UNIVERSITI TEKNOLOGI MARA

University Publication Centre (UPENA)

ESTEEM

Academic Journal UiTM Pulau Pinang

Volume 5, Number 1 June 2009 ISSN 1675-7939

Esteem Academic Journal is jointly published by the Universiti Teknologi MARA, Pulau Pinang and University Publication Centre (UPENA), Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia.

The views, opinions and technical recommendations expressed by the contributors and authors are entirely their own and do not necessarily reflect the views of the editors, the Faculty or the University.

ESTEEM

Academic Journal UiTM Pulau Pinang

Volume 5, Number 1 June 2009 ISSN 1675-7939

Foreword

Alhamdulillah. First of all a big thank you and congratulations to the Editorial Board of *Esteem Academic Journal* of Universiti Teknologi MARA (UiTM), Pulau Pinang for their diligent work in producing this issue. I also would like to thank the academicians for their contributions and the reviewers for their meticulous vetting of the manuscripts. A special thanks to University Publication Centre (UPENA) of UiTM for giving us this precious opportunity to publish this first issue of volume 5. In this engineering issue we have upgraded the standard of the manuscript reviewing process by inviting more reviewers from our university as well as other universities in Malaysia. We have embarked from previous volume to establish a firm benchmark and create a journal of quality and this current issue remarks a new height of the journal quality. Instead of publishing once in every two years, now *Esteem* publishes two issues annually.

In this issue, we have compiled an array of 13 interesting engineering research and technical based articles for your reading. The first article is entitled "The Response of Tube Splitting on Circular Tubes by Using Various Types of Semi-angles Dies and Slits". The authors, Mohd Rozaiman Aziz and Roslan Ahmad investigated the axial splitting and curling behavior of aluminum circular metal tubes which was compressed axially under static loading using three types of dies with different semi-angles. The authors concluded that the introduction of slit to the specimen is necessary to initiate slitting rather than inversion.

Salina Budin, Aznifa Mahyam Zaharudin, and Sugeng Priyanto presents a model of energy conversion and impact energy generation during collision based on free falling experiment, which is closely resembles direct collision between ball and inner wall of the vial. Simulation results from the proposed impact energy model demonstrated that the impact energy generated during the collision is strongly influenced by the thickness of the work materials and reaches zero at certain value of the work materials thickness, which increases with an increase of falling height.

Salina Alias, Caroline Marajan and Mohamad Azrul Jemain wrote an article that looks at adsorption of zinc from waste water using bladderwort (*Utricularia vulgaris*). In batch adsorption studies, data show that dried bladderwort has considerable potential in the removal of metal ions from aqueous solution. The fourth article written by

Muhammad Khusairi Osman et al. looked at 3D object recognition using affine moment invariants and Multiple Adaptive Network Based Fuzzy Inference System (MANFIS). The experimental results show that Affine Moment Invariants combined with MANFIS network attain the best performance in both recognitions, polyhedral and free-form objects.

The article entitled "Construction Waste Management Methods Used by Contractors in the Northern Region" authored by Siti Hafizan Hassan, Nadira Ahzahar and Mohd Nasrul Nizam Nasri reports an ongoing study on the use of construction waste management methods by contractors and its impact on waste reduction in the Northern Region. In conclusion, the sizing and amount of materials to be ordered to reduce wastage is significant in reducing construction waste generation waste, alleviating the burden associated with its management and disposal. The sixth article by Muhammad Sofian Abdullah et al. examined on the performance of Performance of Palm Oil Fuel Ash (POFA) with lime as stabilizing agent for soil improvement. The authors concluded that POFA can be used to treat the silty soil as well as to reduce the environmental problem.

The seventh article penned by Soffian Noor Mat Saliah, Noorsuhada Md. Nor and Megat Azmi Megat Johari presents the results of an experimental study on the interfacial bond strength (IBS) of polypropylene fiber concrete (PFC). It was found that the interfacial bond strength between concrete and reinforcement bar was not affected by the inclusion of polypropylene fibers. However, concrete containing fibers exhibited no breaking of concrete and no debonding of reinforcement. The article by Juliana Zaabar and Rusnani measures, evaluates and analyzes the network link performance of fiber optic cable using OTDR. The authors suggested that the major loss for these measurements is connector loss. Preventive maintenance will increase the life time of fiber optic. From some of the findings, the PVC dust cap has been identified as a main source of contamination for the SC connector.

