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The Basic Study of Safety Evaluation for Cylinder wall of Small output 2 Cycle Engine

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Abstract

The small output two-cycle engine is used though the main current of the engine is 4-cycles.It will come to often use the raw material of two-cycle engine with the recycle material. A crack, an empty hole, and the inclusion that cannot do visible at the casting process might mix chiefly, this is not avoided as a recycle raw material. This is exposed under a severe environment in the high temperature and the high pressure in the cylinder, the crack is caused against the cylinder wall, the stress concentration is caused of the destruction while the aged deterioration and the crack progresses. In addition, the cylinder wall deforms heat in the state of a high temperature and high-pressure power. The stress occurs on the crack tip that an empty hole and the inclusion besides the crack are against mixing or the cylinder wall. It is forecast for the stress to concentrate on crack vicinity, for the crack progress to happen. The thermal deformation of a cylinder in two-cycle engine is thought that it is necessary and indispensable to investigate these from the viewpoint of the dynamic mechanics. This research experimented the cylinder deformation under the high temperature, tried to calculate a simulation, and experimented the relation between the temperature and the pressure in the cylinder and measured the deformation of an engine.

Key Words: Experimental Stress analysis, Stress intensity factor, Small output two cycle engine, Crack and hole or inclusion, Photoelasticity, Caustics method

1. Introduction

Thermal deformation [1]-[7] of the cylinder has been researched in the each one movement car maker and the laboratory, etc. up to now. Two-cycle engine [8][9] of a small engine seems still enough from the future viewpoint about the utility value though especially four cycles are the main current and it is used for the vehicle and other the machines. The experiment analysis of four cycle engine is studied enough, but the small two cycle engine is not done to study like the four cycle engine. As for the thermal deformation, four-cycle engine is reported but the deformation of two cycle engine is not reported enough. The 2-cycle engine is working under the high pressure and the high temperature, therefore it is deformed. When this is manufactured for the casting, the crack, the hole and the inclusion mix in the cylinder wall.

The stress occurs at the vicinity of the crack tip, where is the most dangerous under the load.

The authors studied the analysis about the stress on the cylinder wall by the caustic method and the photoelastic method, and obtained the good result.

2. Government equation

The method of calculating stress intensity factor K_{I} and K_{II} in photoelasticity used the extrapolation used in general though it was some. The relation to $K_{\mathrm{II}}/K_{\mathrm{I}}$=A compared with color line stripes loop angle θ_m and the stress intensity factor is shown in expression (1) as generation in the crack point etc.Moreover, it puts, and stress intensity factor K_{I} and K_{II} are calculated from expression (2) with $K_{\mathrm{II}}/K_{\mathrm{I}}$=A

$$\frac{K_{\mathrm{II}}}{K_{\mathrm{I}}} = \frac{2}{3}\left(\cot 2\theta_m \pm \sqrt{\cot^2 2\theta_m + \frac{3}{4}}\right) \quad \cdots\cdots (1)$$

$$\left.\begin{aligned} K_{\mathrm{I}} &= \frac{N_m (2\pi r_m)^{1/2}}{\alpha t[(\sin\theta_m + 2A\cos\theta_m)^2 + A^2\sin^2\theta_m]^{1/2}} \\ K_{\mathrm{II}} &= \frac{A N_m (2\pi r_m)^{1/2}}{\alpha t[(\sin\theta_m + 2A\cos\theta_m)^2 + A^2\sin^2\theta_m]^{1/2}} \end{aligned}\right\} \quad \cdots\cdots (2)$$

$$\left.\begin{aligned} K_{\mathrm{I}} &= \frac{1.671}{z_0 t|c_0|} \times \frac{1}{\lambda^{2/3}} \times \left(\frac{D}{\delta}\right)^{5/2} \times \frac{1}{\sqrt{1+\mu^2}} \\ K_{\mathrm{II}} &= \frac{1.671}{z_0 t|c_0|} \times \frac{1}{\lambda^{2/3}} \times \left(\frac{D}{\delta}\right)^{5/2} \times \frac{\mu}{\sqrt{1+\mu^2}} \end{aligned}\right\} \quad \cdots\cdots (3)$$

$$F_{\mathrm{I}} = \frac{K_{\mathrm{I}}}{\sigma_0\sqrt{\pi\alpha}} \quad , \quad F_{\mathrm{II}} = \frac{K_{\mathrm{II}}}{\sigma_0\sqrt{\pi\alpha}} \quad \cdots\cdots (4)$$

$N_{m.}$ is the number of the fringe number, α is the photoelasticity sensitivity, t is the thickness of the specimen, m is the farthest distance from the crack tip. The value is divided from $\sigma\sqrt{\pi\alpha}$ for the dimensionless.

