Faculty of Science and Mathematics
Universitas Kristen Satya Wacana

Certificate

Award to:

Dr. Eng. I Made Wicaksana Ekaputra

as Presenter

at the 4th International Conference on Science and Science Education (IConSSE) 2021 organized by Faculty of Science and Mathematics-Universitas Kristen Satya Wacana

Salatiga, September 7-8, 2021

Dr. Adi Setiawan, M.Sc.
Dean-Faculty of Science and Mathematics

Dr. Adita Sutresno, M.Sc.
Chairman-The 4th IConSSE 2021

1 Sun, X., Xing, R., Yu, W., Chen, X.

Uniaxial ratcheting deformation of 316LN stainless steel with dynamic strain aging: Experiments and simulation (Open Access)

(2020) *International Journal of Solids and Structures*, 207, pp. 196-205. Cited 7 times.
journals.elsevier.com/international-journal-of-solids-and-structures/
doi: 10.1016/j.ijsolstr.2020.10.017

View at Publisher

2 Kweon, H.D., Kim, J.W., Song, O., Oh, D.

Determination of true stress-strain curve of type 304 and 316 stainless steels using a typical tensile test and finite element analysis (Open Access)

(2021) *Nuclear Engineering and Technology*, 53 (2), pp. 647-656. Cited 28 times.
http://www.kns.org/
doi: 10.1016/j.net.2020.07.014

View at Publisher

3 Ekaputra, I.M.W., Kim, W.-G., Park, J.-Y., Kim, S.-J., Kim, E.-S.

Characterization of the Q* parameter for evaluating creep crack growth rate for type 316LN stainless steel

(2016) *Journal of Mechanical Science and Technology*, 30 (7), pp. 3151-3158. Cited 5 times.
http://www.springerlink.com/content/1738-494X
doi: 10.1007/s12206-016-0625-4

View at Publisher

4 Ekaputra, I.M.W., Kim, W.-G., Park, J.-Y., Kim, S.-J., Kim, E.-S.

Influence of Dynamic Strain Aging on Tensile Deformation Behavior of Alloy 617 (Open Access)

(2016) *Nuclear Engineering and Technology*, 48 (6), pp. 1387-1395. Cited 27 times.
http://www.kns.org/
doi: 10.1016/j.net.2016.06.013

View at Publisher

5 Yang, S., Xue, L., Lu, W., Ling, X.
(2020) *J. Alloys Compd.*, 815, pp. 1-8.

6 Rodriguez, P.

Serrated plastic flow (Open Access)

(1984) *Bulletin of Materials Science*, 6 (4), pp. 653-663. Cited 500 times.
doi: 10.1007/BF02743993

View at Publisher

7 (2021) *Standard Test Methods for Tension Testing of Metallic Materials*. Cited 1546 times.
ASTM E8/E8M-21, ASTM International, West Conshohocken, PA

AIP Conference Proceedings

scitation.org/journal/apc

Volume 2542

The 4th International Conference on Science and Science Education (IConSSE 2021)

Integrating Rapid Technology and Whole Person Education in Science and Science Education to Encounter the New Normal Era

Salatiga, Indonesia • 7–8 September 2021

Editors • Didit Budi Nugroho, Andreas Setiawan, Nur Aji Wibowo, Cucun Alep Riyanto and November Rianto Aminu

AIP Publishing

MENU SIGN IN/REGISTER

AIP Publishing Conference Proceedings

HOME BROWSE MORE

Table of Contents

THE 4TH INTERNATIONAL CONFERENCE ON SCIENCE AND SCIENCE EDUCATION (IConSSE 2021): Integrating Rapid Technology and Whole Person Education in Science and Science Education to Encounter the New Normal Era

PREV NEXT

Conference date: 7–8 September 2021
Location: Salatiga, Indonesia
ISBN: 978-0-7354-4259-7
Editors: Didit Budi Nugroho, Andreas Setiawan, Nur Aji Wibowo, Cucun Alep Riyanto and November Rianto Aminu
Volume number: 2542
Published: Nov 10, 2022

DISPLAY : 20 50 100 all

PRELIMINARY

BROWSE VOLUMES

Table of Contents

THE 4TH INTERNATIONAL CONFERENCE ON SCIENCE AND SCIENCE EDUCATION (IConSSE 2021): Integrating Rapid Technology and Whole Person Education in Science and Science Education to Encounter the New Normal Era

Conference date: 7–8 September 2021
Location: Salatiga, Indonesia
ISBN: 978-0-7354-4259-7
Editors: Didit Budi Nugroho, Andreas Setiawan, Nur Aji Wibowo, Cucun Alep Riyanto and November Rianto Aminu
Volume number: 2542
Published: Nov 10, 2022

PRELIMINARY

CHEMISTRY

No Access . November 2022

Dub Chem Vid module for chemistry topic abstract nature

Muhammad K. A. Ahamad, Nor H. Ibrahim, Johari Surif, Wimbi A. Nursiwan, Chuzairy Hanri, Syarifah Osman, Nina D. Nawi and Corrienna A. Talib

AIP Conference Proceedings **2542**, 020002 (2022); https://doi.org/10.1063/5.0104297

SHOW ABSTRACT

No Access . November 2022

Identification of chemical composition and antibacterial potential of yellow watermelon seed oil (*Citrullus lanatus* L.)

