# CHARACTERISTICS OF VARIOUS FILM COOLING JETS INJECTED IN A CONDUIT

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Film cooling techniques have been investigated[1-2]. Recently the hole geometry for film cooling jet has been devised and remarkable effect for cooling effectiveness has been reported[3-4]. However such a shaped hole geometry is not necessarily easy to open through the real blade wall and the work is sometimes expensive. So in the present study film cooling characteristics by the jets through various easy-to-make straight holes and slots have been investigated.

## EXPERIMENT

In the present study, the film cooling effects through various jet holes and slots have been experimentally examined in a rectangular conduit. Seven kinds of jet holes and slots were used in the experiment and five of them had the same cross sectional area. Their shapes were a circle, three kinds of rectangles, an ellipse, and two kinds of ovals. Their details are shown in **Table 1**.
Changing the mass-flux ratio (M) of the main flow and the cooling jet, the experiment has been carried out. In the present experiment five jet holes were placed in a row through the wall and the jets were injected at an angle of 30 degrees to the main flow. (**Fig.1**) The thermal field in the conduit was measured by the thermal probe, which was made of six Cu-Co thermocouples set 6 mm pitch in a row. The cooling effect of the jets was evaluated by the so-called "cooling effectiveness" : $\eta = (T_f - T_\infty)/(T_j - T_\infty)$.

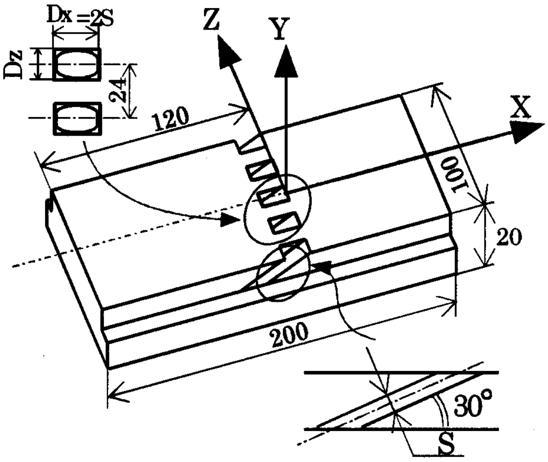


Fig.1 Injection hole and slot

Table.1 Geometry of injection holes

| | Cross section | Dz [mm] | S [mm] | Area [mm²] |
|---|---|---|---|---|
| A | Rectangle | 8.5 | 6.68 | 56.8 |
| B | Circle | 8.5 | 8.50 | 56.8 |
| C | Rectangle | 12.0 | 4.73 | 56.8 |
| D | Ellipse | 12.0 | 6.00 | 56.8 |
| E | Oval | 12.0 | 6.00 | 64.3 |
| F | Rectangle | 18.0 | 3.15 | 56.8 |
| G | Oval | 18.0 | 6.00 | 100.3 |

Typical results of the film cooling effectiveness near the wall are shown in **Fig.2**. They show the distribution of cooling effectiveness at M=1.5 through Y-Z coordinate plane. In the figure the jet through oval slot is leaned against the wall as the jet through the slender rectangular slot.

Typical thermal distributions through X-Y coordinate plane are shown in **Fig.3**. From these figures it is clear that the oval slot is effective for the film cooling on the downstream wall surface.