The method of calculating obtained K_{I} and K_{II} from expression (3) by the caustics method.

Here, λ is $\lambda=(Z_0+Z_i)/Z_i$ by the magnification of the caustic, Z_0, Z_i are a distance from the position of the focus of the settling point of the light to the test piece. In the actual experiment, it is Z_i=1000 mm, and Z_0=2000 mm. In the material with high photoelasticity sensitivity, the obtained caustic image measured the most inside diameter because it became a double image. The order by which K_{I} and K_{II} are obtained requests maximum diameter D_{max} and minimum diameter D_{min} that the image projects first. Next, diameter D in right-angled to the direction of a crack tip is measured. The value of $(D_{max}-D_{min})/D_{max}$ is calculated from this μ and δ were decided from the theory graph, this was substituted for expression (4), and the stress of making to dimensionless expansion coefficient wascalculated. σ_0 is the stress at the central part of the cpecimen. In the case of the isochromatic fringe of the K_{I}, it is the almost circle against the extended line. In the case of the mixed mode of K_{I} and K_{II}, it is asymmetry and the inclined image. The caustic image is not entirely circle[10]-[13].

3.Experiment

3.1 Shape of test piece

In the actual experiment, it made to the polycarbonate (made of Takiron Co., Ltd. and transparency) as a base material, and the inclusion that the shape was decided was made a epoxy resin on the market. The position where the crack was inserted was decided to the part where the deformation of the cylinder was large. The circle hole is made the distance and the angle a variable from this crack tip, decided the position, and the empty hole that is the circle hole. It did about the inclusion as well as the circle hole. The diameter of a circle hole was adjusted to 8mm. The inclusion is the one that epoxy resin whose Young's modulus is higher than that of the base material was cast.

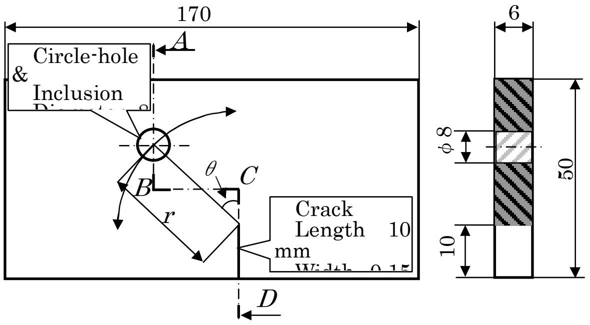

Fig. 1 Shape of specimen

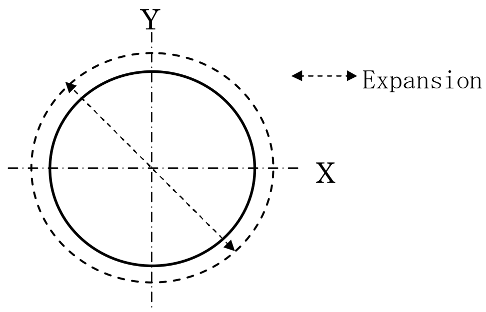

Fig. 2 Direction of stress for the specimen

The shape to develop the cylinder was assumed and it was decided and experimented on shape as a rectangle. Figure 1 shows shape, the crack, and the circle hole and the circle inclusion of the test piece. The crack was assumed to be 10mm in length by the sawing with the blade of thickness of 0.15mm, and a circle hole was assumed to be 8mm in the diameter. Distance r =10(mm) to the center of the crack and the circle hole, 20mm, and 30mm. The rotation corner were assumed to be θ=0°, 15°, 30°, 45°, 60°, 75°, and 90°. The model that is processed is occurred in the stress in it, it is removed the residue stress by the annealing treatment. After doing it, the specimen is almost removed the residue stress.

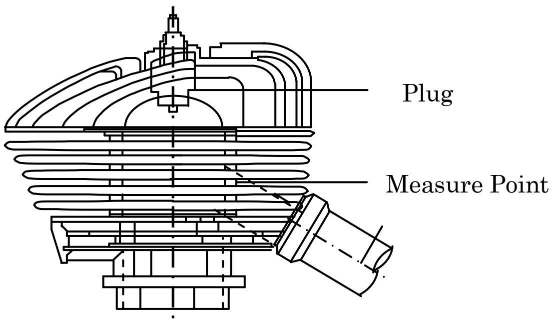

Fig.3 2- Cycle engine

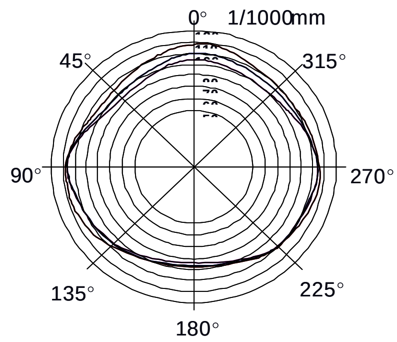

Fig.4 Thermal transformation of cylinder

3.2 Part of strain and direction

The maximum deformation part in the cylinder was given the load of the place to the port in the part of the cylinder. This part is always heated for the vehicle exhaust emission.
It is because the deformation is the biggest any other part. The deformation of the vertical direction does load. The direction of the deformation is small, therefore the experiment is done for the direction of the circumference of the cylinder is large. The specimen is developed the plate that is indicated in Fig. 2.

