms which is used from the research which it sees is the isotropy graphite (IG-110) of the snipe carbon company which is used in the atomic reactor. The quality of the graphite shows on lower part Table 1. The isotropy graphite IG-110 manufactures a CIP method, the outer appearance density 1.75 g/cm3 and elasticity rate 9.6 GPa, 3 hooves the burglar 48.6 MPa who bends, is compressive strength 70.5 MPa. Also very the impurity is about 20 ppm degree and even mouth wondering 10 m is the graphite which has the mouthful light minute

The oxidation examination of the IG-110 used and the SDTA of Mettler toledo company 851e an oxidation speed (wt%/min) it observations the weight weight loss due to an oxidation with with oxidation quantity (%) it measured. It followed in oxidation principal and it differed to test and to objective one temperatures it reached in order it got peeled off and a maintenance hour from 600, 800, 1000℃ and purity 99.99 % to pour the nitrogen gas the oxidation not to happen.
The reaction gas which it uses in oxidation examination was Dry Air and in the enthusiastic quantity analysis flag (TG) where the specimen is put in at flux 40 ml/min it poured. 2.2.2 graphite examination bias surface processing. In order for to become the even luminous intensity 0.2 with 1000 compounds, it polished the isotropy graphite which 6X6X6 manufactures the hazard specimen which confirms the oxidation aspect which it follows in surface processing degree with mm (even luminous intensity 1.4). It excluded the hazard adhesives which the maximum prevents specimen polishing hour be imbrued and the cooling oil and a cooling possibility use. After polishing the hazard which removes the polishing fragments which attach in the specimen surface 3M the company su the car tape 3 affixes - it will burn and it repeated tightly. By surface polishing hour polishing with hazard 8000 MHz supersonic waves washers which grasp the effect where the layer which is damaged goes mad to an oxidation it used in the distilled water and 1min, 30min for it washed and to polishing and and it depended the layer which is damaged is removed the specimen where each it prepared. Surface observing of 2.2.3 graphites Polishing the graphite surface which is processed used the United States Esterline FEDERAL company Surfananalyser 5000 and after shelf processing, after the polishing processing due to 1000 compounds and a surface luminous intensity after damage layer removing due to a ultrasonic cleaning process it measured. Also 1590 cm-1 the surface condition due to a polishing processing used France Jobin-Yvon company LabRam HR (High Resolution) and the D-peak (disorder peak) the G-peak it is 1350 cm-1 and a graphite peek (graphite peak) it observed. Also approximately oxidation after graphite oxidation testing it used the hazard Scanning Electron Microscope (SEM and TAPCON company SM300) which and observations the surface minute structure of the graphite it observed.

3. Results

Fig. 1, 2, 3 the even luminous intensity 1.4 which the shelf is processed initially, shows a weight decrease and oxidation the oxidation in air of the isotropy graphite (IG-110) which has the maximum luminous intensity 17.05 price due to speed and a CO_2 occurrence quantity. The oxidation commencement temperature appeared from near 500℃ and the oxidation happened really from near 700 the oxidation to happen. The oxidation speed 500~600℃ near the, 700~900℃ is showing a B causing to defecate feature oxidation aspect near the and above 1000℃. 500~600℃ It showed a low-end oxidation speed from near the and 700~900℃ from near the oxidation speed was proportionate in temperature and it increased. And it showed a high oxidation speed from above 1000℃ and only Use there was not oxidation speed increase. E The Loren the Fuller and Luo Xiawei back 4,6) this it referred 500~600℃ from near the mainly in graphite reconsideration defect and the impurity mainly to receive an effect, the oxidation happens simultaneously from the surface and the Book of Psalms inside and me chemical regime and 700~900℃ from near the oxidation speed is big in the surface and the oxidation speed the inside appears small and the temperature will increase in the recording surface where it is preponderated and the oxidation happens and me in-pore diffusion from above controlled regime and 1000℃ the oxidation of most happens from the specimen surface and me it is to show the oxidation tendency which is identical with 3 oxidation territories of mass transfer controlled regime. The CO2 occurrence quantity also with 3 oxidation territories with same tendency it was proportionate in oxidation temperature and it increased.