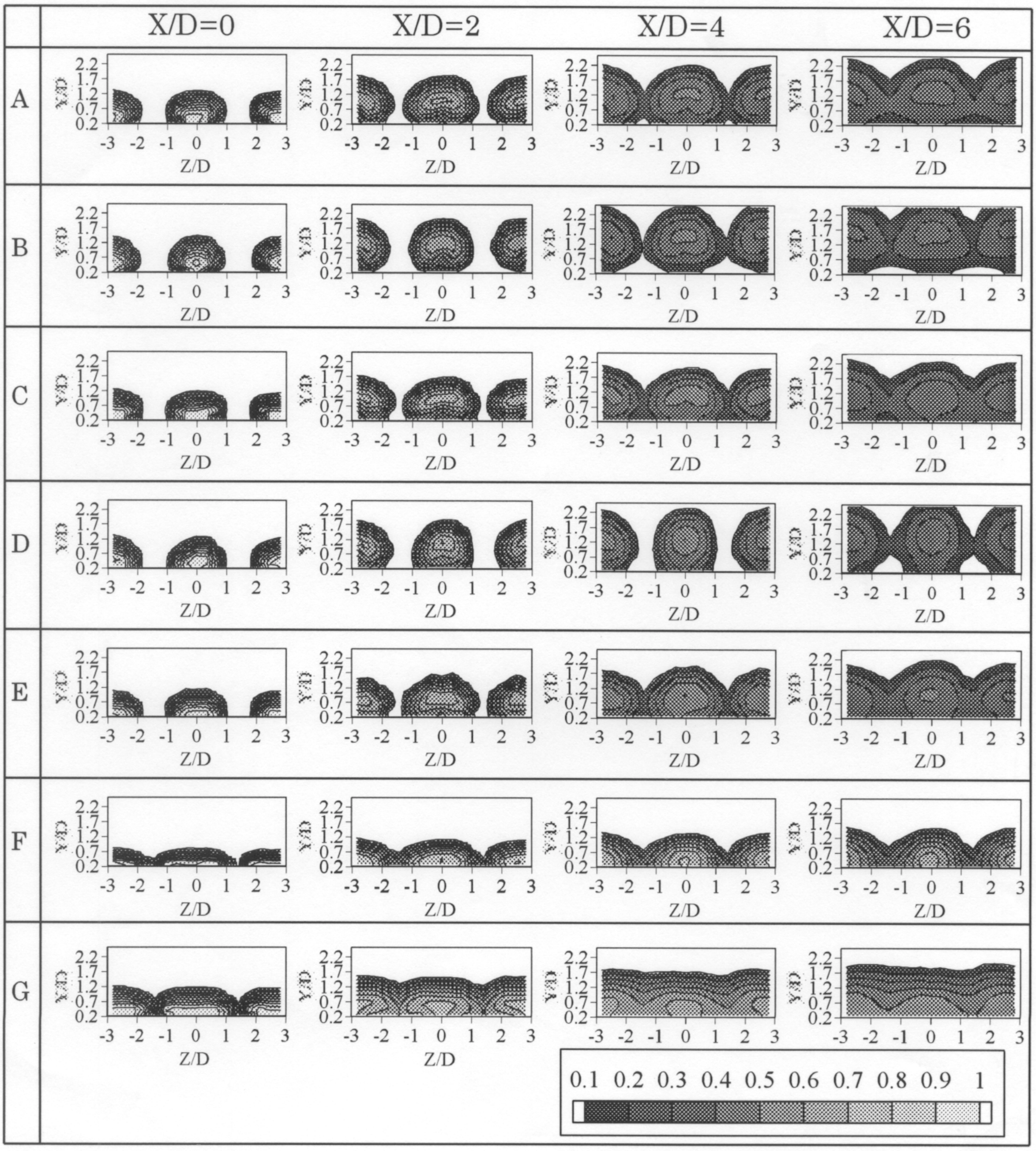


**Fig.2 Distribution of thermal effectiveness on Y-Z plane (M=1.5)**

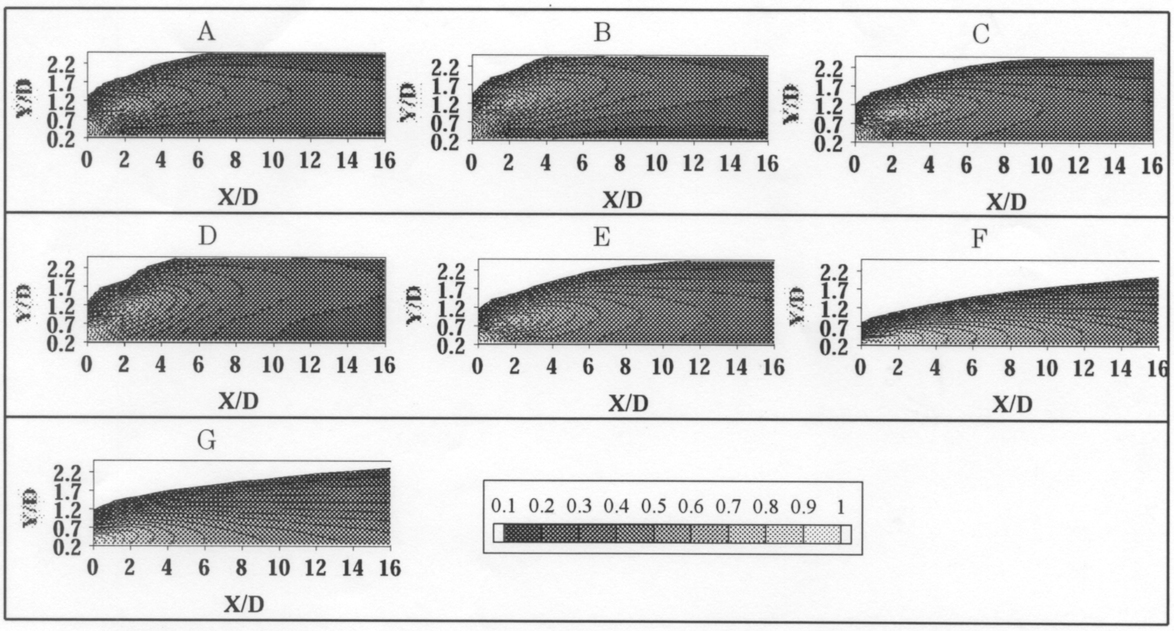


Fig.3 Distribution of thermal effectiveness on X-Y(Z=0) plane (M=1.5)

## CONCLUSION

The main results obtained in the experiment are as follows:

(1) Film cooling jet through a circular hole does not spread over the downstream wall. So the cooling effectiveness by the film cooling jet through circular holes is lower than by the film cooling jet through rectangular holes, whose width is the same as the circular holes.

(2) Among the rectangular hole and slots, which have the same cross sectional area, the highest cooling effectiveness is obtained for the film cooling jet through the widest rectangular slot.

(3) The mass flux ratio M, which gives the highest cooling effectiveness, increases to 1.0 as the injection hole geometry becomes similar to the so-called "slit".

(4) The film cooling jets through the oval slots are leaned against the wall by the mainstream and they spread over the downstream wall earlier than those through the rectangular slots. So the oval slot is the most effective hole for the film cooling jet and it is an easy geometry to open through the real blade wall.

## REFERENCES

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