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Mixed-Adhesive Technique on Joint Strength of Torque Loaded Tube Optimization

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Adhesive bonded joint tubular shape are widely used in the aerospace and automotive industries. However, the literature study showed that the stress distribution at the joint, when loaded, is not evenly distributed and creates stress concentration at the edges. The strength and lifetime of adhesive bonded joints can be significantly improved by reducing the stress concentration at the edges. Attempts have been made by researchers to improve the joint design so that the stress would be more evenly distributed and minimize stress concentration, however, the improvement has been very limited. In this work, a parameter study has been performed to observe the properties of adhesive joint of torque loaded tube. Based on the observation, a new type called mixed-adhesive technique is proposed which successfully reduces the stress concentration at the edge during torque loading. This method successfully increase safety factor to be 18.75 % and 83.88%, respectively compared to the use of brittle alone and ductile adhesives alone.

Keywords : *mixed-adhesive technique, torque loaded tube, stress distribution, finite element method, joint design*

ORAL SESSION SCHEDULE OF IJJSS 2010

Day 1 (September 29, 2010)

Room A

Session	Room A			
	Field	No	Presenter	Title
session 1 (13.30 - 15.30)	Mobile Communication	1	Gunawan Wibisono	Design of Microstrip Branch Line Coupler with T-Junction for Mobile WiMAX at Frequency of 2,3 GHz
	Antenna	2	Basari	Implementation of Antenna System for Land Vehicle Mobile Satellite Application under Real Environment
		3	Toshihiro Kumagai	A small 915MHz receiving antenna for wireless power transmission aimed at medical applications
		4	Fitri Yuli Zulkifli	Mutual Coupling Reduction for MIMO Microstrip Antenna
		5	Mangasi Napitupulu	Compact Dual Band Inverted-F Antenna for 2.3GHz and 3.3GHz WiMAX Application
session 2 (15.45 - 17.45)	Microelectronic	1	Andi Yusuf	Design and Implementation of a RC4 and Chaotic Crypto Processor and Its Application for Data Encryption
		2	Pandung Sarungallo	Sandwiching of ZnO Layer between poly-Si Layers for Extending the Horizontal Dimension of 2.3 GHz Resonant Suspended Gate (RSG)
		3	Sunaryo	Design of Square-ring shaped contour-mode piezoelectric MEMS resonator for oscillator WiMAX frequency 2.3 GHz
	Antenna	4	Disra Agifral	Simulation of Wavelength Division Multiplexing Based on Mach-Zehnder Interferometer Structure with Wavelengths of 1.53033µm, 1.53977µm, and 1.54932µm
		5	Muhammad Hasan Sirojuddiin	A Very High-Speed and Efficient-Area of BCH Decoder Using Modified Direct Solution Algorithm

Room B

Session	B			
	Field	No	Presenter	Title
session 1 (13.30 - 15.30)	Envi. Science	1	Ratih Fitria Putri	Land Use Priority Assessment Based on Evaluation of Land Capability, Landslide Hazard and Population Pressure on Agriculture Land Analysis in Blukar, Bodri, and Blorong Watersheds; Central Java Indonesia
		2	Ratih Fitria Putri	Feasibility Analysis of Fresh Water Condition in Mangunan Village - Dlingo Subdistric After Earthquake Bantul May 2006
		3	Miga Magenika Julian	Simulation of River Discharges in Major Watersheds of North-Western Java from 1901 to 2006
		4	Amano Yoshimasa	The effect of Phosporus Reduction Following Dilution on a Control of Cyanobacterial Blooms in Eutrophic Lakes
		5	Suciati Putri	Study of Sea-Air CO2 Net Flux in Indonesian Seas
session 2 (15.45 - 17.45)	Metalurgy and material	1	Akhmad Herman Yuwono	Fabrication of Highly Ordered TiO2 Nanoparticle Arrays in Polymethyl methacrylate Matrix by Diblock Copolymer Templating
		2	M. Chalid	The Influence of Porosity on Mechanical Behaviour of Polyamide Thin Films
		3	Anne Zulfia	Metal Oxide Coating on Al2O3 Particles Reinforced Composites
	Biomedical	4	Bowolaksono Anom	Survival Roles of LH in Bovine Luteal Cells
		5	Arman Djohan	BLOOD DISEASE IDENTIFICATION USING IMAGE PROCESSING TECHNIQUE AND HIDDEN MARKOV MODEL