The oxidation quality which it follows in surface processing of the isotropy graphite (IG-110) Fig. 4 is the result which measures the surface luminous intensity which it follows in specimen processing. The surface luminous intensity of the isotropy graphite which is processed initially showed the even 1.4 and maximum luminous intensity showed 17.05 and after polishing due to 1000 compounds the luminous intensity showed the even 0.2 and maximum luminous intensity came to be small with 1.65. Polishing layer removal of the specimen which is polished 1 minutes, 30 minute ultrasonic cleaning process from hazard distilled water inside. 1 minute after washing the luminous intensity showed the even 0.31 and maximum luminous intensity showed 2.1 and U again the surface came to be rough. And 30 minutes after ultrasonic cleaning process the luminous intensity average 0.55, showed the maximum luminous intensity 4 and U surface came to be rougher in small quantity. After ultrasonic cleaning process the regions which the surface luminous intensity omits roughly the position thing by supersonic waves polishing layer fall and they go out and the surface is roughly judged with the position thing. Fig. 5 polishing the specimen and polishing which are processed when 2 wt% oxidations happen each from the hazard 600℃, 800℃, 1000℃ which observation the oxidation aspect which it follows in surface condition of the specimen which is not processed until, it measured a weight decrease. The oxidation examination which it executes from 600℃ surface luminous intensity the low-end specimen polishing the graphite specimen which it does not process compared to the oxidation quickly became progress. Case surface luminous intensity of the oxidation examination which it executes from 800℃ the difference where the oxidation of the low-end specimen is quickly advanced was small excessively. The oxidation examination which it executes from 1000℃ in the surface luminous intensity which it follows in polishing processing the higher officer without oxidation became the progress at the speed which is identical. Graphite oxidation the oxidation which is advanced from near 1000 in surface luminous intensity with mass transfer controlled regime corresponded to a surface reaction and it followed and the difference was born plentifully and the oxidation which is advanced from near 600 corresponded to chemical regime and the oxidation was simultaneously advanced from the surface and the inside and the result with the fact that it will not receive an effect in surface luminous intensity was equally divided and it appeared. Fig. 6 polishing the specimen and polishing which are processed after oxidizing of the specimen which is not processed it is a surface photograph. The surface the surface which the specimen which is polished oxidizes being uniform, the oxidation was happening and the surface the specimen which is not polished the pitch binder oxidation happened Hwag softly and the oxidation the enemy with the insect position my coke accomplished a contrast relativity. 2 wt% which are identical it is a surface photograph which oxidizes but the surface oxidation of the specimen which oxidizes from high temperature to be serious becomes progress and from mass transfer controlled regime territory the oxidation happens mainly from the surface it will be able to confirm.7) 3.3. The oxidation quality which it follows in surface layer ultrasonic cleaning process of the isotropy graphite (IG-110) Fig. 7, 8 only the hazard which confirms the surface decisive condition which it follows in polishing processing of the specimen surface the vibration of the surface element with the spectral diffraction law observed. The specimen which is an even surface luminous intensity 1.37 which is manufactured in shelf processing graphite decision the century of the G-peak it means is clear and it appears, it is disordered and the century of the D-peak it shows the decision which is damaged is appearing small. This time the D/G is showing 0.27 price. By a polishing processing the specimen where the even surface luminous intensity is 0.24 the century of the D-peak as the G-peak or three U to come D/G price is showing 1. By a polishing processing the polishing layer where the surface luminous intensity comes to be small with 0.24 but puts on a damage and it was exchanged it means the thing with amorphousness. 1 minutes ultrasonic cleaning process the case D-paek century of the specimen which rose in small quantity with the doing even surface luminous intensity 0.31 comes to be small and the D/G price is showing 0.8. The century of the D-peak the case even surface luminous intensity of the specimen which does 30 minutes ultrasonic cleaning processes to rise with 0.55 comes to be low and the D/G price shows 0.23 and it is Uss. Ultrasonic cleaning process it leads and the graphite decisions of the polishing layer which the specimen surface is damaged are removed and the specimen surface was recovered becomes increase at decisive layer. Fig. 9 leads and ultrasonic cleaning process they are 600 oxidation test results of the specimen which removes a polishing layer. Ultrasonic cleaning process it led and the specimen where the polishing layer of the surface is removed was processed polishing and the surface luminous intensity happened oxidation more slowly the low-end specimen than. Also, Fig. It shows the result where the oxidation speed of the specimen where the surface polishing layer is removed is same relativity lowly even from oxidation speed observing of 10.