The article entitled "Symbolic Programming of Finite Element Equation Solving for Plane Truss Problem" by Syahrul Fithry Senin proposed a plane truss problem to be solved by finite element method using MAPLE 12 software. The numerical solution computed by the author was almost matched with the commercial finite element software solution, LUSAS. The tenth article by Nor Azlan Othman, Nor Salwa Damanhuri and Visakan Kadirkamanathan presents a detail review of fault diagnosis in rotating machinery using pattern recognition technique. The authors proposed a solution based on artificial neural network (ANNs) which is Multi-Layer Perceptron (MLP). The authors concluded that the proposed methods are suitable for rotating machinery on fault detection and diagnosis.

The eleventh article is entitled "RAS Index as a Tool to Predict Sinkhole Failures in Limestone Formation Areas in Malaysia". Damanhuri Jamalludin et al. found that, using the RAS classification method, the prediction of sinkhole occurrences can be easily be made by simply knowing the weekly rainfall especially in areas having limestone as the bedrock. The twelfth by Muhammad Hafeez Osman et al. explores cases regarding the histories of rock slope repair and stabilization of unstable boulder along the road from Bukit Cincin to Genting Highland and along the road from Gap to Fraser Hill. The last article is "Soil Nail and Guniting Works in Pahang". The authors, Damanhuri Jamalludin et al. concluded that if the stability of the embankment needs to be improved, soil nails can be installed and embankment surface can be covered with gunite to prevent erosion.

We do hope that you not only have an enjoyable time reading the articles but would also find them useful. Thank you.

Mohd Aminudin Murad
Chief Editor
Esteem, Vol. 5, No. 1, 2009
(Engineering)

Esteem Academic Journal *Vol. 5, No. 1, 1-10, 2009*

The Response of Tube Splitting on Circular Tubes by Using Various Types of Semi-Angles Dies and Slits

Mohd Rozaiman Aziz
Faculty of Mechanical Engineering
Universiti Teknologi MARA (UiTM), Malaysia
Email: man@ppinang.uitm.edu.my

Roslan Ahmad
Universiti Sains Malaysia, Pulau Pinang
Email: roslan@eng.usm.my

ABSTRACT

This paper investigates the axial splitting and curling behavior of aluminium circular metal tubes which was compressed axially under static loading. An experimental investigation was carried out by using three types of dies with different semi-angles, α which was 45°, 60° and 75°. To ease the splitting process, the tube was introduced with 4 and 6 slits with the length of 5 mm at the leading edge of the tube. The slit prevents the tubes from buckling and establishes the split and curl mode during the compression process. The effects depending on the number of slits and the different semi-angles, a employed are presented in this paper.

Keywords: *Axial loading, curling, semi-angles, slits*

Introduction

It is a common fact that during impact, energy is produced. The energy can be absorbed by deforming structural members such as axial loading, lateral indentation, lateral flattening, axial crushing and axial splitting. Basically, the energy absorbed is dissipated by various failure mechanisms

ISSN 1675-7939

such as plastic deformation and fracture of tearing. Splitting mode of deformation is a special case of tube inversion where the die radius is large enough to cause splitting instead of inversion.

Stronge, Yu and Johnson (1983) conducted a study of square aluminium that pressed over die whereby the square aluminium tubes were split at corners and curled outwards in quasi-static loading. An experiment on the effect of die radius showed that a remarkably constant force causes rate independent deformation in tubes. Stronge et al. (1983) suggested that square aluminium tubes, which experienced both split and curled conditions, could be designed for energy absorbing systems.

Reddy and Reid (1986) investigated the tube splitting of aluminium and mild steel tubes compressed onto die radius of 4 mm, 6 mm and 10 mm under quasi-static loading. From this research, Reddy and Reid (1986) concluded that compared to axial loading and tube inversion, the operating load for tube splitting was lower. The advantages of tube splitting are the flat load deflection characteristics and that it can be operated successfully with a wide range of tube properties and die geometries, which can not be achieved together by axial loading and tube inversion under similar loading condition.

Huang, Lu and Yu (2002) carried out a study into energy absorbing behavior of axially splitting square metal tubes under quasi-static loading. The observation obtained was in energy dissipating system, there were three components i.e., tearing energy, plastic deformation and frictional energy. On top of that, Huang et al. (2002) stated that tubes that are both split and curled may be efficient by increasing the stroke energy absorbing devices, which is much related to the claim made by Stronge, Yu and Johnson (1983).

