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## **Perforation of oil well casing with submerged abrasive waterjets with multiple nozzles**

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**Abstract:** In the South Kanto natural gas fields, Japan, a technique for perforating steel casing has been required to improve poorly performing wells and also to cement an annulus between casing and formation. Nowadays, perforations are widely performed by gun perforators with shaped-charge explosives. However, they must be conformed to tough regulations concerning explosives and furthermore they may cause casing splitting when perforating heavily corroded casing of small diameter. Therefore, a perforating system without using shaped-charge explosives has been required.

In this study, we developed an abrasive waterjets system with four nozzles to perforate four holes in a steel casing at once. To clarify the effect of ambient and driving pressures and impinging time after perforation on perforated hole area, laboratory perforation tests were conducted under ambient pressure of up to 3 MPa. Main results obtained in this study are summarized as follows : (1) The developed system can perforate four holes at once for a steel casing with a thickness of 6.35 mm under ambient pressure of up to 3 MPa. (2) The perforation performance of each nozzle in the nozzle system was similar to that of a single nozzle system. Accordingly, a nozzle system with four nozzles can be designed based on a methodology for designing a single nozzle system. (3) For repeated perforation, the optimum impinging time for each perforation is determined so that average increase rate of hole area may be maximum.

**Key words:** [perforation](#), [abrasive waterjets](#), [multiple nozzles](#), [optimum impinging time](#)

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