Sri Hartini, Sekar Nurani Saptaningtyas and Hartati Soetjipto

AIP Conference Proceedings **2542**, 020003 (2022); https://doi.org/10.1063/5.0103223

SHOW ABSTRACT

No Access . November 2022

Fingerprint analysis of solvent utilized in *Curcuma longa* and *Curcuma xanthorrhiza* extraction using UV-VIS spectroscopy combined with chemometric

Yohanes Martono and Jodelin Muninggar

AIP Conference Proceedings **2542**, 020004 (2022); https://doi.org/10.1063/5.0103210

SHOW ABSTRACT

No Access . November 2022

Surface analysis of activated carbon from rice husk based on carbonization and activation method

Cucun A. Riyanto, Alvama Pattiserlihun, Ezra Kurniawan, Blessy Y. Andiani and Fahmi P. Perdani

AIP Conference Proceedings **2542**, 020005 (2022); https://doi.org/10.1063/5.0103325

SHOW ABSTRACT

No Access . November 2022

Chemical composition and profile characterisation of wax gourd (*Benincasa hispida* (Thun.) Cogn.) seed oil

Hartati Soetjipto

AIP Conference Proceedings **2542**, 020006 (2022); https://doi.org/10.1063/5.0103258

SHOW ABSTRACT

COMPUTER SCIENCE AND TECHNOLOGY

BROWSE VOLUMES

SHOW ABSTRACT

No Access . November 2022

Tensile behavior of austenitic stainless steel 316L(N) at high temperatures: A preliminary study

I. Made Wicaksana Ekaputra

AIP Conference Proceedings **2542**, 050005 (2022); https://doi.org/10.1063/5.0103550

SHOW ABSTRACT

No Access . November 2022

The effect of multiple changes in motor parameter values simultaneously on the PMSM speed sensorless control system

Bernadeta Wuri Harini

AIP Conference Proceedings **2542**, 050006 (2022); https://doi.org/10.1063/5.0103207

SHOW ABSTRACT

No Access . November 2022

Evaluation of TLD position in eye lens dosimeter Hp(3) using 3D printed head phantom

Amalia A. Inayah, Betty Rahayuningsih, Kardianto, Fakhrusy R. Ramadhan, Anthonia W. Pitaloka and Endarko

AIP Conference Proceedings **2542**, 050007 (2022); https://doi.org/10.1063/5.0103193

SHOW ABSTRACT

No Access . November 2022

Development of measuring quality to Buffalo's meat in Toraja

Wilson Jefriyanto, Benyamin Salu, Ishak Pawarangan and Welsiliana

AIP Conference Proceedings **2542**, 050008 (2022); https://doi.org/10.1063/5.0103438

SHOW ABSTRACT

No Access . November 2022

Feasibility study of Samarium-153 production by secondary fast neutron bombardment

Imam Kambali and Isdandy R. Febrianto

AIP Conference Proceedings **2542**, 050009 (2022); https://doi.org/10.1063/5.0104756

SHOW ABSTRACT

BROWSE VOLUMES

Tensile behavior of austenitic stainless steel 316L(N) at high temperatures: A preliminary study

Cite as: AIP Conference Proceedings **2542**, 050005 (2022); https://doi.org/10.1063/5.0103550
Published Online: 10 November 2022

I. Made Wicaksana Ekaputra

Tensile Behavior of Austenitic Stainless Steel 316L(N) at High Temperatures: A Preliminary Study

I Made Wicaksana Ekaputra[a)]

Universitas Sanata Dharma, Paingan, Maguwoharjo, Depok, Sleman, Yogyakarta 55282, Indonesia

[a)]Corresponding author: made@usd.ac.id

Abstract. Austenitic stainless steel 316 L(N) behaviour due to tension load at elevated temperatures must be considered since the abnormal strain hardening may not be predicted. The abnormal strain hardening at the plastic region may appear with various type of serrated yielding. In this study, the austenitic stainless steel 316 L(N) was investigated under tension load for various temperature with the range of 24 ºC–655 ºC at 10^{-5}/s of deformation rate. The specimens are cylindrical, following the ASTM standard. During the test, the thermocouple was attached to the surface of the specimen. In this preliminary study, the results were to obtain the area of serrated yielding that occurred from the ultimate tensile strength, yield strength, and constant material values of flow relationship.

