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An Analysis Study on Durability and Mechanical Characteristic of Notched Tensile Specimens by Material

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Abstract: Since, stainless steel, aluminum and bronze as a single material are directly connected with safety as the materials most universally employed, sufficient advance experiments before use are an essential requirement. Based on such point, notch tensile analysis with simulation was conducted in the present study by designing notched tensile specimen models of the same specification for stainless steel, aluminum and brass. In the present study, notched tensile specimen models made of stainless steel, aluminum and brass were subjected to 3D modelling using CATIA design program for which notched tensile analysis in simulation was performed. By designing notched tensile specimen models per material and conducting a notch tensile analysis, tensile strength characteristic and durability of each material could be affirmed. According to the results of conducting the notched tensile analysis, the loads were shown to have tendency for gradual increase until the maximum load was exhibited in the case of aluminum notched tensile specimen model and brass notched tensile specimen model. In the case of stainless steel tensile specimen model, the loads were rapidly increased until the forced displacement progressed by about 3 mm followed by tendency for gradual increase shown subsequently. This study is aimed at notch tension of universally employed materials such as stainless steel, aluminum and brass among materials to identify material properties of heterogeneous materials and composite materials it is considered that the data secured through the relevant study can be utilized as basic data for the investigations to be conducted in the future.

Key words: Notched tensile specimen, material, mechanical characteristic, maximum load, durability, steel

INTRODUCTION

Recently, the use scope of materials is gradually being expanded with the use in diversified areas. At the same time, material types are also being diversified. These materials include materials consisting of a single metal and the composite materials such as CFRP (Carbon Fiber Reinforced Plastic) produced to simultaneously have high durability and weight reduction characteristics heterogeneous properties by employing the method of combining and maximizing advantages of each material with the materials of mutually different properties (Ohguchi and Kurosawa, 2016; Ma *et al*., 2016; Komori, 2016; Kumar *et al*., 2016). However, since, stainless steel, aluminum and bronze as a single material are directly connected with safety as the materials most universally employed, sufficient advance experiments before use are an essential requirement (Akbary *et al*., 2014; Perez *et al*., 2014). Based on such a point, notched tensile analysis in simulation was conducted in the present study by designing notched tensile specimen models of the same specification for stainless steel, aluminum and brass. It is considered that the data derived through this procedure in this study can be utilized as basic data in the actual tensile tests as well as the comparative studies with composite and heterogeneous materials to be performed in the future (Bayley and Aucoin, 2013; Aslani, 2013; Zhang *et al*., 2012a, b).

MATERIALS AND METHODS

In this study, notched tensile specimen models of stainless steel, aluminum brass were subjected to 3D modelling using CATIA design program for which notched tensile analysis in simulation was conducted. Figure 1 shows specification of the notched tensile specimen model with the specification for all notched tensile specimen models being the same. Namely, lateral length of the notch specimen models is 15 mm, the longitudinal length 80 mm the width 0.5 mm with the

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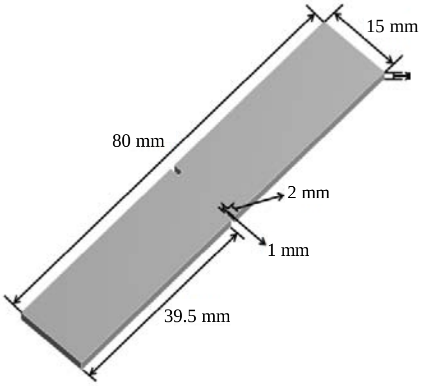

Fig. 1: Dimensions of notched tensile specimen

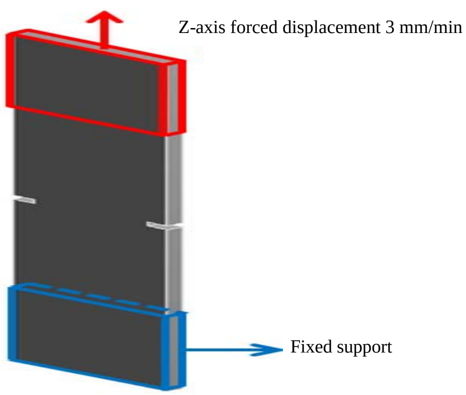

Fig. 2: Boundary conditions of notched tensile specimen models

Table 1: Material properties

Materials	Stainless steel	Aluminum	Brass
Density (kg/m^3)	7750	2770	8300
Young's modulus (GPa)	193	71	110
Poisson's ratio	0.31	0.33	0.34
Yield strength (MPa)	207	280	280
Ultimate strength (MPa)	586	310	430

lateral length of each notch being 2 mm and the longitudinal length 1 mm. In this study, tensile strengths of such notched tensile specimen models were studied. Also, Table 1 shows material properties of the notched tensile specimen models (Katnam *et al*., 2012; Abu-Farha *et al*., 2011; Elambasseril *et al*., 2011; Lee and Cho, 2016).