In conclusion, even though tube splitting has the potential to be applied as an energy absorbing devices, not much work has been carried out to fully understand the mode of deformation and parameter that affect the energy capabilities of the tube. Hence, the effect of the number of slits and semi-angle die are highlighted in the present study whereby the energy absorbing capabilities are influenced by these factors.

Experimental Details

In this section, the details of the preparation of specimen and die are revealed, followed by the axial compression set-up.

Specimen and Die Preparation

Initial preparation for the specimen in tube splitting such as cutting, end turning and stress relief were involved. The length of aluminium tube was chosen as 200 mm since a larger stroke is needed for the tube to split and slide along the die. For tube splitting, a die with three different semi-angles, namely α at 45°, 60° and 75°, was employed. The die was made of mild steel. Schematic drawing of die with semi-angle of 45° is shown in Figure 1 (all dimensions in mm) and a photograph of actual dies used in the experiment is presented in Figure 2. Figure 3 shows the flow chart of the specimen and die preparation for tube splitting.

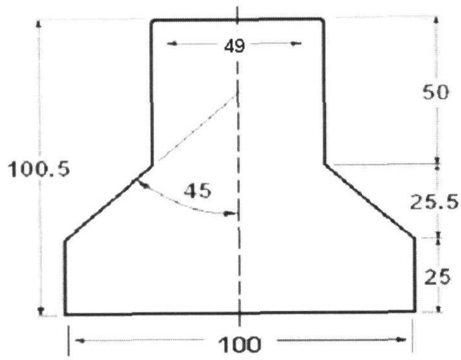
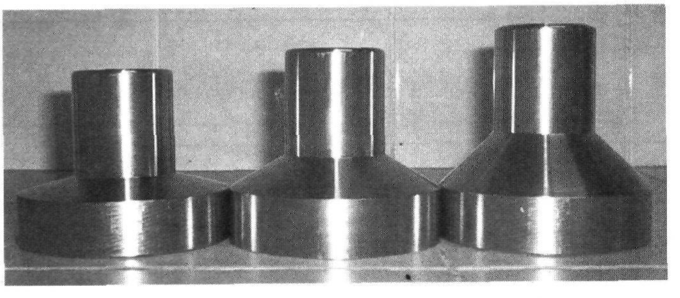


Figure 1: Schematic Diagram of Splitting Die for 45° Semi-Angle



(a) (b) (c)

Figure 2: Photograph of Splitting Die: (a) 75° Semi-Angle (b) 60° Semi-Angle (c) 45° Semi-Angle

Axial Compression Set-Up

The specimen was snugly fitted to the shank of the die. The die together with the specimen was placed between the two platens of universal testing machine. The crosshead speed of universal testing machine was set to 0.0833 mm/s to comply with the static loading. As the compression proceeds, the load-displacement curve response of the specimen was automatically registered, plotted and saved.