The place where the air and the contact area are small surface luminous intensity with the fact that the oxidation of the low-end specimen happens quickly oxidation from near 600 size of the oxygen and the contact area compared to the effect due to the defect, the minute order water and the decisive condition back of the specimen is govern with chemical reaction and the surface luminous intensity low-end namely, the specimen where the surface is damaged with polishing is judged with the fact that the oxidation happens quickly. Consequently the processing for the actual application of the isotropy graphite with 1000 compounds together the processing which is precise it is difficult and must stop at line half price process degree. Processing ultrasonic cleaning process after if necessary is in the flood control which is precise and by the compound processing leads and must remove the polishing layer which the surface is damaged.

Conclusion

Isotropy graphite (IG-110) from oxidation in this air the oxidation commencement temperature appeared from near 500℃ and 500~600℃ near the, 700~900℃ near the, the oxidation aspect appeared differently in 3 territories above 1000℃. 3 oxidation territories chemical regime and in-pore diffusion controlled will be showing regime and mass transfer controlled regime each and they will be able to confirm 3 oxidation territories even from CO_2 occurrence quantity. The oxidation examination which it executes from 600℃ surface luminous intensity the low-end specimen polishing the graphite specimen which it does not process compared to the oxidation quickly became progress. Case surface luminous intensity of the oxidation examination which it executes from 800℃ the difference where the oxidation of the low-end specimen is quickly advanced was small excessively. The oxidation examination which it executes from 1000℃ in the surface luminous intensity which it follows in polishing processing the higher officer without oxidation became the progress at the speed which is identical. The surface oxidation of the specimen which oxidizes from near 1000℃ to be serious became progress and mainly it happens it will be able to confirm oxidation of mass transfer controlled regime territory from the surface. Ultrasonic cleaning process it led and the D/G price where the even surface luminous intensity comes to be high but came to be low, ultrasonic cleaning process it led and the surface layer which is damaged confirmed was removed. Ultrasonic cleaning process it led and the polishing layer which is damaged was removed and the oxidation speed happened slowly and the surface layer which is damaged confirmed was recovered. Precision processing of the isotropy graphite hazard mirror surface polishing damages a surface layer consequently and it will be able to promote an oxidation precision processing ultrasonic cleaning process after the case processing whose hazard mirror surface polishing will be necessary leads and must remove the polishing layer which the surface is damaged.

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Table 1. Properties of nuclear graphite IG-110

Property	Value
Bulk Density (g/cm^3)	1.75
Young's Modulus(GPa)	9.6
Flexural Strength (MPa)	48.6
Comp. Strength (MPa)	70.5
Impurity (ppm)	$<$ 20
Ave. Grain Size (μm)	10