Room C

Session	C			
	Field	No	Presenter	Title
session 1 (13.30 - 15.30)	Mechatronic and control	1	Abdul Muis	Development of Lowcost SAR Robot using Tracked Wheel on Four Leg Mechanism
	Mechanical	2	Jamiatul Akmal	Mixed-adhesive technique to optimization of joint strength of torque loaded tube
		3	I Made Parwata	Contact Pressure Behavior Due to Wheel and Rail Contact in Curve Track
		4	Adi Surjosatyo	Optimation of Fluidized Bed Combustor Operation of Wood Branch Combustion
		5	Takehiro Watanabe	Laser Materials Processing from Micro- to Macro-Machining
	Metalurgy and material	6	Sri Harjanto	Thermal Conductivity Enhamcement of Water-TiO2 Suspension Synthesized by Wet Mechanochemical Process
session 2 (15.45 - 17.45)	Chemistry	1	Sri Atun	CYTOTOXIC EFFECT SOME PHENOLIC COMPOUNDS FROM FERMENTED BLACK SOYBEANS (GLICINE SOJA) EXTRACT AGAINST AS BREAST CANCER CELL LINE T47D
		2	Winarto Haryadi	Molecular Docking of 6-Deoxyerythromycin-A, Chlarythromycin and Erythromycin-A to rRNA 23S Deinococcus radiodurans and Study of Their Binding Mode to the Macromolecule Target
		3	Sri Handayani	Synthesise and 2-Deoxyribose Degradation Inhibition of Two Benzalacetone Derivatives
		4	Heri Hermansyah	Synthesis of Dimethyl Ether Using Cu-Zn/HNZ Catalyst in Fixed Bed Reactor
		5	Cahyorini Kusumawardani	Synthesis of Nitrogen-doped TiO2 and Its Photocatalyst Activity under Visible Light on Decoloration of Methylene Blue

	Microelectronic	6	Nji Raden Poespawati	Design of GaAs/Si Solar Cell with Graded Si0.9Ge0.1 Layer

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Day 2 (September 30, 2010)

Room A

Session	A			
	Field	No	Presenter	Title
session 1 (08.30 - 10.30)	Mobile Communication	1	Deni Lumbantoruan	Cross Layer Approach to OLSR Performance Improvement Considering Link Quality
		2	Filbert Juwono	PPAR Reduction Using RLE in OFDM System
		3	Gunawan Wibisono	Design of MEMS-TFBAR Filter for Mobile WiMAX 2,3 GHz Application
		4	Muhamad Asvial	Simulation of Real TimeVideo Stream Watermarking Using Discrete Wavelet Transform
		5	Ahmad Munir	Parametrical Study of Microwave Radar Absorber Loaded with Varactor Diode
session 2 (10.45 - 12.45)	Laser and Optical Communication	1	Nobuo Takeuchi	Applicability of TDLAS Gas Detection Technique to Combustion Control and Emission Monitoring under Harsh Environment
		2	Ary Syahriar	Characteristic of L Band Erbium Doped Fiber Amplifier in ITU grid Wavelength
	Energy and Power System	3	Chairul Hudaya	Microhydro Project Evaluation Using RETScreen : Study Case Wangan Aji MHP