INTRODUCTION

The austenitic stainless steel 316L(N) or 316 L(N) SS has been investigated comprehensively for application in a high-temperature environment [1–3]. This alloy is still an option for the component in the power plant due to its beneficial features such as good resistance to high-temperature environment, suitable with particular coolant, and appropriate weldability. Since this steel is applied in a harsh environment, several laboratory examinations for high-temperature testing are still being investigated. The basic properties of the tensile test at high-temperature condition must be obtained before further testing.

It has been reported that a particular temperature and deformation rate conditions, the phenomenon of serrated yielding occurred due to tension load. The serrated yielding phenomenon, also known as dynamic strain ageing (DSA) or Portevin-Le Chatelier (PLC) effect, was related to the hardening process where mobile dislocation associates with the diffusing solute atom [4–6]. The serrated yielding region may be indicated by the curve trend of ultimate and yield strength, work-hardening parameters, and ductility [6]. The curve trend of the serrated yielding region can be manifested as presented in Fig. 1. The serrated yielding region for several alloys was found in the plastic region at an intermediate temperature [4].

In this study, the 316 L(N) SS was investigated under various temperature conditions at 10^{-5}/s of deformation rate. The occurrence of serrated yielding was determined based on the plateau occurrence on the ultimate tensile strength, yield strength, and parameters curves of flow relationships. Finally, the serrated yielding area for the 316 L(N) SS at 10^{-5}/s of deformation rate can be determined from these preliminary results.

EXPERIMENTAL PROCEDURE

The tensile test specimen had a cylindrical form with a diameter of 6 mm and a gauge length of 30 mm. All specimens were manufactured in the rolling direction, as shown in Fig. 2. For the final preparation, the specimens were polished along the surface with #2000-grit sandpaper. All of the specimen preparations followed the ASTM E8 [7].

The 4th International Conference on Science and Science Education (IConSSE 2021)
AIP Conf. Proc. 2542, 050005-1–050005-8; https://doi.org/10.1063/5.0103550
Published by AIP Publishing. 978-0-7354-4259-7/$30.00

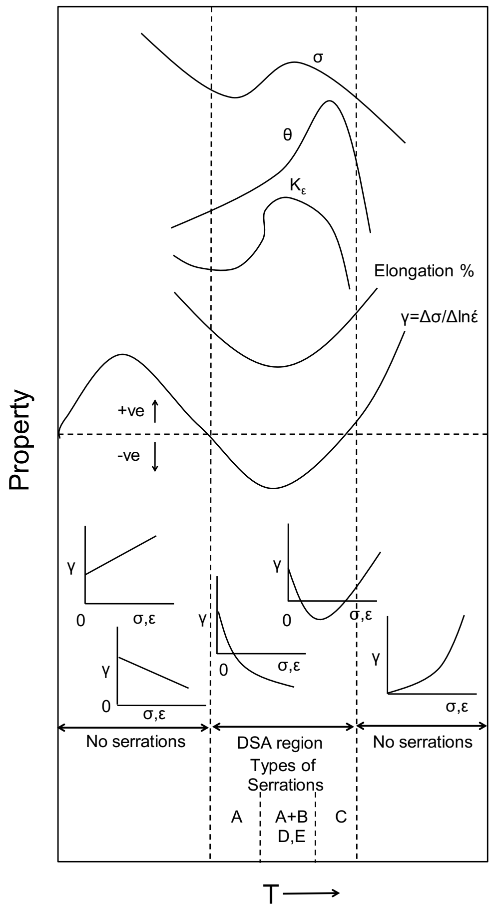


FIGURE 1. Several manifestation to determine the serrated yielding region [6].

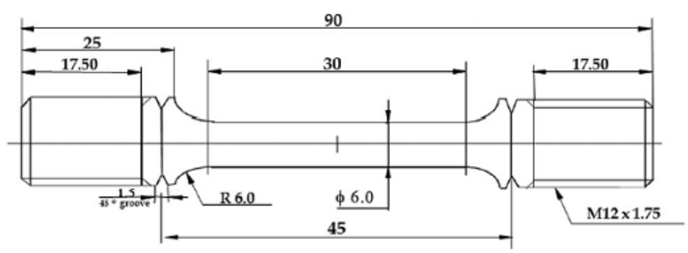


FIGURE 2. Cylindrical specimen for tensile test

The tension test was conducted at various temperatures ranging from 24 ºC to 655 ºC and a deformation rate of 10^{-5}/s. The tension test followed the ASTM E21 [8] for the tensile test at high temperature. The tensile test was conducted using a universal testing machine with a capacity of 50 kN. The test was controlled via a data acquisition card embedded in the PC and connected to the test machine. The deformation rate was entered in the control programme in PC with the value of 10^{-5}/s. The cylindrical specimen was put at the centre of the furnace in line with the load direction. The thermocouple was attached to the specimen surface with the temperature control range within ± 3 ºC. The elongation was measured from the displacement of the crosshead movement of the machine. After conducting the test, the tensile data were evaluated and discussed.