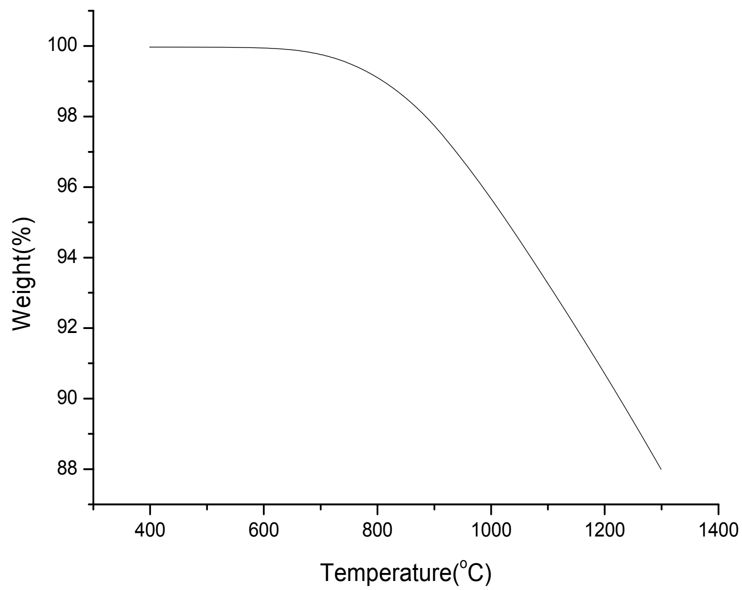


Fig. 1. TG Curves of nuclear graphite specimen as a function of temperature

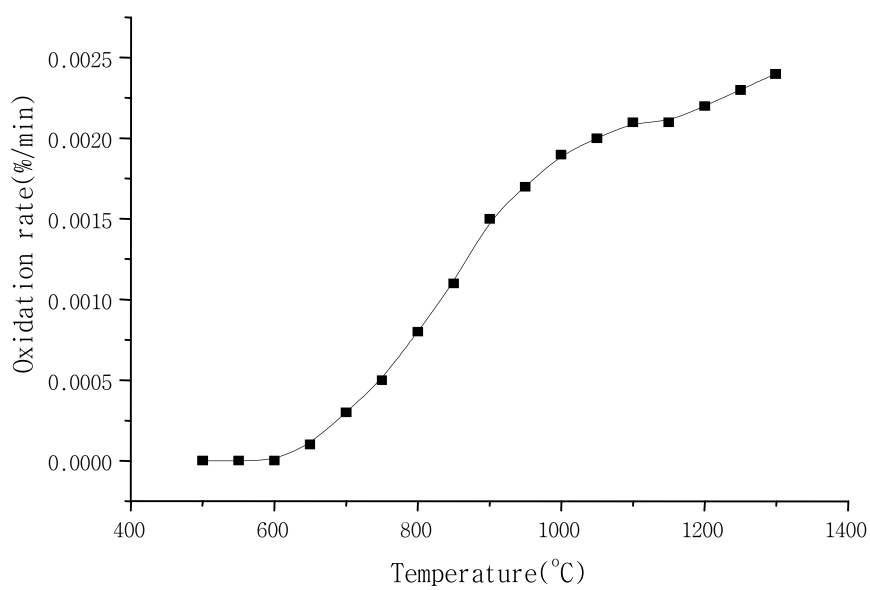


Fig. 2. Oxidation rate(%/min) of nuclear graphite specimen as a function of temperature

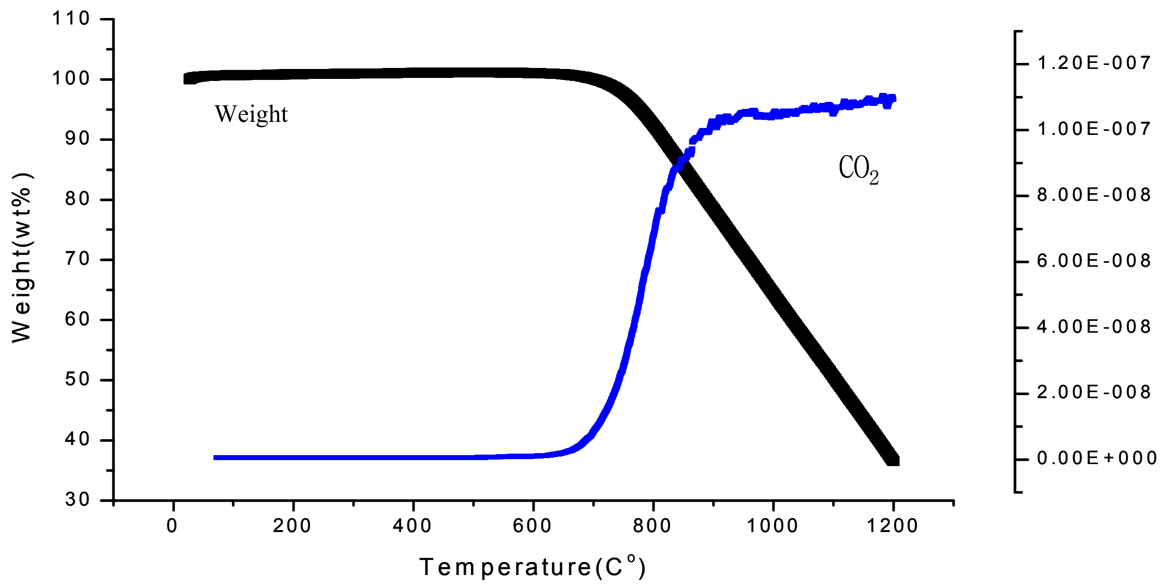


Fig. 3. TG Curves and CO_2 concentration of nuclear graphite specimen as a function of temperature