	Architecture	4	Antony Sihombing	Kampung Kota: Locality of Places and Spaces
		5	Ika Esterina	Rhythm in A Region: A Study of Physical Environment and Social Environment in Kemang Food Festival Region and Sabang Region
	Long-distance Communication	6	Ucuk Darusalam	Free Space Optical Communication Performance Influenced by Rain Effects
session 3 (13.30 - 15.30)	Envi. Chem.	1	Is Fatimah	Catalytic Activity Of Cu-Exchanged Ti-Pillared Montmorillonite In NOX Reduction
	Chemistry	2	Jaka Nugraha	Application of Logit Model Toward The Study on The Effect of Catalyst Dosage to Methylene Blue Photodegradation
	Energy and Power System	3	Rumbayan Meita	Resource and Economic Assessment of Solar Irradiation Potential in an Island Community
		4	Manjang Salama	STUDY OF HTV SILICONE POLYMER FOR HIGH VOLTAGE INSULATOR MATERAL
		5	Mohd Izhar A. Bakar	A Modeling for High Power of 5kW Single Phase Inverter by Using PWM Switching Technique
		6	Aji Nur Widyanto	DESIGN OF AUTOMATIC METER READING MONITORING SYSTEM USING WEB SERVER BASED
		7	Iwa Garniwa	Development of Centered Corona Detector for 20 kV Medium Voltage Cubicle

Room B

Session	B			
	Field	No	Presenter	Title
session 1 (08.30 - 10.30)	Mechatronic and control	1	Wahidin Wahab	Issue on the Integration of The Open Source Software EMC2 to A Computer Numerical Control (CNC) Using DC servomotors
		2	Feri Yusivar	Design of Model Predictive Control Without Constraint for Proton Exchange Membrane Fuel Cell System
	Remote Sensing	3	Zainuddin Mukti	APPLICATION OF TRMM/TMI SATELLITE MICROWAVE REMOTE SENSING TO SIMULATE FISH MIGRATION PATTERN: A CASE STUDY OF ALBACORE TUNA
		4	Josaphat Tetuko Sri Sumantyo	Differential Synthetic Aperture Radar Interferometry for Subsidence Monitoring of Bandung city, Indonesia
	Computer and Information Technology	5	Risnandar	E-Government Applications Based on GIS for Potential Advertisement Tax (Case Study: Bandung)
session 2 (10.45 - 12.45)	Computer and Information Technology	1	N R Poespawati	Design of Application Warehouse Management System Based on RFID
		2	Yeni Anistyasari	DESIGN OF HIGHER EDUCATION LEARNING MANAGEMENT SYSTEM INTEROPERABILITY
		3	Tomy Abuzairi	Design and Prototype Construction of Automatic Parking System Using RFID Reader Technologies with Parking Fee Debit Feature via SMS
		4	Harco L. Hendric Spits Warnars	Human Face as Human Single Identify

		5	Mia Rizkinia	Comparison of DSR and AODV Performance in Mobile Animal Forest Anti Fire Wireless Sensor Network Simulation with NS-2
	Image Processing	6	Benyamin Kusumoputro	AUTOMATIC FACE RECOGNITION SYSTEM BASED ON INFRA-RED IMAGES AND A NEURAL NETWORK
session 3 (13.30 - 15.30)	Nursing	1	Setyowati	The Experiences of Indonesian Nurses in Japan in Facing the Job and Cultural Stress in Their Work: A Qualitative Study
		2	Ratna Sitorus	ANALYSIS OF NURSING CARE PROFESIONALISM BASED ON NURSING INTERVENTION PROVIDED FOR INPATIENT UNIT WITH MEDICAL SURGICAL PROBLEMS AT THE HOSPITALS
		3	Yeni Rustina	DESIGN OF HIGHER EDUCATION LEARNING MANAGEMENT SYSTEM INTEROPERABILITY
		4	Budi Anna Keliat	COMMUNITY MENTAL HEALTH NURSING IN ACEH, INDONESIA: LESSON LEARNED 2005 - 2010
		5	Surya Marthias	Factors Related to Delayed Presentation to Public Health Centers among Pulmonary Tuberculosis Patient: a study in East Nusa Tenggara, Indonesia
		6	Setyowati	The ethnography study of nutritional status of pregnant women in Banten Indonesia

