where -0.5<β<0 stated drawing process in steel sheet, β≈0 stated as a plane strain process and 0<β<1 stated a biaxial tension.

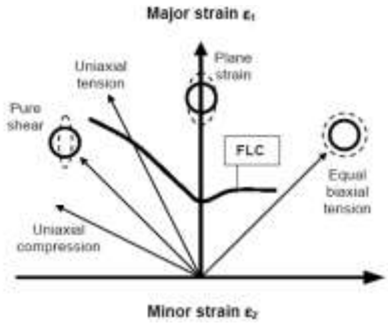


Figure 2: FLD, showing variation of linear strain [2, 3].

According to ASTM E8, the main parameter that being measured in the tensile testing are stress and strain, where strain defined as the dimensional change or elongation on unit length (Δ*L*) caused by the linear force. Strain can be defined as mathematic equation, for engineering strain, *e*, and true strain (ε) [8].
Related to the testing of Thermo Mechanical Process, the value of the true strain can be connected with the hot tensile testing, which is:

$$\varepsilon = 1.155 \cdot [\ln 1/(1-r)] \qquad (2)$$

where r is reduction of thickness in the hot rolling process [1].

2. MATERIAL and METHOD

Commercial C-Mn steel and HSLA steel was used on this study and the detailed composition are given in Table 1 and 2.

Table 1: Composition of C-Mn Steel (% of weight)

C	Si	Mn	P	S	Al	Cu	Cr	Fe
0,085	0,004	0.5022	0.019	0.004	0,019	0,271	0.156	98,783

Table 2: Composition of HSLA Steel ASTM A572 Gr 50 (% of weight)

C	Si	Mn	P	S	Ni	Al	Cu	Nb	V	Ti	Cr	Mo	Fe
0,085	0,222	1,45	<0.003	<0.003	<0.005	0,049	0,045	0,028	<0.002	<0.002	<0.003	<0.005	98,141

The cold and hot tensile test was carried out in a laboratory using a universal tensile test machine that having 20 kN tensile load capacity. Samples with 2 mm thickness (parallel to the rolling direction) were machined from the material (Figure 3) with the specimen dimension as mention in Table 3.The cold tensile test was carried out for A, B, C and D specimens, to investigate the deformation mechanism on the specimen to find out the plane strain deformation. After the plane strain deformation achieved, hot tension test was done.

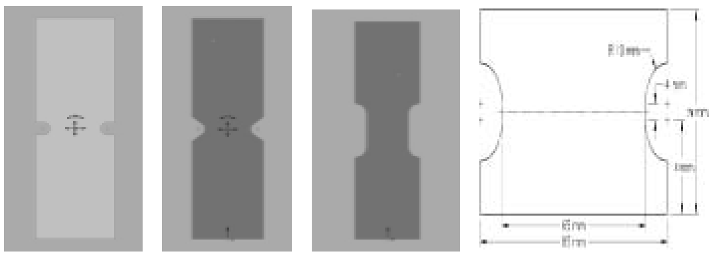
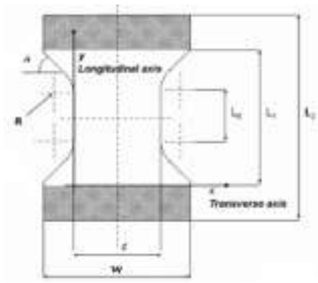


Figure 3: Geometry of Specimen A, B, C and D [2, 7].

Heat treatment of the D specimens fitted with the thermocouple was performed by heating at a constant rate of 0.3 °C.s^{-1} to temperatures of 820 °C. Then hot tensile test done for the specimen on 0.01/s strain rate at two different temperatures of about 690^{o}C and 750^{o}C, to study the influence of the temperature on the deformation mechanism. Then hot rolling was done to compare the result.