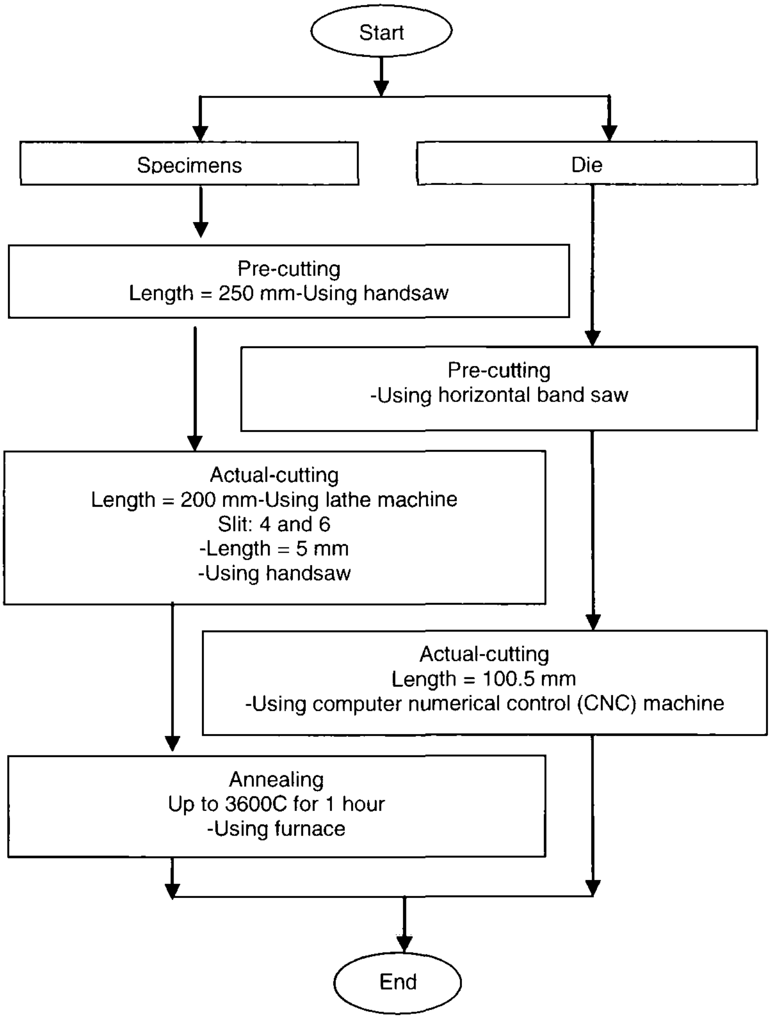


Figure 3: Flowchart of Tube and Die Preparation for Tube Splitting

Results and Discussion

The results obtained from applied force-compression curve and the modes of deformation are discussed.

Applied Force-compression Curve

Typical applied force-displacement traces for three different cases ($\alpha = 45^{\circ}$, 60° and 75°) for 4 and 6 initial slits are shown in Figures 4 and 5 respectively. In each case, the force initially increased linearly to a peak, which corresponded to initiation of 4 or 6 cracks. After that, the load decreased rapidly as the cracks propagated along the tube by ductile tearing. The splitting sides then began to roll into curls. With increasing plastic deformation, the load again increased. Eventually, the curls formed with a constant radius as the plastic bending and load had reached a steady state. Similar pattern of applied force-compression curve was observed by Huang et al. (2002) as shown in Figure 6.

The peak load is tabulated in Table 1. In the case of 4 slits, the peak load increased as the semi-angle changed from 45° to 75°. The same pattern was observed when a die with 6 slits was employed. It can be concluded that the peak load increased when the die becomes steeper. It is because in order to start the bending, stretching and tearing process, a higher load is required for a steeper die compared to a less steep die. It is believed that if the tube has been pre-formed, the peak load will become less. The finding of this study is also backed up by Huang et al. (2002) who confirmed similar result.

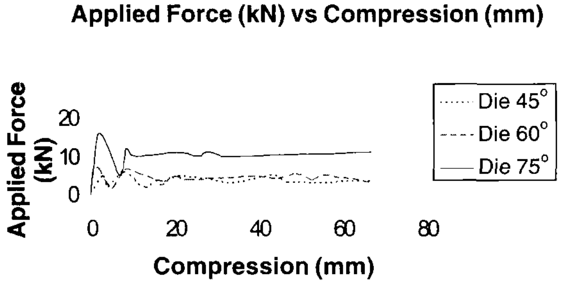


Figure 4: Applied Force-Compression Curves for 4 Initial Slits with Various Semi-Angle Die

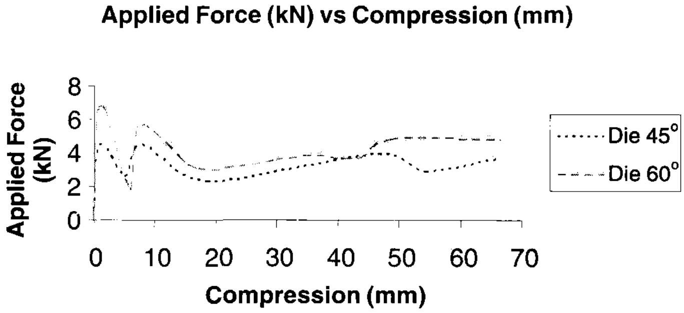


Figure 5: Applied Force-Compression Curves for 6 Initial Slits with Various Semi-Angle Die

