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Increasing Precision of Pipe Forming Process by Burring and Ironing of Steel Pipe in FEM Analysis

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ABSTRACT : *This paper describes increasing precision of Pipe Forming process by burring and ironing of large diameter steel pipe in FEM analysis. Branch pipes are one of the components of the piping system in a factory that serves as a flow path for gases and fluids. The bifurcated tube is formed by burring as a typical molding technique. The burring process is to form a branch pipe by raising the peripheral portion of the prepared hole formed in the mother pipe. There is a problem that the cutting of the edge is required in the post process. Therefore, a branch pipe batch forming method has been developed in which burring processing that does not require a cutting step in the subsequent step is combined with ironing processing using FEM analysis. The purpose of this research is to improve the accuracy of FEM analysis in the branch pipe batch forming method using burring process and ironing process by cutting the material into a cylindrical shape and performing a compression test to obtain the deformation resistance of the actual material.*

KEYWORDS – *Burring, Ironing, SGP pipe, Compression test, FEM analysis*

I. INTRODUCTION

This paper reports on the increasing precision of batch pipe forming method using burring and ironing of large diameter steel pipe in FEM analysis. A branch pipe is one of the parts that make up the piping system in factory piping that serves as a flow path for gas and fluid. Fig. 1 shows an overview of the branch pipe. SGP large diameter pipe is used as an example of a branch pipe. Burring is a typical forming technique for branch pipes, and a rigid body drawing method [1]-[5] has been developed. Burring is a process of forming a branch pipe with a circular end at the periphery of an elliptical pilot hole drilled in the mother pipe, and there is a problem that post process cutting takes time and cost. In addition, the pilot hole shape is often based on field experience and intuition, and it is difficult to say that it is the optimum shape. In the previous research, a branch pipe batch molding method that combines burring and ironing has been developed. By this branch pipe batch forming method, the end face of the branch part can be machined flat, and machining that does not require end face cutting in the subsequent process has become possible. Therefore, in this study, we cut out a test piece from an SGP large-diameter pipe, perform a compression test, and obtain the deformation resistance of the actual material, with the aim of further improving the accuracy of the branch pipe batch molding method in FEM analysis [6]-[10].

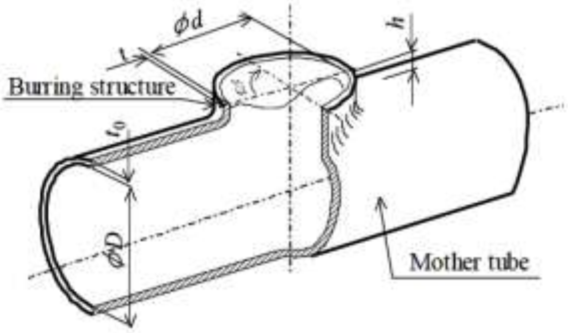


Fig. 1 Overview of branch pipe [2]

II. EXPERIMENTAL CONDITION AND RESULT

A cylindrical specimen was cut out of an SGP large-diameter pipe and a compression test was conducted. Graphite-based lubricant was used as a lubricant. TENSILON (RTF-2430) was used for the experiments. The universal testing machine used in the experiments is shown in Fig. 2. In the FEM analysis in the previous study, the deformation resistance was based on the AISI.cold data from Yamanaka Gokin Co. AISI.cold is the deformation resistance of S10C and has a value of 4 points only. Therefore, it is thought that the use of the deformation resistance obtained by compression tests on actual materials can improve the accuracy of FEM analysis.

Fig. 2 TENSILON(RTF-2430)

Table 1 AISI.cold

Strain [-]	Stress [MPa]
0	380
0.1	433.349
0.7	663.837
2	669

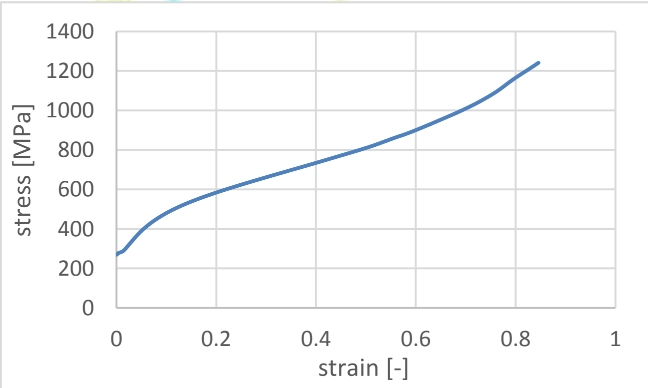


Fig. 3 Deformation resistance obtained from experiments

III. FEM ANAYLSIS

FEM analysis was performed using the deformation resistance obtained from the experiments. In this study, a nominal diameter of 80A, a diameter of 89.1 mm, and a wall thickness of 4.2 mm for the SGP pipe and a nominal diameter of 50A, a diameter of 60.5 mm, and a wall thickness of 2.5 mm for the bifurcation pipe were selected. The height of the bifurcation is set at 10 mm. Fig. 4 shows the target shape. A commercial FEM analysis software, DEFORM, was used for the analysis. Fig. 5 shows the analytical model. The analytical model is a 1/4 model in consideration of symmetry. The analysis was performed with 50,000 configuration elements. The analysis involves holding the SGP pipe in a die and pulling a spherical punch from inside the pipe in the direction of the arrow in Fig. 5. The tapered portion at the bottom of the punch causes ironing at the same time as the burring process, and it is designed so that the edge face is flat when the material fills the space in the stepped portion of the die. A tapered portion is provided in the die so that the beveling can be machined at the same time as the branched portion is formed. The bending radius was set at 5 mm. Figures 6 and 7 show the die and punch drawings, respectively. The analysis was performed several times by changing the shape of the pipe preparation hole.