RESULTS AND DISCUSSION

A typical curve of engineering stress-strain for 316 L(N) SS was shown in Fig. 3. It can be seen that under a particular temperature, the serrated yielding appears very clearly. It is seen that serrated yielding started at 510 ºC to 655 ºC. However, the serrated yielding regions must be determined carefully from several manifestations, as explained in Fig. 1. It is also seen that all of the curves shows the strain hardening process for all temperatures. For particular alloy, it has been reported that the softening process could have occurred at high temperature [4]. In this preliminary discussion, the serrated yielding will be determined based on the ultimate tensile strength (UTS) and yield strength (YS) curve. In addition, the serrated yielding region will also be determined from the parameter value curve of flow relationships.

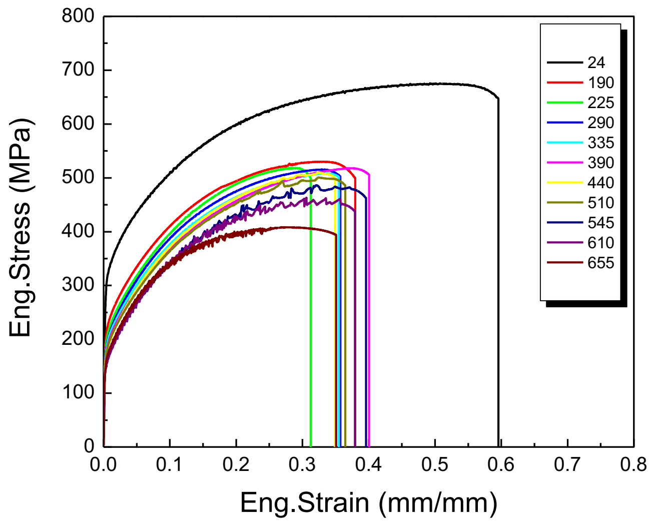


FIGURE 3. Engineering stress-strain curve for 316 L(N) SS

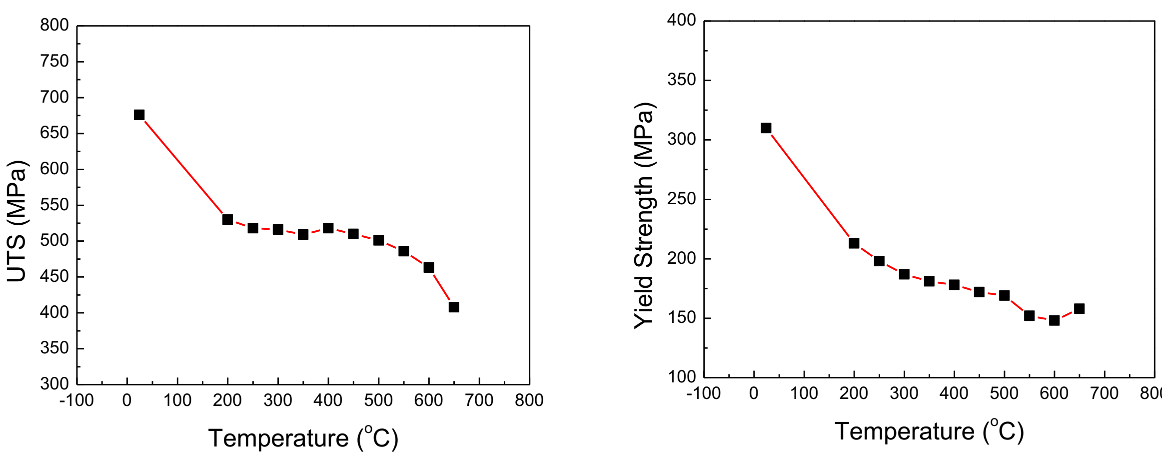


FIGURE 4. Tensile properties of 316 L(N) SS (a) ultimate tensile strenght; (b) yield strength

Based on the engineering stress-strain curve, the UTS and YS curve are presented in Fig. 4. Both UTS and YS almost show a similar curve trend, where the values are decreased with an increase in temperature. The recovery occurrence can simply explain it at a higher temperature. A significant decrease starts at 190 ºC and a bit of drop to 655 ºC. A gradual decrease makes the curve plateau alike. It has been reported that plateau alike indicated the serrated yielding occurrence [4]. It is also suitable with the curve trend shown in Fig. 1.