Boundary conditions: Figure 2 shows the boundary conditions applied to each notched tensile specimen model to conduct the simulation tensile analysis. All boundary conditions applied to the specimen models were the same where the specimen was first assumed to be fixed to the lower load cell, the fixed support points were given to the bottom part of the specimen model the forced displacement condition of 3 mm/min was imposed on the top part of the specimen model with the specimen being assumed to be pulled by the upper load cell to perform the test.

RESULTS AND DISCUSSION

Figure 3 graphically shows the result values of load as a function of forced displacement for a stainless steel notched tensile specimen. According to the results of conducting tensile analysis, the loads applied to the specimen model showed tendency for gradual increase as the forced displacement progressed and then a rapid increase until the forced displacement proceeded by about 3 mm, followed by a gradual increase in loads subsequently until the forced displacement progressed by about 10 mm. When the forced displacement progressed by about 10 mm, the maximum load of about 32500 N was observed for the specimen model it could be affirmed that loads acting on the specimen model were gradually reduced as rupture occurred in the specimen model. Also, Figure 4 and 5 show the stress and the total deformation produced in the stainless steel notched tensile specimen model it could be affirmed that the total deformation was shown to be about 0.044 mm the stress about 221.88 MPa.

Figure 6 graphically shows the result values of load as a function of forced displacement for the aluminum notched tensile specimen model. Although, a similar tendency to that for the stainless steel notched tensile specimen model was observed, the point of occurrence of rupture, etc. were shown to be different. Whereas the loads were drastically increased up to a given forced displacement followed by gradual increase afterwards in the case of stainless steel notched tensile specimen model, the loads could be affirmed to constantly increase as a whole. Namely, considering the graph, the loads were shown to have tendency for gradual constant increase until the forced displacement progressed by about 7 mm the maximum load of about 21000 N was observed when the forced displacement reached about 7 mm. After occurrence of the maximum load, the rupture occurred in the relevant specimen model with subsequent drastic reduction in the loads. Figure 7 and 8 schematically show total deformation and stress produced in the aluminum notched tensile specimen model it could be affirmed that the total deformation was shown to be about 0.093 mm the stress about 166.42 MPa.

In a similar way to the tensile analysis results described earlier, Fig. 9 graphically shows the load result values for the brass notched specimen model as a function of forced displacement. As a result of conducting the tensile analysis, the brass notched tensile

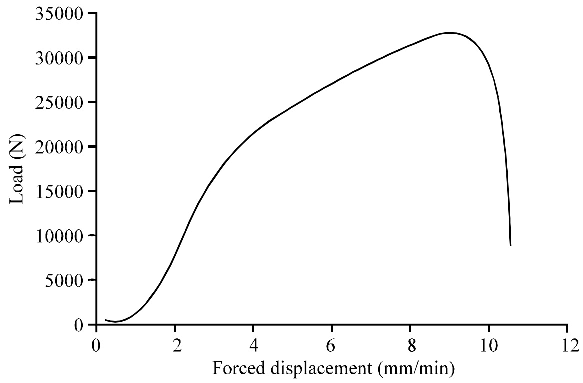

Fig. 3: Graph of load due to forced displacement at tensile analysis (stainless steel notched tensile specimen model)