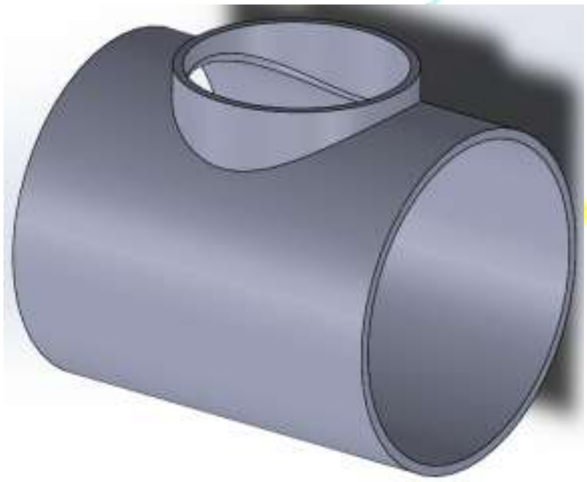


Fig. 4 Target model

Fig. 5 Analysis model

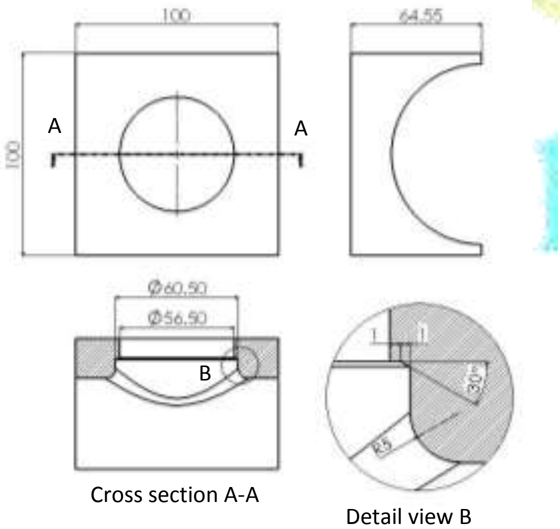


Fig. 6 Drawing of die

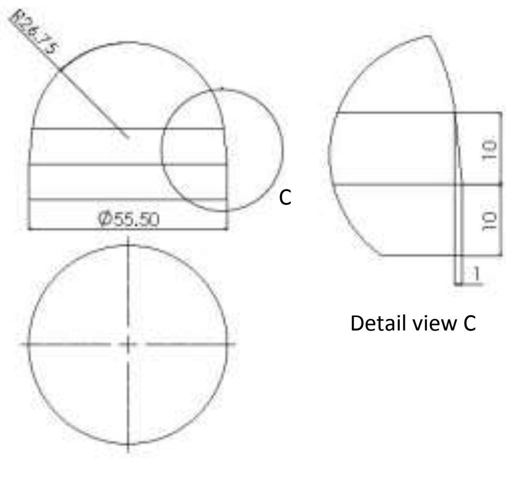
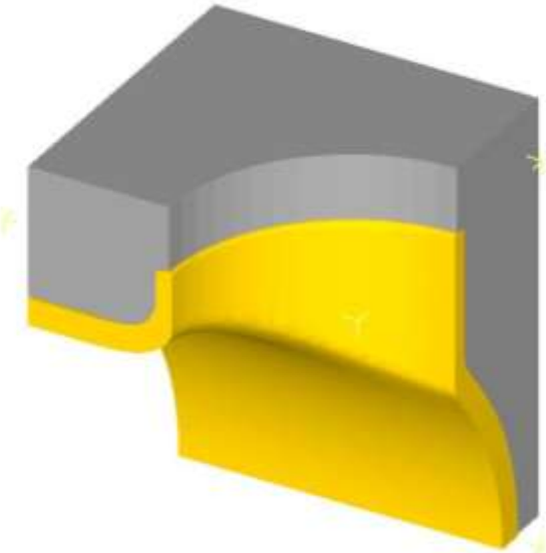


Fig. 7 Drawing of punch

Fig. 8 shows the results of the analysis. A flat bifurcation that does not require any subsequent processing was achieved. It is suggested that the beveling can be done simultaneously with the shaping of the bifurcation by this processing method.



(a) 1/4 model

(b) 1/4 model

(c) Side view

Fig. 8 Analysis results

IV. CONCLUSION

This paper reported on the increasing precision of batch pipe forming method using burring and ironing of large diameter steel pipe in FEM analysis.

Compression tests were conducted using actual materials to obtain the deformation resistance, which is thought to improve the accuracy of FEM analysis. A flat bifurcation that does not require any subsequent processing was achieved. It is suggested that the beveling can be done simultaneously with the shaping of the bifurcation by this processing method. In the future, a mold will be fabricated based on the analysis results and the actual machining will be performed.

V. Acknowledgements

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