Room C

Session	C			
	Field	No	Presenter	Title
session 1 (08.30 - 10.30)	Remote sensing	1	Ratih Fitria Putri	Predicting Tsunami Inundation Hazard Impact of Paddy Field Area and Non Paddy Field Area in Parangtritis Coastal Area, Indonesia
		2	Victor Wissan	Data Compression using Pulse Synthesizing Method for Circularly Polarized Synthetic Aperture Radar
		3	Kenji Kuriyama	Visible and near-infrared differential optical absorption spectroscopy (DOAS) for the measurement of nitrogen dioxide, carbon dioxide and water vapor
		4	Gede Karang	Internal Waves Observed in the South of Lombok Strait by using ALOS-Palsar
		5	Ratih Fitria Putri	Disaster Mitigation Using Remote Sensing and Geographic Information System of Tsunami Inundation Hazard Scenario; Study Case Parangtritis Coastal Area, Indonesia
session 2 (10.45 - 12.45)	Remote sensing	1	BASARI	Implementation of Antenna System for Land Vehicle Mobile Satellite Application under Real Environment
		2	Rokhmatuloh	REGRESSION TREE METHOD AND ITS APPLICATION FOR PERCENT TREE COVER MAPPING
		3	Dodi Sudiana	Analysis of Channel Selection and Window Size in Automatic GCP Selection for LANDSAT Geometric Correction
		4	Arry Retnowati	Dynamic Breaking Waves and Surf Zone Assessment of Parangtritis Coast Applying Edge Detection on ALOS PALSAR Image

	Image Processing	5	Karlina Khiyarin Nisa	Object Recognition System Based on Local Feature with Nearest Neighbour Search
		6	R.S.Bellina	A Comparative Study between SURF-PNN and SIFT PNN by using Single Feature Neural Network
session 3 (13.30 - 15.30)	Horticulture and Fisheries	1	St Aisjah Farhum	Improving Quality Pole and Liner Stability By Reconditioning Live Bait Tank
		2	TRESNATI Joeharnani	Gonad maturity of fish-Bonti Bonti (Paratherina striata Aurich, 1935) in Towuti Lake, South Sulawesi.
	Agriculture	3	Yudithia Maxiselly	Diversity Genetic of kimpul (xanthosoma sagittifolium (L.) Schott) from West Java Based on Morfological and Agronomy Traits
		4	Windhy Chandria	Genetic Diversity among West Java Indonesia Sweet Potato (Ipomea batatas (L.) Lamb) genetic Resources based on Cluster Analysis Using Phenotypic Traits
		5	Triyono Agus	Study of Making Flour Matured Banana (Musa paradisiaca) and Its Characterization Using The Addition of Maltodextrin and Computation Process
		6	Triyono Agus	Starch Potentials From Source Tubers for Modified Starch Production as Food Material Substitution
		7	Anggia eka putri	Orientation Dose (Ld50) Corn Collections Unpad (Dr And Sr) Of Gamma Rays Irradiated (CO60)

Mixed-Adhesive Technique on Joint Strength of Torque Loaded Tube Optimization

J. Akmal[1], IGN W. Puja[2], I. W. Suweca[2], S. S. Brodjonegoro[2]
[1]Department of Mechanical Engineering, Faculty of Engineering, University of Lampung, Indonesia
[2]Faculty of Mechanical and Aeronautical Engineering, Institut Teknologi Bandung, Indonesia

Abstract—**Adhesive bonded joint tubular shape are widely used in the aerospace and automotive industries. However, the literature study showed that the stress distribution at the joint, when loaded, is not evenly distributed and creates stress concentration at the edges. The strength and lifetime of adhesive bonded joints can be significantly improved by reducing the stress concentration at the edges. Attempts have been made by researchers to improve the joint design so that the stress would be more evenly distributed and minimize stress concentration, however, the improvement has been very limited. In this work, a parameter study has been performed to observe the properties of adhesive joint of torque loaded tube. Based on the observation, a new type called mixed-adhesive technique is proposed which successfully reduces the stress concentration at the edge during torque loading. This method successfully increase safety factor to be 18.75 % and 83.88%, respectively compared to the use of brittle alone and ductile adhesives alone.**