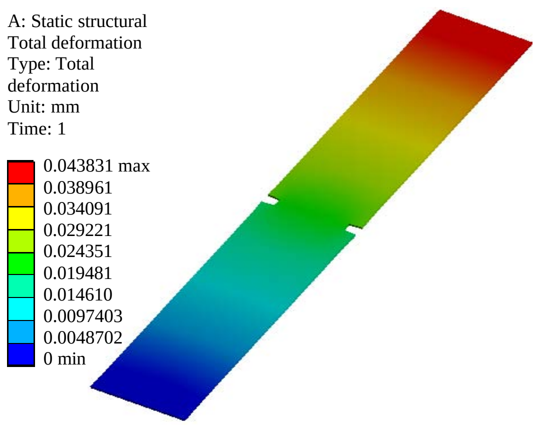

Fig. 4: Total deformation of stainless steel notched tensile specimen model

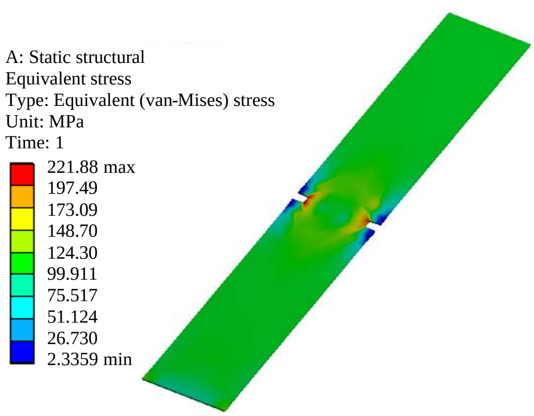

Fig. 5: Equivalent stress of stainless steel notched tensile specimen model

specimen model also showed tendency for load increase similar to that for the stainless steel notched tensile

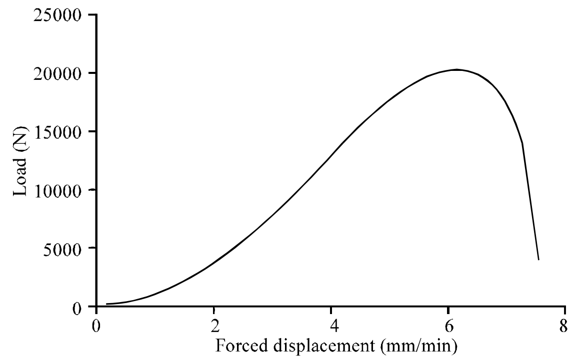

Fig. 6: Graph of load due to forced displacement at tensile analysis (aluminum notched tensile specimen model)

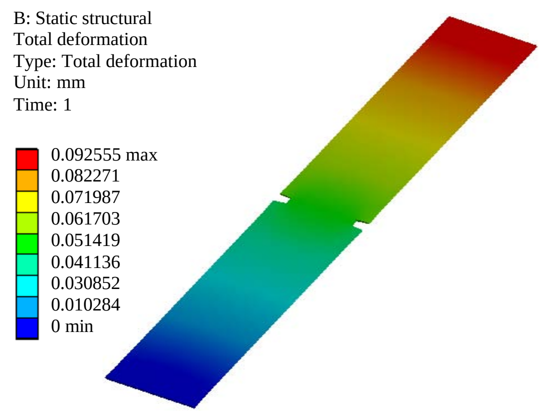

Fig. 7: Total deformation of aluminum notched tensile specimen model

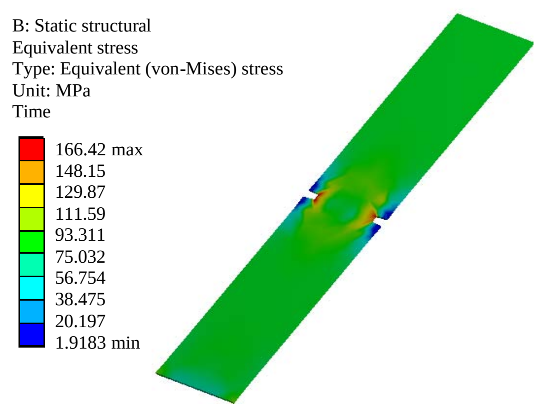

Fig. 8: Equivalent stress of aluminum notched tensile specimen model

specimen model as well as the aluminum notched tensile specimen model where the loads were gradually increased up to a given forced displacement and then drastically

Table 2: Comparison analysis results of notched tensile specimen models

Notches	Maximum deformation (mm)	Maximum equivalent stress (MPa)
Stainless steel tensile specimen with notches	0.640000	229.44
Aluminum tensile specimen with notches	0.000571	170.31
Brass tensile specimen with notches	0.000650	258.96

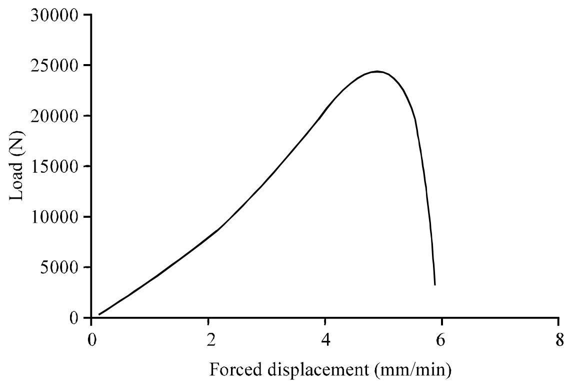

Fig. 9: Graph of load due to forced displacement at tensile analysis (brass notched tensile specimen model)