3.3 experiment temperature

The experiment temperature reproduced the temperature in an actual cylinder at the normal temperature because it was impossible.

4.Experiment result and consideration

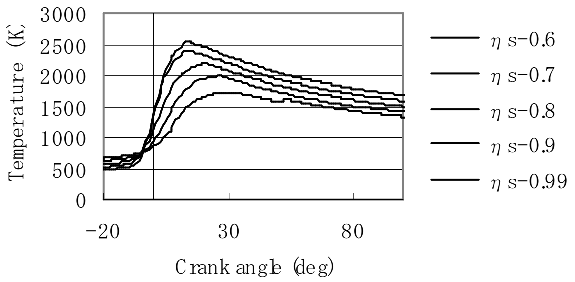

Fig.5 Comparison of temperature in cylinder

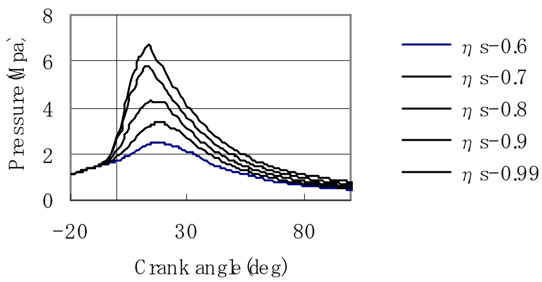

Fig.6 Comparison of pressure in cylinder

Fig.3 is a side chart of 2- cycle engine, and the measurement place of the cylinder deformation is shown. It is the one that the deformation of the cylinder was shown in Fig.4. It did not entirely deform in thermal deformation and it became a biased transformation. This is the cause that the vicinity of the exhaust part is heated by the exhaust gas and this part is higher than any other part.

Fig.5 and Fig.6 are the simulations that are shown as a result as for the thermal change and the pressure change in the cylinder and they show the thermal changes in the cylinder and the results by the simulation of the pressure change. ηs shows the scavenging efficiency. ηs shows the scavenging efficiency., K is displayed at the absolute temperature. From the result of a simulation, Maximum temperature is about 2500K(absolute temperature) and the pressure rises to 7 MPa in the cylinder. Fig.7 and Fig.8 are the result of one of the image by the photoelastic method, the former is for the circle hole and the later is for the circle inclusion. The load is 2.45kN, the distance is 10mm.

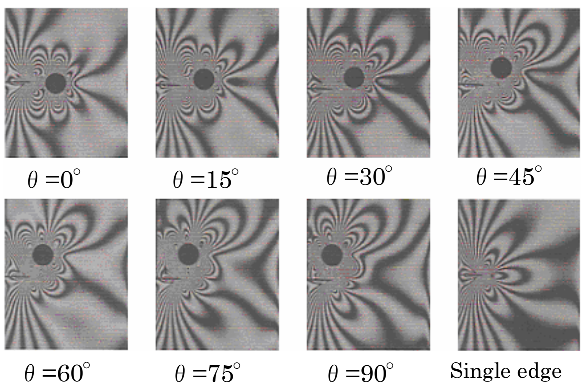

Fig.7 Example of photographs obtained by experiment (crack and circle hole, *r* =10mm, *F* =2.45kN)

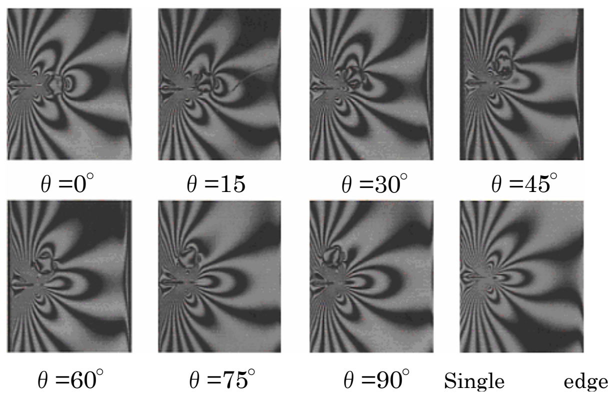

Fig.8 Example of photographs obtained by experiment (crack and circle inclusion, *r* =10mm, *F* =2.45kN)

Fig.9 is one of the examples of the caustic image with which the circle inclusion. The caustic image is possible to see clearly in it. The crack is a position on the left side.

