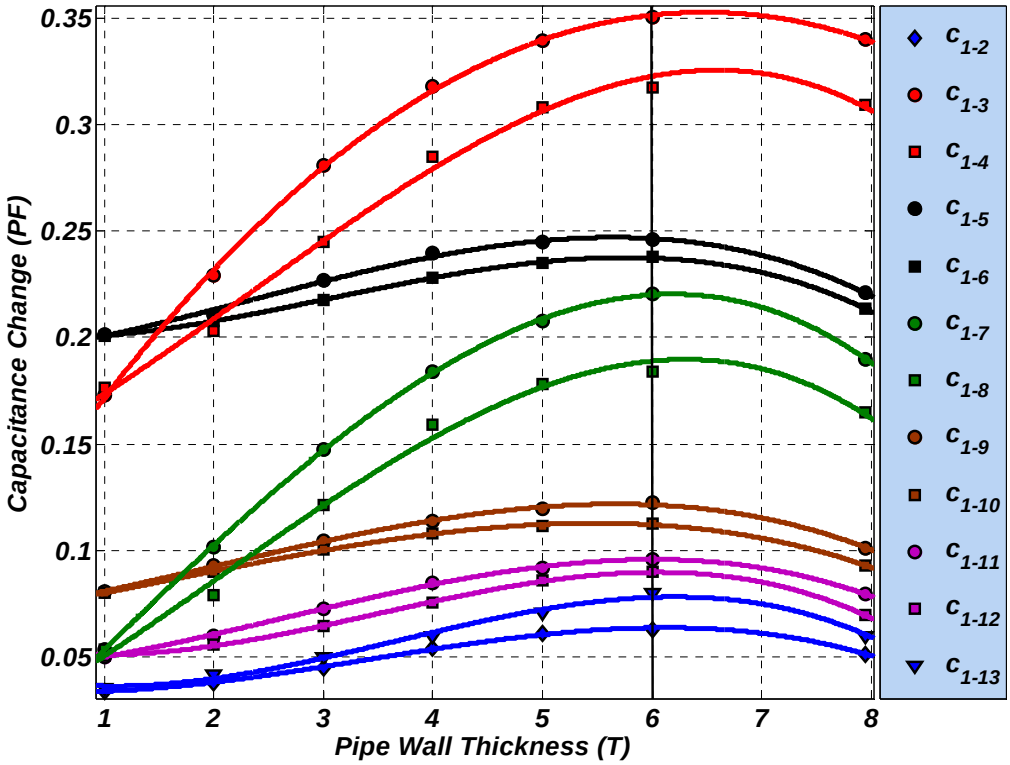

Fig.12 Expected Data of Capacitance change at $\theta = 60℃$

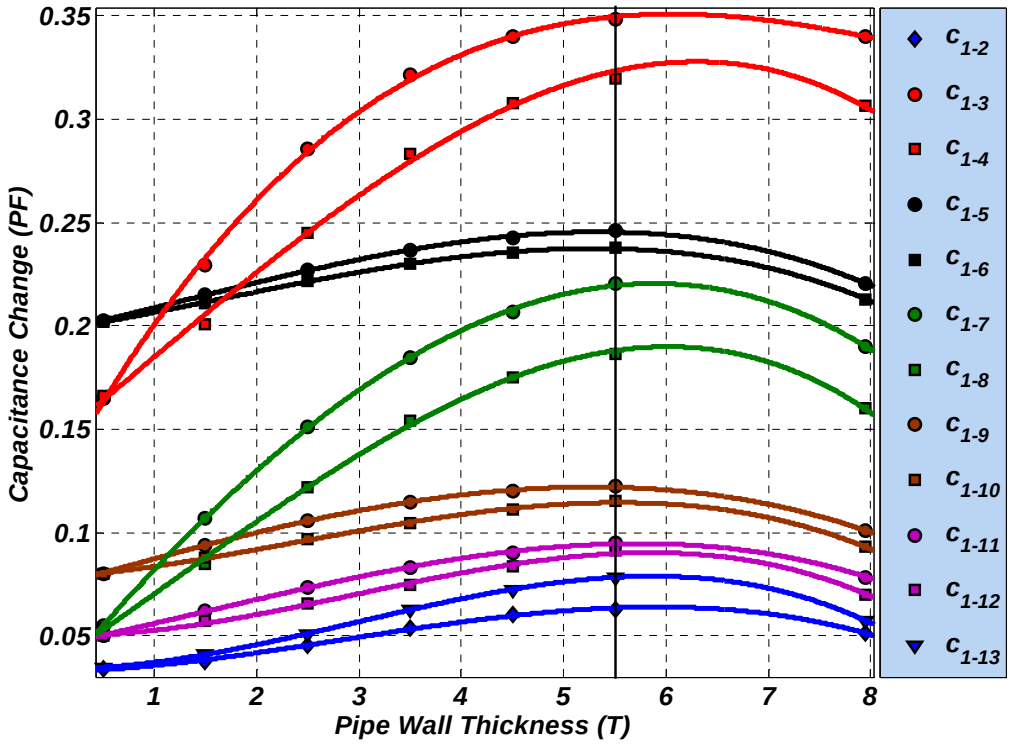

Fig.13 Expected Data of Capacitance change at $\theta = 80℃$

Table 3.Corrosion rate Constants (a_{ij}), (b_{ij}), (k_{ij}) and (h_{ij}) at $\theta = 25℃, 40℃, 60℃$ and $80℃$

	θ	C_{1-2}	C_{1-3}	C_{1-4}	C_{1-5}	C_{1-6}	C_{1-7}	C_{1-8}	C_{1-9}	C_{1-10}	C_{1-11}	C_{1-12}	C_{1-13}
a_{ij}	*25℃	**-7867**	**-1107**	**-1533**	**-2860**	**-3277**	**-4094**	**-4718**	**-5964**	**-6254**	**-6823**	**-7072**	**-7643**
	**40℃	-7713	-952	-1376	-2691	-3125	-3942	-4562	-5805	-6100	-6668	-6918	-7485
	**60℃	-7396	-632	-1054	-2372	-2806	-3623	-4241	-5493	-5785	-6353	-6593	-7173
	**80℃	-7172	-413	-832	-2158	-2581	-3411	-4028	-5272	-5552	-6126	-6372	-6951
$b_{ij} \times 10^{-4}$	*25℃	**-0.1907**	**-0.1987**	**-0.1967**	**-0.1938**	**-0.1921**	**-0.1953**	**-0.1928**	**-0.1973**	**-0.1980**	**-0.1972**	**-0.1924**	**-0.1983**
	**40℃	-0.1923	-0.1997	-0.1955	-0.1923	-0.1912	-0.1942	-0.1936	-0.1922	-0.1911	-0.1958	-0.1966	-0.1998
	**60℃	-0.1979	-0.1982	-0.1927	-0.1931	-0.1953	-0.1966	-0.1919	-0.1925	-0.1995	-0.1969	-0.1939	-0.1974
	**80℃	-0.1958	-0.1959	-0.1986	-0.1924	-0.1972	-0.1939	-0.1923	-0.1982	-0.1988	-0.1917	-0.1987	-0.1961
	Avg.	**-0.1942**	**-0.1981**	**-0.1959**	**-0.1929**	**-0.194**	**-0.195**	**-0.1926**	**-0.1951**	**-0.1969**	**-0.1954**	**-0.1954**	**-0.1979**
	S.D.	**0.0033**	**0.0016**	**0.0025**	**0.0007**	**0.0028**	**0.0012**	**0.0007**	**0.0031**	**0.0039**	**0.0025**	**0.0028**	**0.0016**