Keywords— **mixed-adhesive technique, torque loaded tube, stress distribution, finite element method, joint design**

I. INTRODUCTION

Adhesive bonded joint is extensively used in tubular component, included piping system. Ideally, a piping system would be designed without joints and elbow, since joints and elbows could be a source of weakness and/or excess weight. However, limitations on component size imposed by manufacturing process and the requirement of inspection, accessibility, repair, and transportation/assembly necessitates some load carrying joints and elbows in most piping systems. Thus, the elbow and the joint will become the important parts for piping systems.

Research and development of the elbow on the pipe have been carried out by many researchers. As an example is the non linear analysis of piping elbow under mechanical loading [1]. Similarly, research and development of the pipe joint have also been done. This study will also discuss the behavior of the pipe joints as an effort to improve performance.

Adhesive-bonded pipeline networks, involving adhesive-bonded socket, butt-and-strap and flanged joints etc., are regarded as one of the most efficient and important methods, especially for the offshore oil and gas exploration and transportation [2]. However, there are still some problems with using this joint type; one of the problems is frequent leaks in pipe joints. This research's aim is to improve performance of adhesive-bonded socket joint, as shown in Fig. 1. The problem is ascertainable that stress distribution fields on joints are not uniform, in contrast, a significant peel/shear stress concentration always exists in the edge region at the adhesive layer bond-line [3,4,5,6]. This problem will significantly reduce the strength of joints.

For improving the joint performance, innovation and parametric optimization need to be done. In the present study, innovation is made to improve the strength of tubular adhesive joint under torque. Innovation is carried out so that the stress that occurs in the pipe joint can be more evenly distributed.

Previously, an innovation was made to improve joint performance by making a tapered socket [7]. In addition, different methods have also been carried out to improve performance [8]. However, those methods have not significantly improved the joint performance. From the analysis conducted on those models, it shows that a significant shear stress concentration always exists in the edge region at the adhesive layer bond-line. In other study, a new model is introduced by making the thicker layer of adhesive in the edge region of joint [9] and making groove at the socket [10]. Though success is significantly lower stress concentration at the edge of the connection, but this way is relatively more difficult to do because we have to do the machining process at the end of the pipe joint. Therefore, in this study a new type called mixed-adhesive technique is proposed. This method was successfully reduces the stress concentration at the edge during torque loading. In this technique, joint is performed a combination of brittle and ductile adhesives.

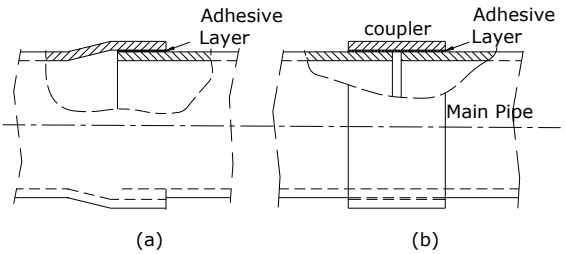

Fig. 1. The Adhesive Bonded Joint of Pipe

(a) Single Lap Joint (b) Socket Joint

II. METHODOLOGY

To determine the stress distribution along the joint conducted analytical and numerical study. Analysis was done to a model joint by using two type of adhesive material, which was classified as brittle adhesive and ductile adhesives. The optimization was conducted to determine the optimal ratio of the long fraction of both.

A. Analytical Solution

Analysis is carried out on adhesive joint composite pipe, as shown in Figure. 1b. Because of symmetry, the analysis is conducted in half as illustrated in Fig. 2 [11]. It is assumed that the joint length is L and the coordinates of x starting from the middle of the joint. Free-body diagram for a piece of pipe and socket with a length *dx* is shown in Fig. 3.