Another serrated yielding region is determined from the trend of flow relationship constant values. The constant material values are obtained by applying suitable flow relationship from five flow relationships; Ludwigson, Hollomon, Ludwik, Swift, and Voce. It has been reported that these five flow relationship had described the serrated yielding region very satisfactorily [4].

Fig. 5 shows a typical true stress-strain curve in a double-logarithmic scale for 316 L(N) SS. All curves are at the plastic region after passing the yielding strength. It is seen that a significant gap is formed between 24 °C and 190 °C. While the curves with the temperature range of 190 °C to 655 °C are stacked to each other. Five flow relationships are fitted to each temperature range, as shown in Figa. 6a–6c. The Ludwik shows the goodness fit lines with the R^2 (coefficient of determination) value has the closest value to 1. The Ludwik flow relationship is expressed with the following equation:

$$\sigma = \sigma_0 + K_L \varepsilon^{n_L}, \tag{1}$$

where σ_0 is constant stress, K_L is a strain hardening coefficient, and n_L is a strain hardening exponent. The constant material values of the Ludwik equation are presented in the curved line, as shown in Fig. 7. It can be seen that the trend of all material constants shows a similar trend. However, the values of K_L and n_L are decreasing significantly at 655 °C. It has been reported that a decreasing value was caused by the change of slip and dislocation mechanism [4].

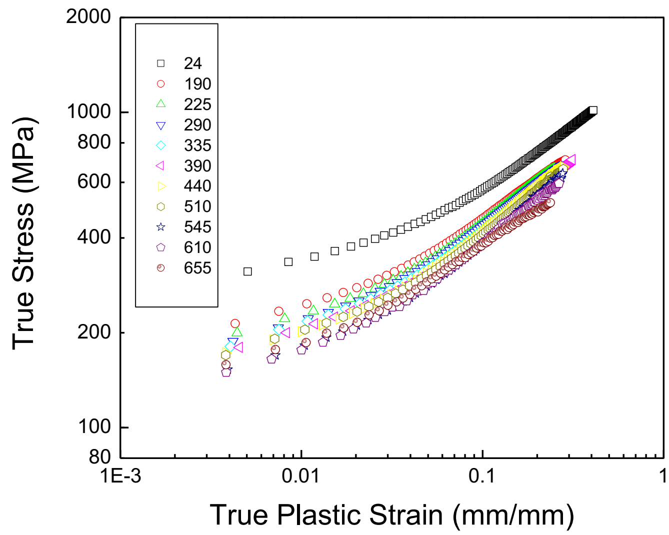


FIGURE 5. True stress-strain cuve of 316 L(N) SS

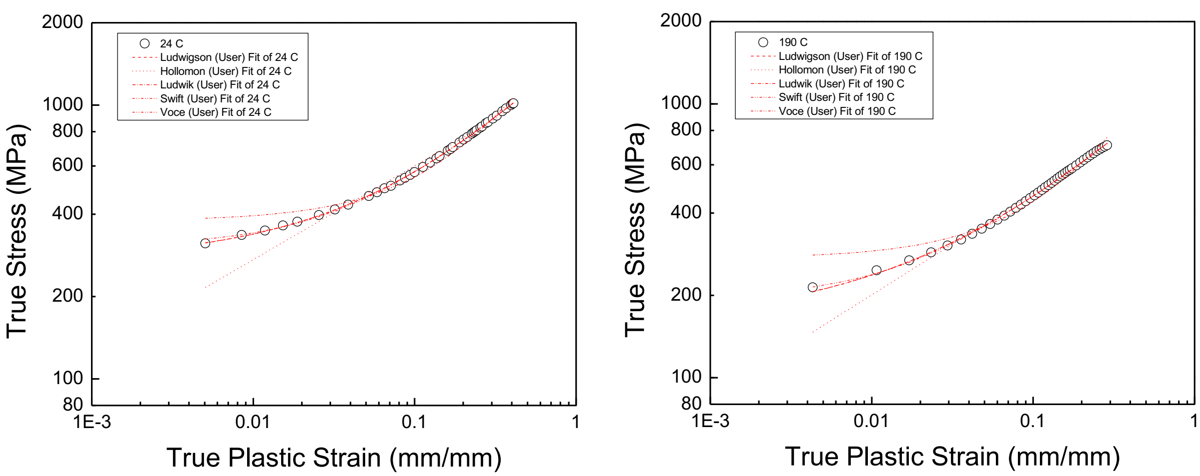


FIGURE 6a. The fitted line of five flow relationships to each temperature condition of true stress-strain curve.