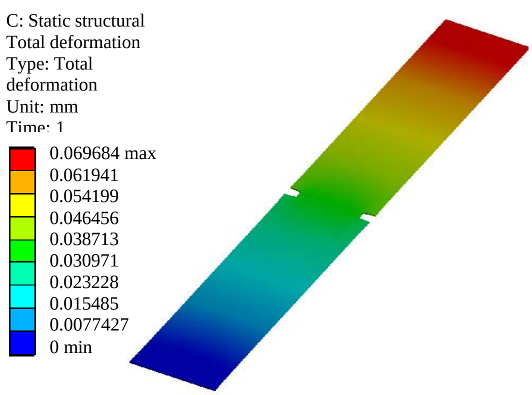

Fig. 10: Total deformation of brass notched tensile specimen model

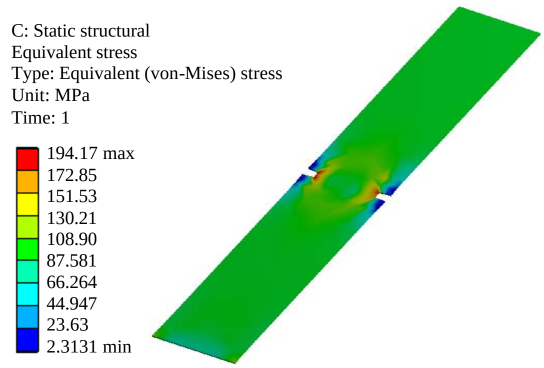

Fig. 11: Equivalent stress of brass notched tensile specimen model

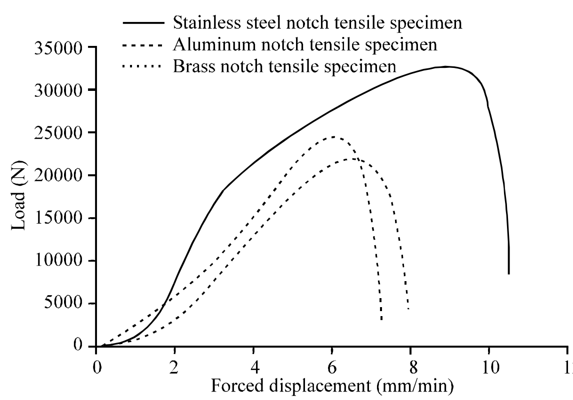

Fig. 12: Comparison graph of load due to forced displacement at tensile analysis (stainless steel, aluminum and brass notched tensile specimen model)

reduced as rupture occurred in the specimen model after appearance of the maximum load. Namely, the loads were gradually increased until the forced displacement progressed by about 6.2 mm could be affirmed to be drastically reduced following occurrence of rupture after the maximum load of about 24000 N was shown at the relevant forced displacement. Figure 10 and 11 schematically show total deformation and stress produced in the brass notched tensile specimen model where the total deformation can be affirmed to be about 0.070 mm the stress about 194.17 MPa.

Figure 12 shows mutual comparisons of load result values as a function of forced displacement for stainless steel, aluminum brass notched tensile specimen models while Table 2 is shown to specifically compare the analysis results for each notched tensile specimen model resulting from simulation tensile analysis. When the 3 types model were mutually compared, the maximum load of about 32500 N was observed in the case of stainless steel notched tensile specimen model when the forced displacement progressed by about 10 mm the maximum load of about 21000 N was shown in the case of aluminum notched tensile specimen model when the forced displacement progressed by about 7 mm. And the case of brass notched tensile specimen model, the maximum load of about 24000 N was observed when the forced displacement progressed by about 6.2 mm. Also, the total deformation and the stress of the stainless steel notched tensile specimen model were shown to be about 0.044 mm and about 221.88 MPa, respectively while the total deformation and the stress of the aluminum notched tensile specimen model were shown to be about 0.093 mm and 166.42 MPa, respectively. Lastly, in the case of brass notched tensile specimen model, the total deformation and the stress could be affirmed to be about 0.070 mm and about 194.17 MPa, respectively. Thus, this study is directed to notched tension for stainless steel, aluminum and brass which are universally used among materials aimed at securing of basic data as a study to identify material property values of heterogeneous materials as well as diversified composite materials to be investigated in the future. Based on the data secured through the relevant study, comparative study can be performed with composite materials such as CFRP and heterogeneous materials combining features of mutually different materials.

CONCLUSION

In this study, stainless steel, aluminum brass notched tensile specimens were produced to conduct notched tensile experiments the following conclusions have been derived by conducting a simulation analysis for verification of the experimental results.