k_{ij}	*25℃	**7867**	**1107**	**1533**	**2860**	**3277**	**4094**	**4718**	**5964**	**6254**	**6823**	**7072**	**7643**
	**40℃	7713	952	1376	2691	3125	3942	4562	5805	6100	6668	6918	7485
	**60℃	7396	632	1054	2372	2806	3623	4241	5493	5785	6353	6593	7173
	**80℃	7172	413	832	2158	2581	3411	4028	5272	5552	6126	6372	6951
$h_{ij} \times 10^{-4}$	*25℃	**0.1921**	**0.1986**	**0.1977**	**0.1927**	**0.1960**	**0.1964**	**0.1976**	**0.1978**	**0.1903**	**0.1929**	**0.1995**	**0.1973**
	**40℃	0.1956	0.1945	0.1945	0.1941	0.1921	0.1949	0.1932	0.1998	0.1982	0.1941	0.1925	0.1946
	**60℃	0.1962	0.1969	0.1987	0.1911	0.1982	0.1962	0.1925	0.1999	0.1913	0.1964	0.1987	0.1997
	**80℃	0.1933	0.1948	0.1964	0.1987	0.1949	0.1942	0.1928	0.1983	0.1920	0.1981	0.1922	0.1921
	Avg.	**0.1943**	**0.1962**	**0.1968**	**0.1942**	**0.1953**	**0.1954**	**0.194**	**0.199**	**0.193**	**0.1954**	**0.1957**	**0.1959**
	S.D.	**0.0019**	**0.0019**	**0.0018**	**0.0033**	**0.0025**	**0.0011**	**0.0024**	**0.0011**	**0.0036**	**0.0023**	**0.0039**	**0.0033**
C.F	*25℃	**0.9945**	**0.9921**	**0.9908**	**0.9369**	**0.9928**	**0.9701**	**0.9828**	**0.9628**	**0.9043**	**0.9946**	**0.9715**	**0.9932**
	**40℃	0.9994	0.9995	0.9976	0.9921	0.9948	0.9999	0.9989	0.9983	0.9855	0.9993	0.9911	0.9897
	**60℃	0.998	0.9994	0.9946	0.9939	0.9991	0.9999	0.9921	0.9987	0.9963	0.9994	0.9993	0.9903
	**80℃	0.9977	0.9992	0.9973	0.999	0.9993	0.9999	0.9988	0.9991	0.9984	0.9993	0.9955	0.9999