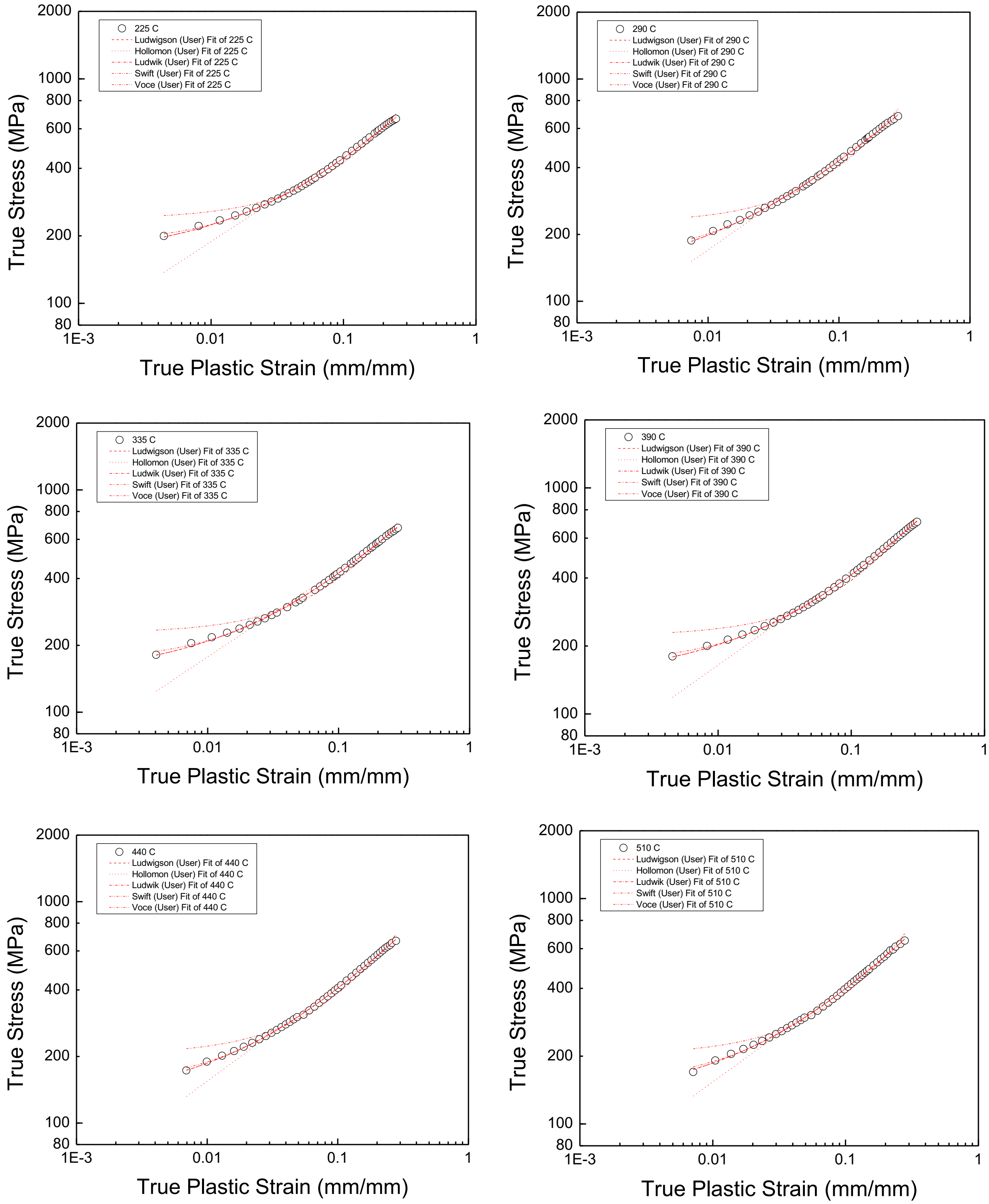


FIGURE 6b. The fitted line of five flow relationships to each temperature condition of true stress-strain curve.