Table 3: Specimen dimension

Specimen Design	Size (mm)					Angle
	W	**L_0**	**L_1**	**L_2**	**R**	**(A)°**
A	31.2	2.4	20	200	4	0
B	31.2	2.4	16	200	4	45
C	31.2	15.7	35	200	8.5	0
D	85	4	24	200	10	0



The strain limit of FLD can be defined mathematically or experimentally. To define experimentally, FLC can be count from the measurement result of the grids dimension, which can be shape as a circle, a cubic or a dot that being placed in the surface of the specimen gage area. These grids afford as a measurement base zone on the strain. The deformed grids measured and then compared with the initial grid's dimension, to calculate the ratio of the main strain that used to obtain the value of β. By variation the specimen dimension and the amount of the deformation, it was expected to obtain β≈0, so the analysis of the plane strain in the thermo mechanical process can be done using tensile testing machine [2].

3. RESULTS and DISCUSSION

Due to the absence of a standard that defines the geometry of the plane strain specimens; different shapes are proposed according to the literature. However, in characterizing the local behavior of materials from the experimental measured data, one should pay attention to the validity of the plane strain assumption. Dimensional change observation was done as analytical observation phase to observe the formation of plane strain mechanism deformation which successfully being recorded by digital video camera. This observation focused on the dimensional change of every grid on specimen to measure the spread of the minor and major strain on seven testing point position (from yield until rupture) during cold and hot tensile test. It's shown that the value of FLC point equal to zero (β=0) for the seven position of all specimens. It means that all of the specimens attain plane strain deformation during cold tension. One of the result observation points for cold tension can be show on 1.155 of yield point position as shown on Figure 4.

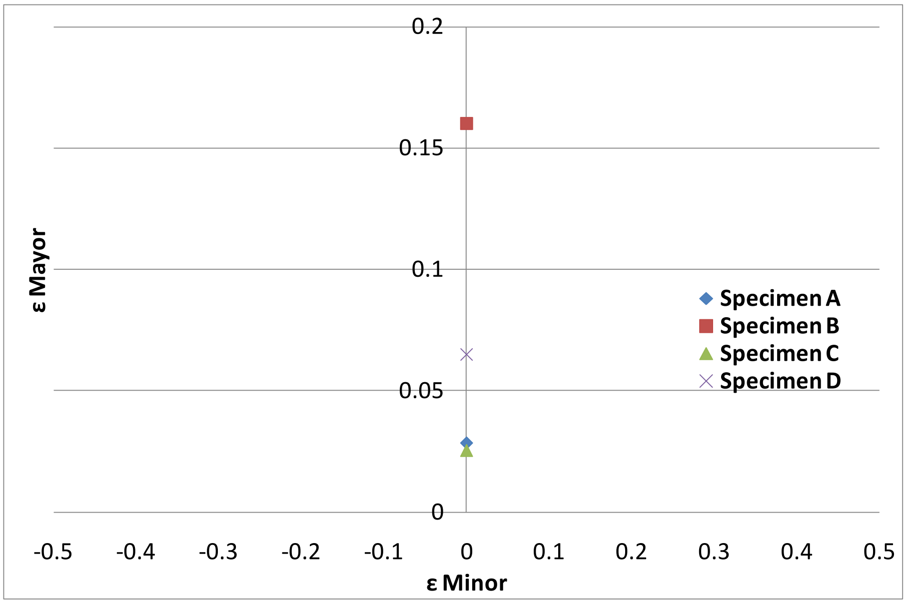


Figure 4: FLD value of all specimens at 1.155 of yield point position.

The different specimens taken from the literature survey showed that both major and minor strain fields can be obtained, which indeed make the plane strain tensile test very attractive. Refer to the result on cold tension test, the next observation focused on the spread of the major and minor strain for hot tension test on several temperatures. Base on the test result (compare of gage length and mayor strain of each specimen) and the literature, D specimen was chosen for the hot tension test. It's shown that the value of FLC point equal to zero (β=0) for the position at 1.155 of yield point and the result can be show on Figure 5.