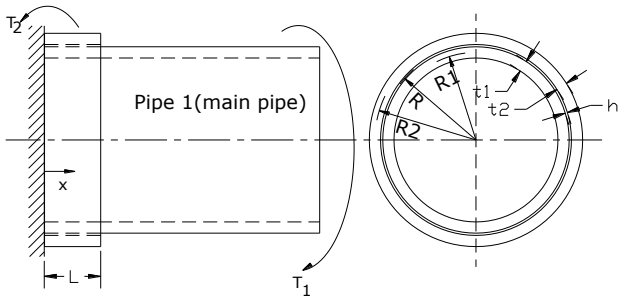

Figure 2: Adhesive Joint of Composite Pipe with A Simplified Model [11]

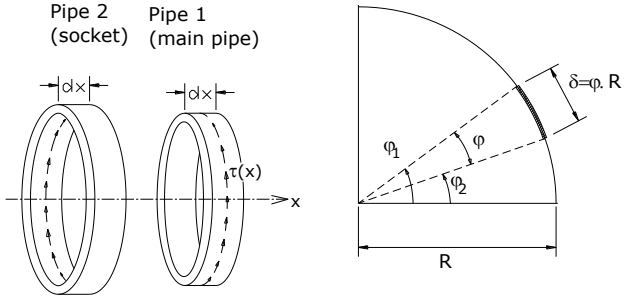

Fig. 3. Free-body Diagram for A Small Piece of Pipe with A long dx [5]

Z. Ouyang & G. Li (2009) states that the distribution of stress on the adhesive layer is [5]

$$\tau(x) = \frac{\varphi(x)R}{h_a} G_a \tag{1}$$

Where

R is average radius of adhesive layer

G_a and h_a, respectively, are the shear modulus and the thick layer of adhesive

$\varphi(x)$ is the angle strain distribution can be expressed by Eq. 2.

$$\varphi(x) = T\left[\frac{\frac{1}{\alpha G_1 J_1} + \frac{1}{\alpha G_2 J_2} e^{(\alpha L)}}{e^{(\alpha L)} - e^{(-\alpha L)}}\right] e^{(-\alpha x)} + \ldots$$

$$T\left[\frac{\frac{1}{\alpha G_1 J_1} + \frac{1}{\alpha G_2 J_2} e^{(-\alpha L)}}{e^{(\alpha L)} - e^{(-\alpha L)}}\right] e^{(\alpha x)} \tag{2}$$

T is torque that occurs at the pipe joint.

G_1 and G_2, respectively, are shear modulus of main pipe and socket.

J_1 and J_2 , respectively, are polar moment of inertia of main pipe and socket, as expressed by Eq. 3.

$$J_1 = 2\pi R_1^3 t_1 \quad ; \quad J_2 = 2\pi R_2^3 t_2 \tag{3}$$

L = long half-pipe joint

$$\alpha = \sqrt{2\pi R^3 \cdot k_e \cdot \frac{G_1 J_1 + G_2 J_2}{G_2 J_2 G_1 J_1}} \tag{4}$$

Where

$$R = \frac{\left(R_1 + \frac{t_1}{2}\right) + \left(R_2 - \frac{t_2}{2}\right)}{2} \tag{5}$$

$$k_e = \frac{\tau_f^2}{2G_f} \tag{6}$$

Analysis has been done on the model with material specification as shown in Table I [12] and dimensions as shown in Table II. Change the interface shear stiffness, k_e, as it exists in Eq. 6 with $G_a / h_a \cdot G_a$ and h_a respectively, are the shear modulus and the thickness of adhesive layer [5]. Solving Eq. 1 will give the stress distribution along the adhesive layer.