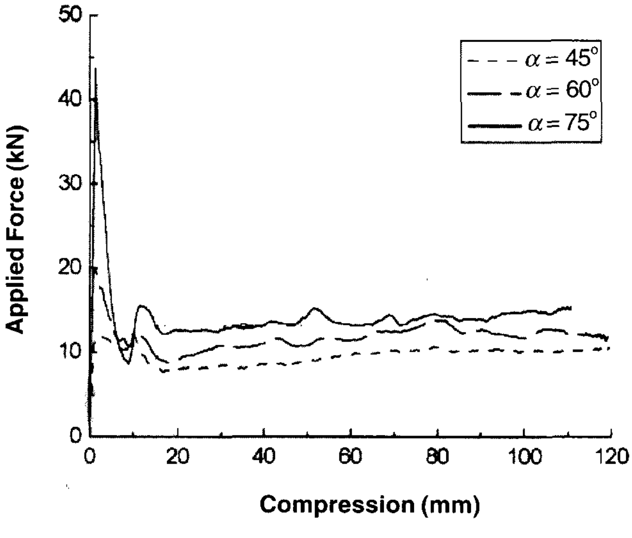


Figure 6: Applied Force-Compression Curves for Mild Steel Tubes (Huang et al., 2002)

Table 1: Peak Load and Mean Load for Respective Slit and Semi-Angle Die

Initial saw cuts	Semi-angle α (°)	Peak load (kN)
4	45	4.6
	60	6.9
	75	16.1
6	45	4.5
	60	6.7

Modes of Deformation

Figures 7 and 8 show the modes of deformation for both tubes with 4 and 6 initial slits, respectively after compression. At the beginning of the compression process, the strips between initial slits buckled and flared as guided by the respective die, which led to the circumferential stretching of the tube. After a certain level has been reached, cracks occur at some initial slits locations and they are propagated along the axial due to continuous ductile tearing. Strips are formed as cracks roll up into curls because of the strips ends which are free to bend themselves. Then, after these curls have completed one revolution, the front edges of the curls contacts the wall of the tube. Even though initially a number of 4 slits are introduced to initiate the split, eventually the split increases in number. For 45° die, the number of split remained 4 after the compression, whereas the 60° die resulted in a number of 6 splits instead of 4 splits. The 75° die resulted in a number of 4 splits with slight tearing and merging of the cracks.

For a specimen with 6 initial slits, the number of slits remained the same as the deformation progressed. There was no merging or branching that took place when it is compressed on a die with a semi angle of 45° and 60°. The type of failure mode observed with respect to the number of slit and semi angle die is summarized in Table 2. Similar observation was also observed by Huang et al. (2002) when testing mild steel tubes with 8 slits. Their specimen as shown in Figure 9 also experienced merging or branching.