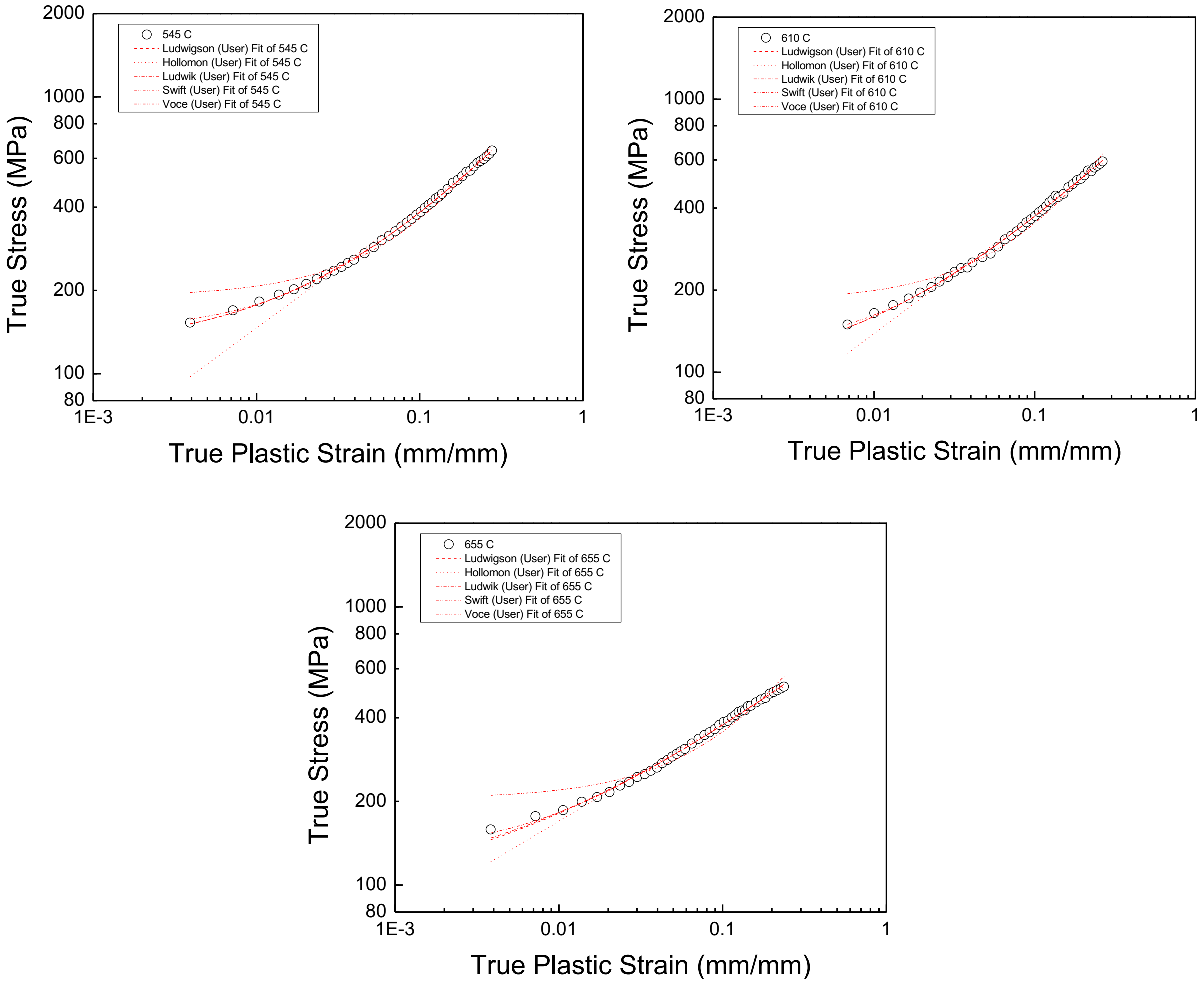
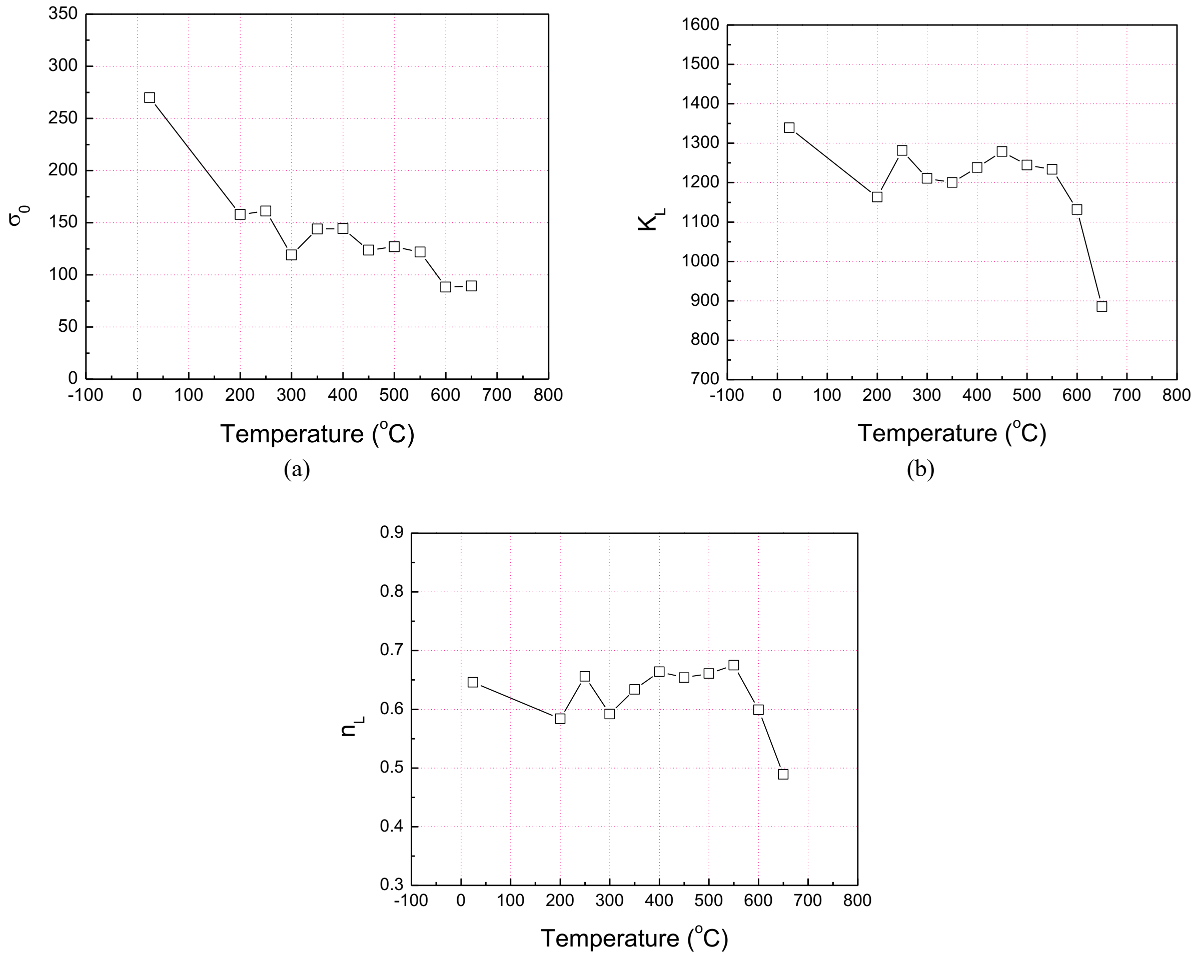