By designing notched tensile specimen models of the same specification per material and performing a notch tension analysis, tensile strength characteristics and durability of individual materials could be affirmed.

In the case of stainless steel notched tensile specimen model, the maximum load of about 32500 N was observed when the forced displacement progressed by about 10 mm while the maximum load of about 21000 N was shown in the case of aluminum notched tensile specimen model when the forced displacement progressed by about 7 mm. And in the case of brass notched tensile specimen model, the maximum load of about 24000 N was observed when the forced displacement progressed by about 6.2 mm. Also, the total deformation and the stress for stainless steel notched tensile specimen model were shown to be about 0.044 mm and about 221.88 MPa, respectively while the total deformation and the stress for aluminum notched tensile specimen model were shown to be about 0.093 mm and 166.42 MPa, respectively. Lastly, in the case of brass notched tensile specimen model, the total deformation and the stress could be affirmed to be about 0.070 mm and about 194.17 MPa, respectively.

According to the results of conducting a notched tensile analysis, the loads were shown to have tendency for gradual increase until the maximum load was observed in the case of aluminum and brass notched tensile specimen models while the loads were shown to be drastically increased until the forced displacement progressed by about 3 mm, followed by having tendency for gradual increase in the case of stainless steel notched tensile specimen model. In all tensile specimen models, rupture occurred at the same time as appearance of the maximum load the loads acting on the specimen models were drastically reduced subsequently.

RECOMMENDATIONS

This study is directed to the tension state in notched specimens for stainless steel, aluminum and brass which are universally used among materials aimed at identification of material property values for heterogeneous and composite materials. It is considered that the data secured through the relevant study can be utilized as the basic data for the investigations to be conducted in the future.

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REFERENCES

Abu-Farha, F., M. Nazzal and R. Curtis, 2011. Optimum specimen geometry for accurate tensile testing of superplastic metallic materials. Exp. Mech., 51: 903-917.

Akbary, F.H., M.J. Santofimia and J. Sietsma, 2014. Elastic strain measurement of miniature tensile specimens. Exp. Mech., 54: 165-173.

Aslani, F., 2013. Effects of specimen size and shape on compressive and tensile strengths of self-compacting concree with or without fibres. Mag. Concr. Res., 65: 914-929.

Bayley, C. and N. Aucoin, 2013. Fracture testing of welded single edge notch tensile specimens. Eng. Fract. Mech., 102: 257-270.

Elambasseril, J., R.N. Ibrahim and R. Das, 2011. Evaluation of fracture characteristics of ceramic coatings on stainless steel substrates using circumferentially notched tensile specimens. Compos. Part B. Eng., 42: 1596-1602.

Katnam, K.B., A.J. Comer, W.F. Stanley, M. Buggy and T.M. Young, 2012. Investigating tensile behaviour of toughened epoxy paste adhesives using circumferentially notched cylindrical bulk specimens. Intl. J. Adhes. Adhes., 37: 3-10.

Komori, K., 2016. Predicting ductile fracture in pure metals and alloys using notched tensile specimens by an ellipsoidal void model. Eng. Fract. Mech., 151: 51-69.

Kumar, K., A. Pooleery, K. Madhusoodanan, R.N. Singh and A. Chatterjee *et al*., 2016. Optimisation of thickness of miniature tensile specimens for evaluation of mechanical properties. Mater. Sci. Eng. A., 675: 32-43.

Lee, J.H. and J.U. Cho, 2016. Evaluation and verification on material strength of specimen with the notches at both sides. J. Korean Soc. Mech. Technol., 18: 759-764.

Ma, Z., H. Zhao, S. Lu, H. Li and C. Liu, 2016. Method for determining the true stress of cross-shaped specimens subjected to biaxial tensile loads. Instrum. Exp. Tech., 59: 287-293.

Ohguchi, K.I. and K. Kurosawa, 2016. An evaluation method for tensile characteristics of Cu/Sn IMCs using miniature composite solder specimen. J. Electron. Mater., 45: 3183-3191.

Perez, A.R.T., D.A. Roberson and R.B. Wicker, 2014. Fracture surface analysis of 3D-printed tensile specimens of novel ABS-based materials. J. Fail. Anal. Prev., 14: 343-353.

Zhang, F., A.F. Bower and W.A. Curtin, 2012a. The influence of serrated flow on necking in tensile specimens. Acta Mater., 60: 43-50.

Zhang, S., Q. Xia and N. Yuan, 2012b. Mechanical characterization of flat specimens in tensile test and numerical simulation. J. Mech. Sci. Technol., 26: 401-409.