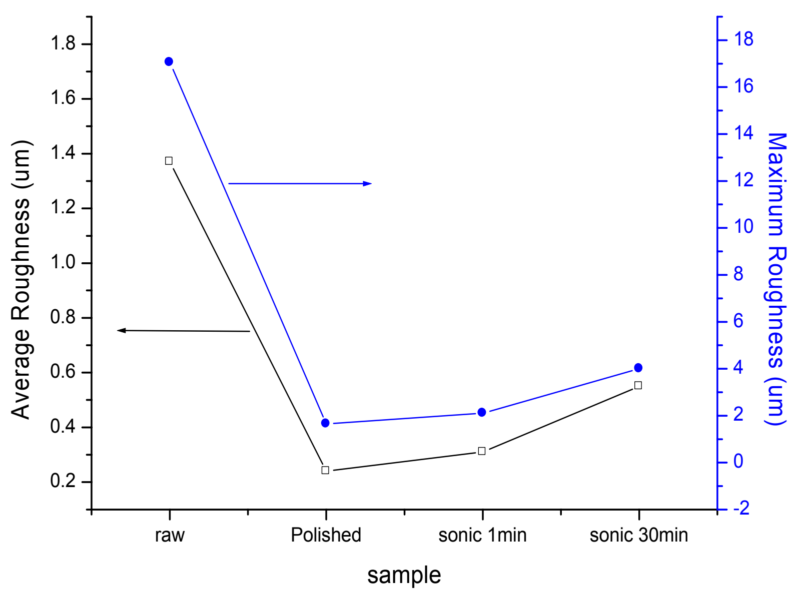


Fig. 4. Roughness of nuclear graphite specimen as a function of surface treatment

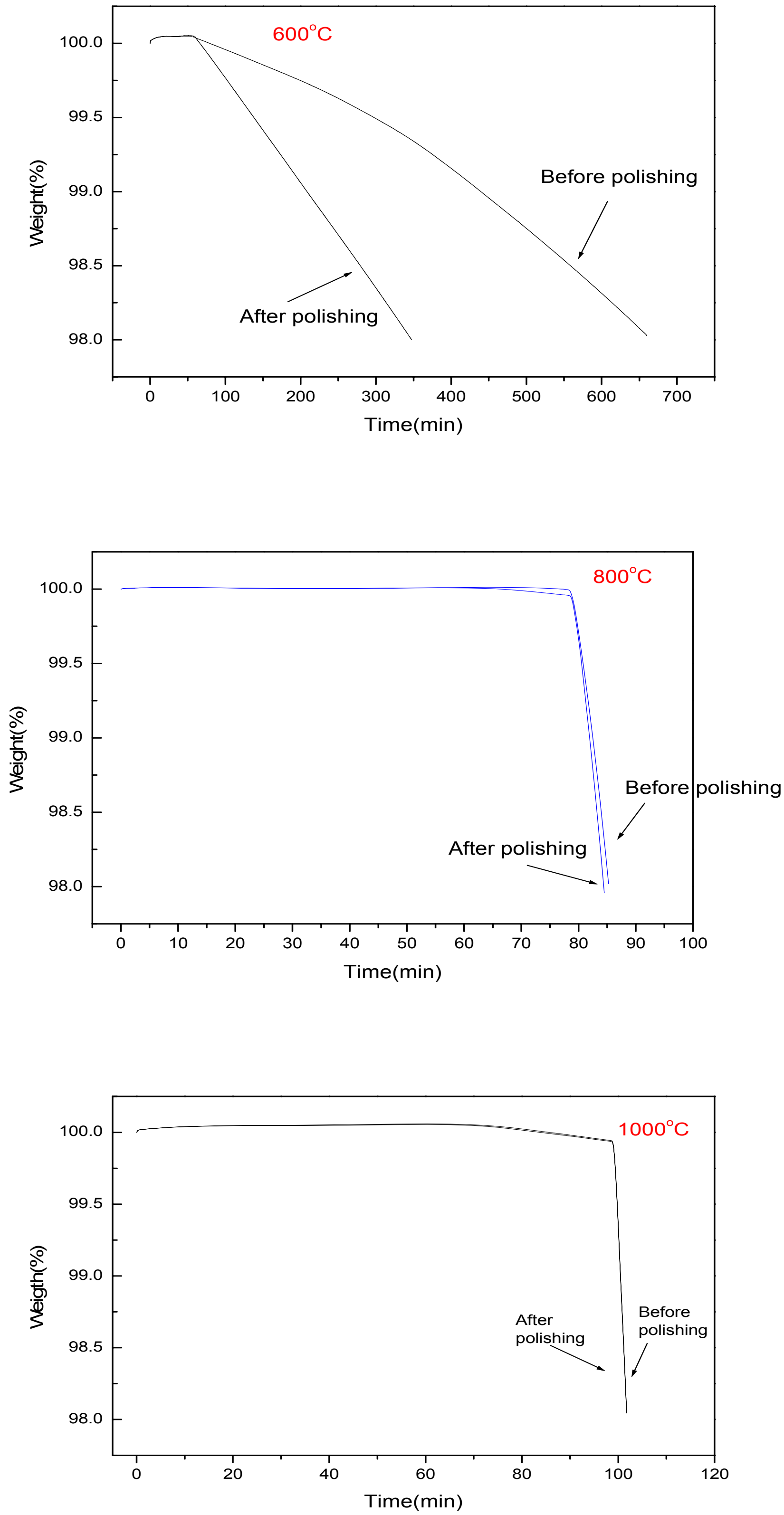
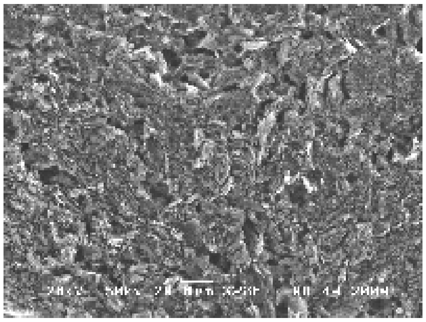
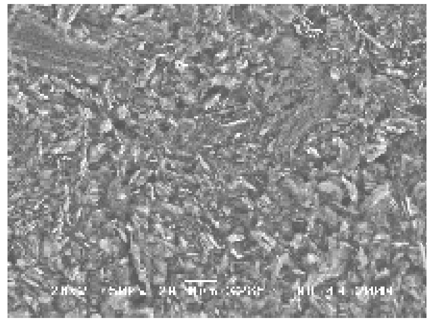
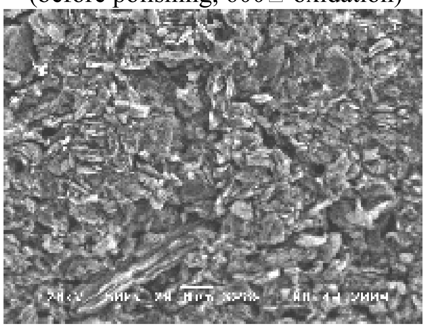