Fig.10 and Fig.11 are the results for K_{I} and K_{II} of the non-dimensionless stress intensity. In the case of a circle hole, the *K* values are distributed; this is the reason that the stress of the vicinity of the crack tip is big and means the danger. As for the circle inclusion, the *K* value is settled to the vicinity of the approximate type of a third degree equation.

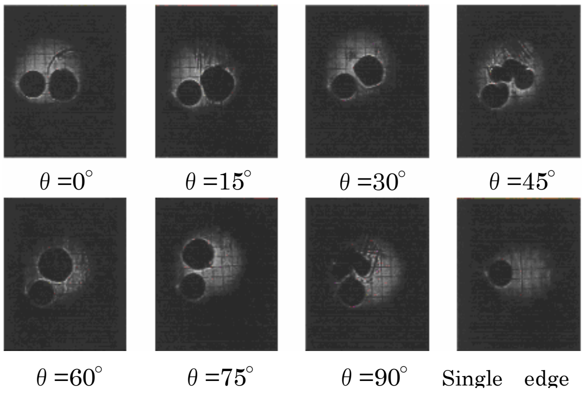

Fig.9 Caustic patterns of inclusin (2.45KN)

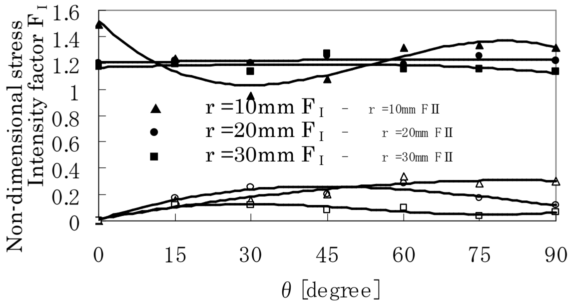

Fig.10 Relation between non-dimensional stress intensity factor F and angle θ for circle-hole

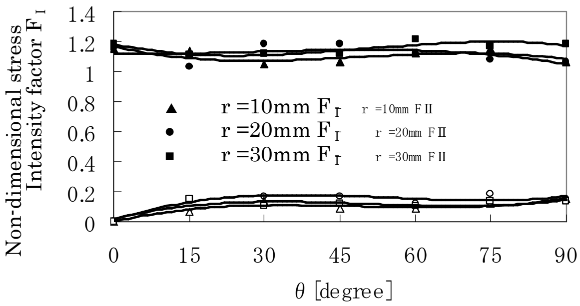

Fig.11 Relation between non-dimensional stress intensity factor F and angle θ for inclusion

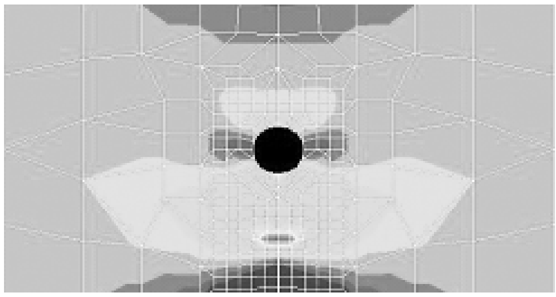

Fig.12 Pattern of simulation of circle hole(2.45kN)

Fig.9 is one of the examples of the caustic image with which the circle inclusion. The caustic image is possible to see clearly in it. The crack is a position on the left side.

Fig.10 and Fig.11 are the results for K_{I} and K_{II} of the non-dimensionless stress intensity. In the case of a circle hole, the K values are distributed; this is the reason that the stress of the vicinity of the crack tip is big and means the danger. As for the circle inclusion, the K value is settled to the vicinity of the approximate type of a third degree equation.

Conclusion

In this research, the experiment analysis of the influence in the crack, the circle hole the material of the cylinder, and the circle inclusion by the mutual interference was done. It was the one that the evaluation comparative study was done by asking the stress intensity factor from the photoelasticity method and the caustic method, and the following results were able to be obtained in the analysis.

When it has the crack and the circle hole, the stress intensity factor indicates a low value when a value that is larger than the experiment value of the one side crack is indicated, and the crack and the lying thing are possessed.

There is little influence in the stress by the angle when the distance of the crack and the circle hole for r=30mm or more. The crack and the circle hole in the cylinder work to exist alone respectively and the mutual interference is not seen.

The stress intensity factor of the crack decreases independently of the inclusion when the one with a high Young's modulus exists from the base material in the inclusion. However, it flakes off when the load becomes more than a constant size.

The stress intensity factor is on the approximation line of the third equation when the one with a high Young's modulus exists.

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