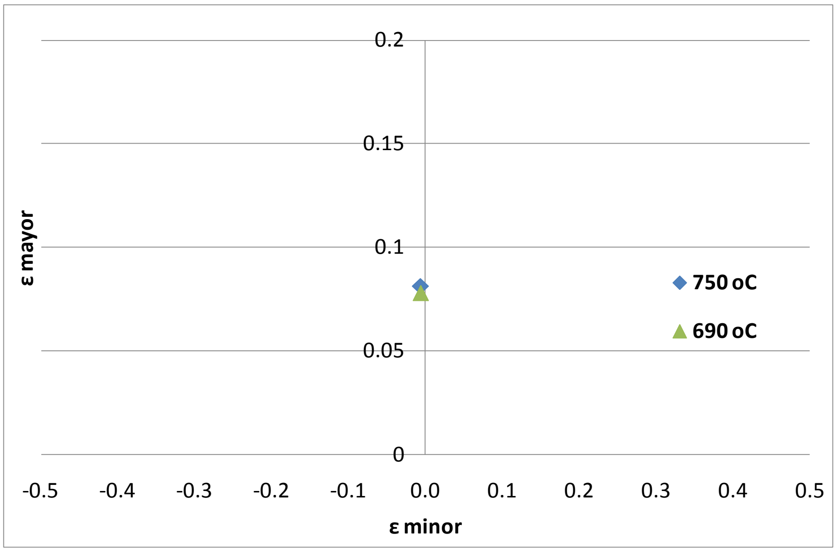


Figure 5: FLD value of D specimen at 1.155 of yield point position on severe temperatures

Data presented in Figure 5 indicated the temperature effect for strain behavior. This temperature indicated a marginal increase in major strain and an insignificant differentiate in minor strain. At this stage, small minor strain observed in the left side of the vertical line. It was indicate that smaller local necking had occurred in the gage area. It could be explained base on the uniaxial tensile method that had done to the specimen.

To observe the deformation mechanism of uniaxial tensile that subjected for the thermo mechanical process, hot rolling was done. By observed the minor and major strain of hot rolling and plotted both with the hot tensile results to the FLD as shown in Figure 6, we can conclude that plane strain deformation occurred in the process. It means that the uniaxial tensile test could be used as one of some method to observe the thermomechanical process.

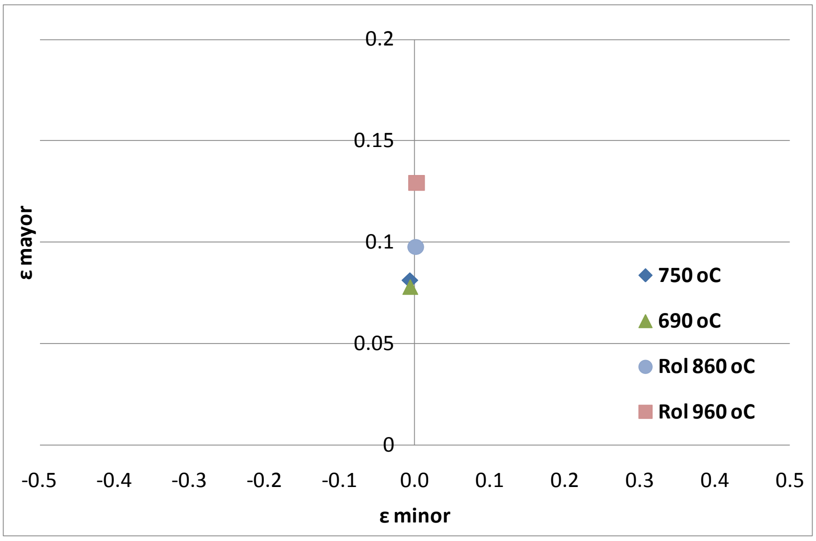


Figure 6: FLD value of hot tension and hot roll on severe temperatures

4. CONCLUSIONS

This research is devoted to the analysis of one of the main observed deformation mechanism in Thermo mechanical process of sheet metals, i.e. the plane strain deformation. An extensive study is proposed with the help of the analysis of an area based image matching dimensional measurement techniques on the entire gage area of the specimen.

Calculation result of the major and minor strain showed that the FLC value equal to zero in the yield point till the ultimate tensile strength point for the A, B and C, and D specimen during cold tensile, and show the FLC of D specimen equal to zero during hot tensile. When combine it with hot rolling process, it look having FLC similar value. It means that uniaxial tensile test method can present the thermo mechanical process in some condition.

Continue research must be done to prove this method, such as study the microstructure evolution between hot tension uniaxial test and hot rolling process to observe and compare the similar grain growth and grain size.

ACKNOWLEDGMENT
We express our gratefulness to DP2M DIKTI for the support of the realization of the present research.