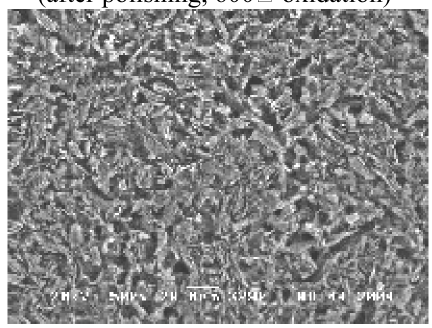
Fig. 5. TG Curves of nuclear graphite specimen as a function of time(min)



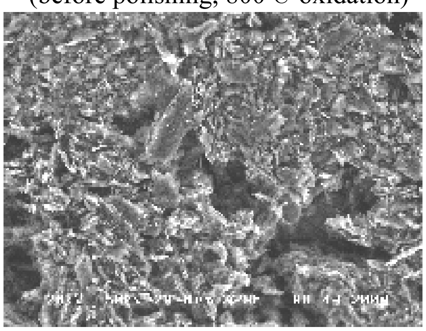


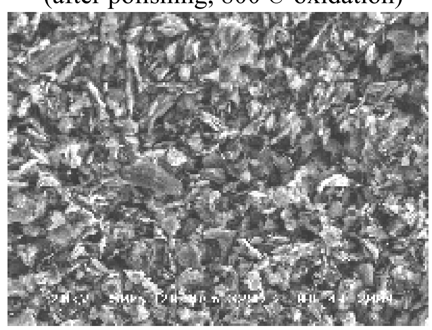
(before polishing, 600□ oxidation) (after polishing, 600□ oxidation)





(before polishing, 800℃ oxidation) (after polishing, 800℃ oxidation)





(before polishing, 1000℃ oxidation) (after polishing, 1000℃ oxidation)