TABLE I
SPECIFICATION OF MATERIALS [12]

Material	**Pipe & coupler (steel)**	**Brittle Adhesive (AV138)**	**Ductile Adhesive (DP-8005)**
Shear Modulus, G (MPa)	80769	1559	178.6
Shear Strength, S_{Sh} (MPa)	200	30.2	8.4
Poisson's ratio	0.3	0.41	0.41

TABLE II
LOAD AND DIMENSION

Torque (N.mm)	200000
t_1 (mm)	2
t_2 (mm)	2
R_1 (mm)	15.7
R_2 (mm)	17.9
R (mm)	16.8
L (mm)	20
Main pipe length (mm)	100
Adhesive thickness (mm)	0.2

B. Validation of Finite Element Method

Finite element analysis is performed with the help of *ANSYS Multiphysics software*. Element type used is *element solid brick 8node 45*. Between the adhesive layer surfaces and pipe surface, it is glued with contact properties: *bonded (always)*. Figure 4 shows the form of elements in the finite element model and dimension joint. Comparison of two analysis results is shown in Fig. 5.

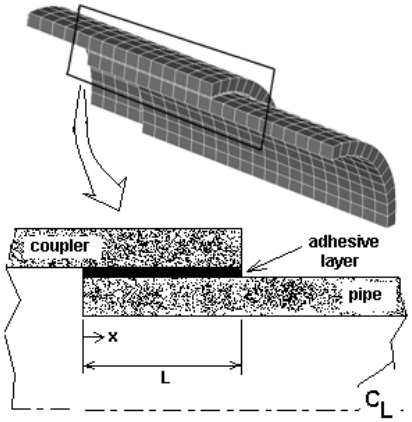

Fig. 4. Element Type and Dimension of Joint

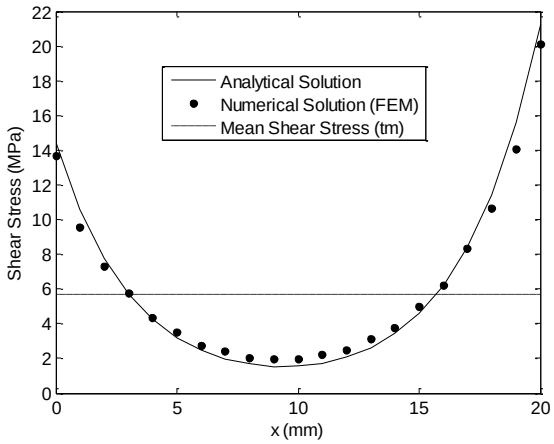

Fig. 5. Shear Stress Distribution at Adhesive Layer for h=0.2 mm: Finite Element Method and Analytical

C. Mixed-Adhesive Technique

To increase the safety factor,the analysis carried out on various combinations ratio of length ductile-adhesive and length joint (a/L), as shown in Fig. 6.

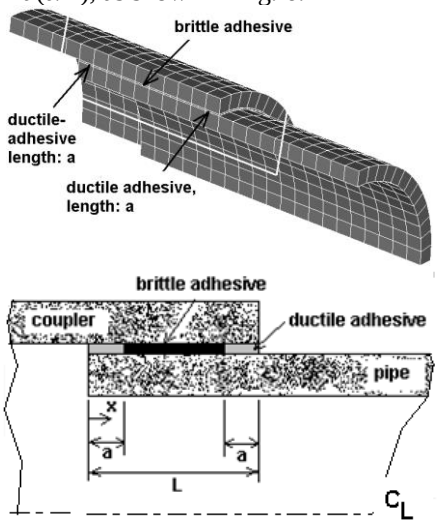

Fig. 6. Mixed Adhesive Joint and Dimension

III. RESULTS

Stress distribution for each combination, showed in Fig. 7, where each shear stress normalized by the nominal shear stress average, $\tau_m = T/2\pi R^2 L$ Stress distribution determined by Finite Element Analysis, as has been done on the previous model.