FIGURE 6c. The fitted line of five flow relationships to each temperature condition of true stress-strain curve.



(c)

FIGURE 7. Ludwik constant material: (a) constant stress, (b) strain hardening coefficient, and (c) strain hardening exponent.

CONCLUSION

The determination of serrated yielding region became essential to make sure the exact characteristic of 316 L(N) SS prior used. In this preliminary study, the serrated yielding region was determined well by three manifestations curve: ultimate tensile strength, yield strength, and constant material of Ludwik's equation. The serrated yielding began at the temperature of 190 ºC. It was also found that there was a change of serrated yielding mechanism at 655 ºC. Further investigation is needed to determine the serrated yielding mechanism due to slip and dislocation under various elevated temperatures and deformation rates.

ACKNOWLEDGMENTS

This study was supported and grant funded by LPPM Universitas Sanata Dharma Yogyakarta.

REFERENCES

1. X. Sun, R. Xing, W. Yu, and X. Chen, Int. J. Solid Struct. **207**, 196–205 (2020).
2. H. D. Kweon, J. W. Kim, O. Song, and D. Oh, Nucl. Eng. Technol. **53**, 647–656 (2021).
3. I. M. W. Ekaputra, W. G. Kim, J. Y. Park, S. J. Kim, and E. S. Kim, J. Mech. Sci. Technol. **30**, 3151–3158 (2016).

4. I. M. W. Ekaputra, W. G. Kim, J. Y. Park, S. J. Kim, and E. S. Kim, Nucl. Eng. Technol. **48**, 1387–1395 (2016).
5. S. Yang, L. Xue, W. Lu, and X. Ling, J. Alloys Compd. **815**, 1–8 (2020).
6. P. Rodriguez, Bull. Mater. Sci. **6**, 653–663 (1984).
7. ASTM E8/E8M-21, *Standard Test Methods for Tension Testing of Metallic Materials*, ASTM International, West Conshohocken, PA (2021).
8. ASTM E21-20, *Standard Test Methods for Elevated Temperature Tension Tests of Metallic Materials*, ASTM International, West Conshohocken, PA (2020).