Fig. 6. SEM of nuclear graphite surface after oxidation test

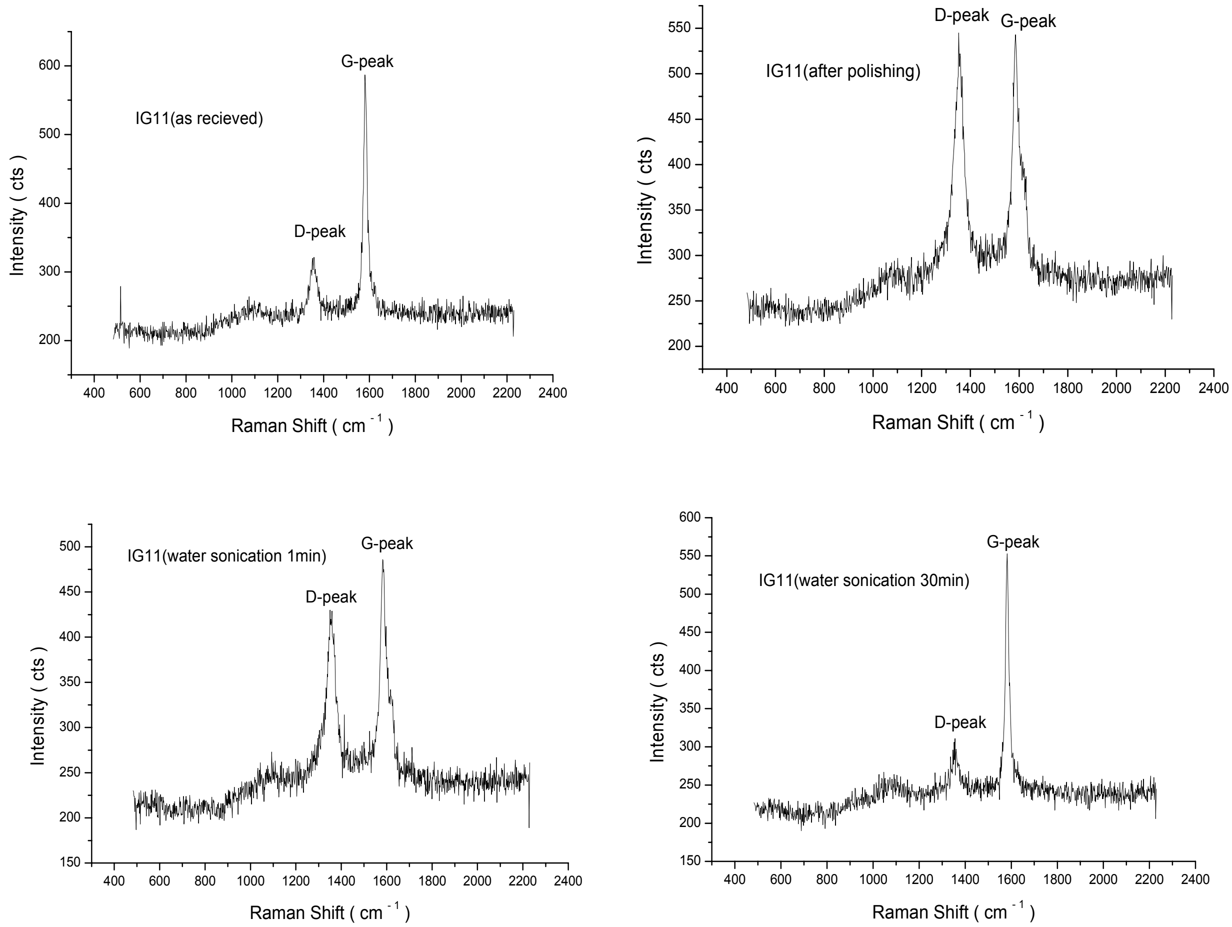


Fig. 7. Raman curves of nuclear graphite as a function of surface condition

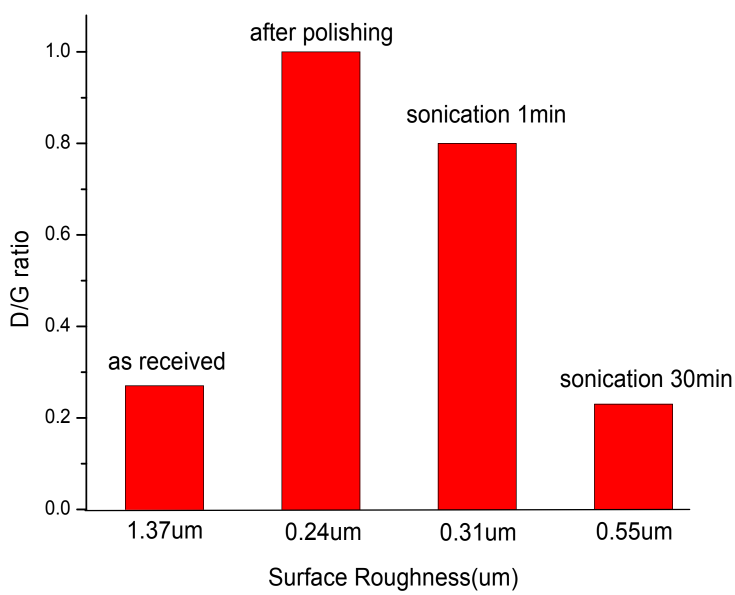


Fig. 8. D/G ratio of nuclear graphite specimen as a function of surface treatment