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Where $\sigma_I^2(0, L + L_f) = \sigma_I^2(D_G)$ is the flux variance and dependent upon the diameter of aperture. Due to the nature of turbulence is random fluctuation, the value of SNR is no longer of deterministic but rather than mean value and can be expressed as [15]:

$$\langle SNR \rangle = \frac{SNR_0}{\sqrt{1+\sigma_I^2 D_G SNR_0^2}} \quad (4)$$

In the presence of optical turbulence the PDF (Eq.3) is considered as conditional probability that must be averaged over the PDF of the signal in order to determine the unconditional mean of BER [15]:

$$\Pr(E) =< BER >= \frac{1}{2}\int_0^{\sim} p_I(u) erfc\left(\frac{\langle SNR \rangle u}{2\sqrt{2}}\right) du \quad (5)$$

Where $p_I(u)$ is the gamma-gamma distribution of unit mean.

III. METHOD OF EXPERIMENT

GaAs diode laser 680-nm is used as the light source at transmitter (TX) by considering the high value of transmission factor in the previous our research, the cheap price and available in the market. The receiver (RX) is using Si PIN photodetector integrated with an simple electronic signal amplification using Op-Amp that capable to convert the current from photodetector into DC voltage as the parameter the signal strength, received from the aperture. The laser diode is configured in direct modulation method using driver laser and the input signal is using function generator. The input voltage signal is injected into the cathode of the diode laser hence perform OOK modulation technique. The collimated laser beam travels along the medium and being assumed as the Gaussian beam that interacting with the turbulence medium. The FSOC system on the experiment is shown in Fig.2:

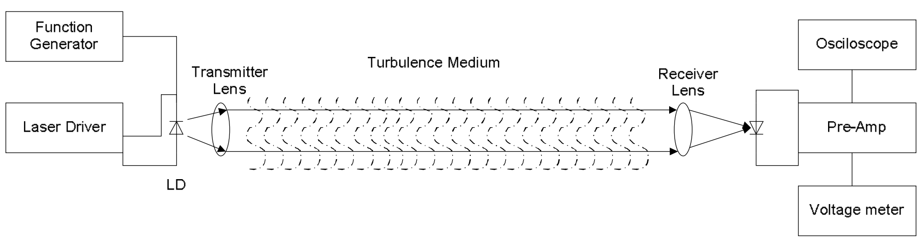

Figure 2: Experiment diagram of FSOC Direct Detection Method.

The power of signal irradiance from the laser is tuned from the amplitude of modulation in the range of 0 – 30 dB. The range of frequency modulation is 10 – 100 MHz, injected into the cathode of laser after being drive by current controller from laser driver. The current is maintained stable by using a current controller in the driver circuit by applying feedback gain control. The laser beam from laser is collimated by the transmitter lens passing throught the simulator turbulence medium (tube propagation simulator). The receiver lens is focusing the beam coming from turbulence medium alligned with the optical axis of transmitter lens to avoid the large beam wandering. The set-up of experiment is shown in Fig. 3. The main measured parameters the strength of the optical beam that already interacted with the turbulence medium.

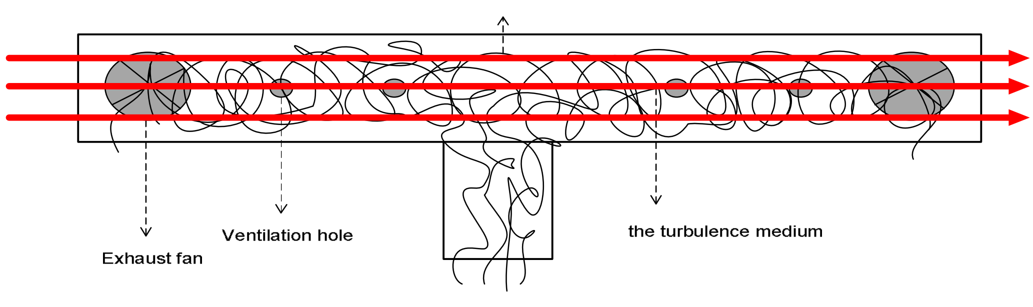

Figure 3: Experimental set-up of turbulence medium as the optical beam propagation (random media of tube propagation simulator).