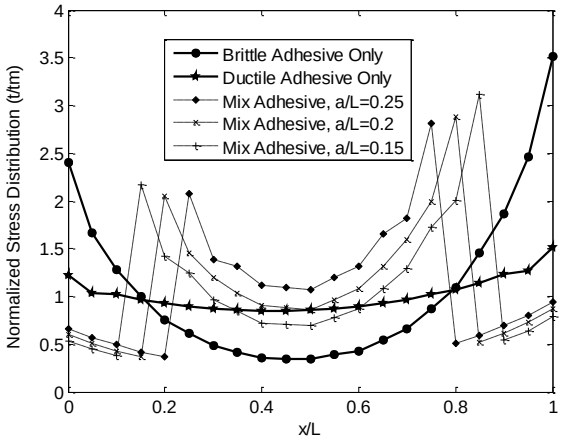

Fig. 7. Normalized Shear Stress Distribution in Combinations Ratio of Length Ductile-Adhesive and Length of Joint (a/L)

Furthermore, safety factor (SF) calculated by Eq. 7, where S_{Sh} is shear strength of adhesive material and τ_{max} is maximum shear stress occur at the edges (x=L). safety factor for each brittle-adhesive-component and ductile-adhesive components are shown in Fig. 8.

$$SF = \frac{S_{Sh}}{\tau_{max}} \quad (7)$$

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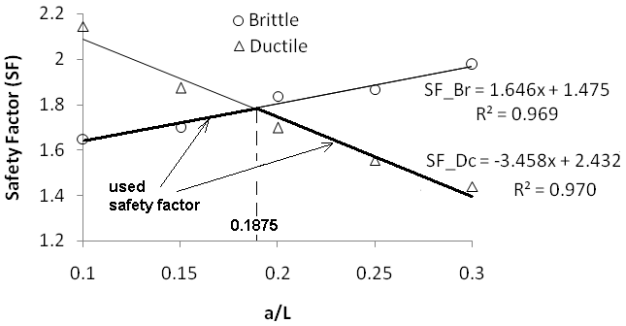

Fig. 8. Safety Factor of Brittle Adhesive (SF_Br) and Ductile Adheive (SF_Dc)

IV. DISCUSSION

Fig. 7 shown using ductile adhesive, relatively make more evenly distributed and minimize stress concentration at the edge of joint. It be caused by the shear modulus of ductile adhesive is lower than shear modulus of brittle adhesive. In this case did not mean that applying for ductile adhesive always give a higher strength relatively, be caused ductile adhesive have low shear strength, as shown in Table. I. Safety factor not only determined by lower occur stress, but also determined by shear strength of adhesive material.

Fig. 8 shows the safety factors for each type of adhesives. The increase in the ratio a/L will increase the safety factor at the brittle component adhesive but will reduce the safety factor on ductile component adhesive. Joint safety factor is determined by a lower value of each type of adhesive. Thus the optimum joint safety factor is the meeting point between the safety factor of two component adhesive with the value of a/L = 0.1875.

Optimum safety factor is SF = 1.78 was obtained at a/L = 0.1875. When compared with the safety factor in the use of brittle adhesive individually, as shown in Table III, the safety factor improvement occurred is 18.75%. Even when compared to the ductile adhesive individually the safety factor improvement is 83.88%.

TABLE III
SAFETY FACTOR IMPROVEMENT

	Brittle Adh. Only	Ductile Adh. Only
Shear Strength, S_{sh} (MPa)	30.200	8.400
Max. shear stress, $\tau(L)$ (MPa)	20.095	8.675
Safety Factor	1.503	0.970
Mix Adhesive Optimum Safety Factor=1.784		
Improvement	18.75 %	83.88%

V. CONCLUSION

Mixed-adhesive technique to optimization of joint strength of torque loaded tube was studied to improving safety factor. The main conclusions are:

(1) A joint with the ductile adhesive alone, relatively make more evenly distributed and minimize stress concentration at the edge of joint. In this case did not mean that applying for ductile adhesive relatively give a higher strength joint, be caused ductile adhesive have low shear strength.

(2) The increase in the ratio a/L will increase the safety factor at the brittle component adhesive but will reduce the safety factor on ductile component adhesive.

(3) Mixed-adhesive joints give a higher joint strength than a joint with the brittle adhesive alone or ductile adhesive alone.

(4) For the overlap ratio used here, ratio a/L=0.1875 give an optimum safety factor. This point successfully increase safety factor to be 18.75 % and 83.88%, respectively compared to the use of brittle alone and ductile adhesives alone.

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