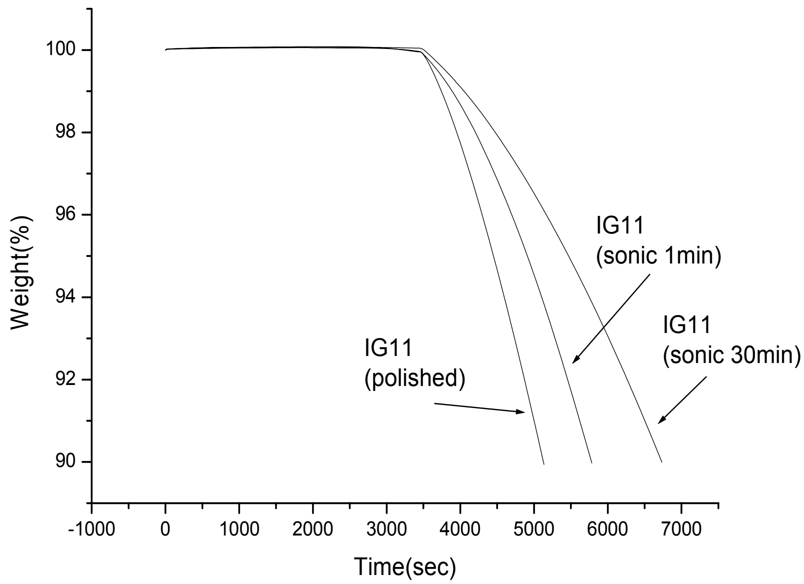


Fig. 9. TG of nuclear graphite specimen as a function of surface treatment

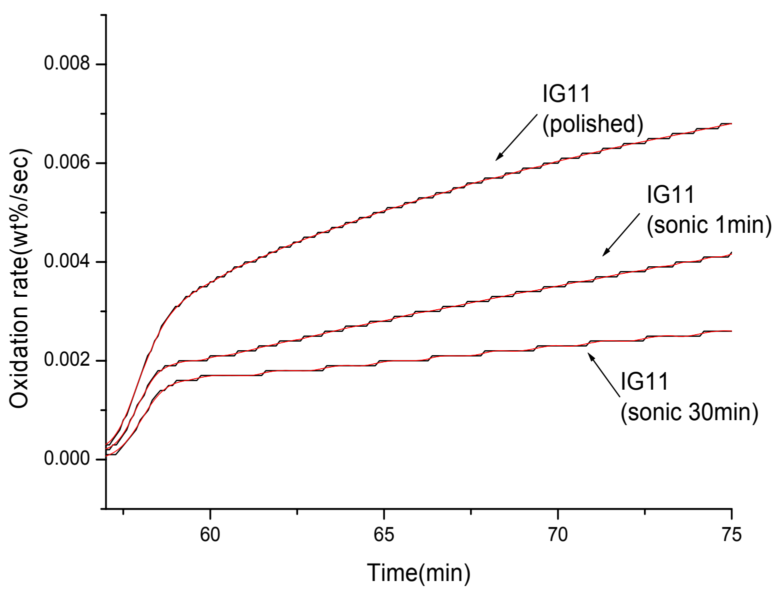


Fig. 10. Oxidation rate of nuclear graphite specimen as a function of surface treatment