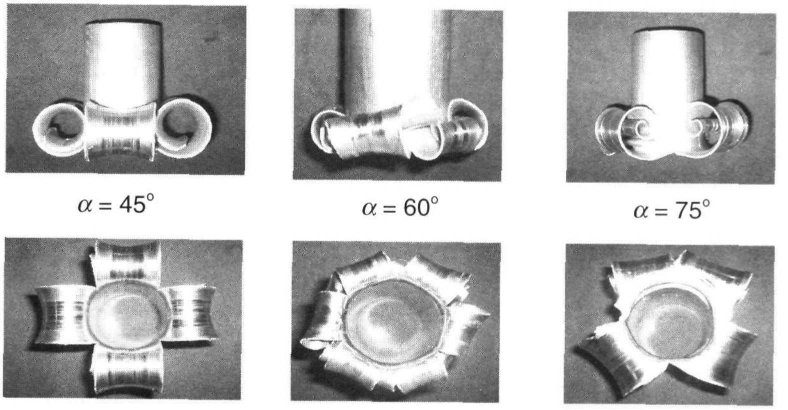


Figure 7: Deformation Mode for Tube Splitting with Initial 4 Slit

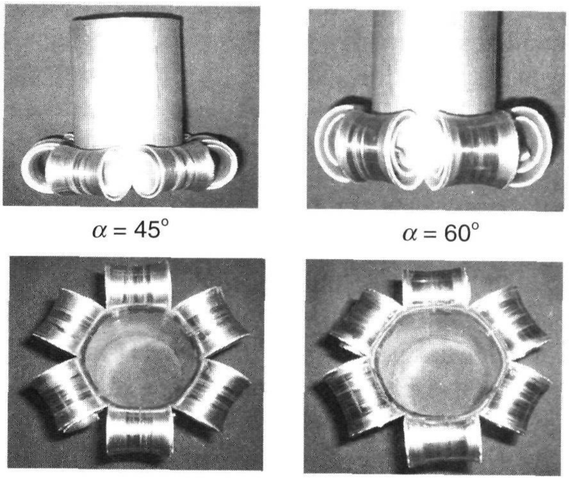


Figure 8: Deformation Mode for Tube Splitting with Initial 6 Slit

Table 2: Number of Splits Before and After Test

Semi-angle die	Number of split		Remarks
	Before test	After test	
45°		4	Number of slits remained
60°	4	6	Number of slits branched
75°		4	Number of slits remained with slight tearing and merging
45°	6	6	Number of slits remained
60°		6	Number of slits remained

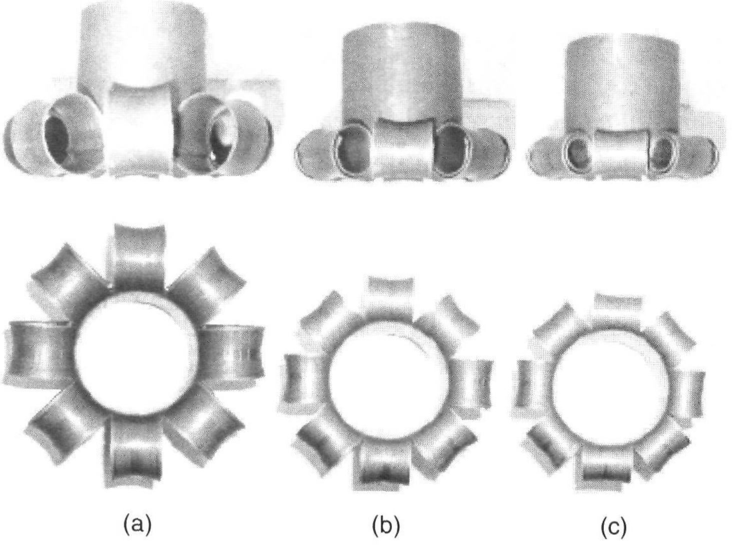


Figure 9: Mild Steel Tubes after Compressed Onto: (a) 45° (b) 60° (c) 75° Semi Angle Die (Huang et al., 2002)

Conclusion

The introduction of slit to the specimen was necessary to initiate slitting rather than inversion. The load-displacement curve initially increased linearly to a peak, which corresponded to the initiation of cracks and then decreased rapidly as the cracks propagated along the tube by ductile tearing. The mode of deformation involves the process of bending, stretching, tearing and curling or rolling. For a specimen with 4 initial saw cuts, the number of slits remained except for semi angle die of 60° which branched into 6 splits. For a specimen with 6 initial saw cuts, the effect of semi angle die was insignificant. The number of slits remains the same after compression. The mean load was proportional to the semi angle die.

References

Alghamdi (2001). Collapsible impact energy absorbers: An overview. *Thin-Walled Structures, 39*, 189-213.

Atkins, A. G. (1987). On the numbers of cracks in the axial splitting ductile metal tubes. *International Journal of Mechanical Sciences, 29*(2), 115-121.

Huang, X., Lu, G., & Yu, T. X. (2002). On the axial splitting and curling of circular metal tubes. *International Journal of Mechanical Sciences, 44*, 2369-2391.

Lu, G., Ong, L. S., Wang, B., & Ng, H. W. (1994). An experimental study on tearing energy in splitting square metal tubes. *International Journal of Mechanical Sciences, 36*(12), 1087-1097.

Mamalis, A. G., Manolakos, D. E., Demosthenous, A. G., & Ioannidis, M. B. (1997). Experimental determination of splitting in axially collapsed thick-walled fibre-reinforced composite frusta. *Thin-Walled Structures, 28*, 279-296.

Reddy, T. Y., & Reid, S. R. (1986). Axial splitting of circular metal tubes. *International Journal of Mechanical Sciences, 28*(2), 111-131.

Reid, S. R. (1993). Plastic deformation mechanisms in axially compressed metal tubes used as impact energy absorbers. *International Journal of Mechanical Sciences, 35*(12), 1035-1052.

Stronge, W. J., Yu, T. X., & Johnson, W. (1983). Long stroke energy dissipation in splitting tubes. *International Journal of Mechanical Sciences, 25*(9~10), 637-647.