*** FEM Data**

**** FFNN Expected Data**

6. CONCLUSION

For this work, the finite element method (FEM) and artificial neural network (ANN) techniques were used for modeling and simulating the electrical capacitance tomography (ECT) sensor to detect the corrosion rates inside steel pipelines and study and predict the effect of pipeline environment temperature (θ) on the corrosion rates, the following conclusions can be drawn:

1) The pipeline internal corrosion is means decrease of the pipeline thickness was discussed completely by FEM numerical simulation software ANSYS. The influence of pipeline to electrode pairs decreases followed by ($C_{1\text{-}3}$, $C_{1\text{-}4}$, $C_{1\text{-}5}$, $C_{1\text{-}6}$, $C_{1\text{-}7}$, $C_{1\text{-}8}$, $C_{1\text{-}9}$, $C_{1\text{-}10}$, $C_{1\text{-}11}$, $C_{1\text{-}12}$, $C_{1\text{-}13}$ and $C_{1\text{-}2}$). Maximum capacitance change is gotten at X = 6.95 mm, ρ = 0.79, which is beneficial for capacitance measurement. With the decrease of pipe wall thickness (X) or decrease of the radius-electrode ratio (ρ), the distortion of ECT sensor sensitivity becomes more serious.
2) An artificial neural network can be used as a method for simulating the ECT sensor to expect the non-FE Data of capacitance change at the pipeline environment temperature $\theta = 25℃, 40℃, 60℃$ and $80℃$.
3) Training a neural network is heavily time consuming.
4) Using the exponential formula $C_{ij} = a_{ij}e^{b_{ij}X} + k_{ij}e^{h_{ij}X}$ has proved its suitability for present study, and it is found that, the deviation of the constants (b_{ij} & h_{ij}) for different pipeline environment temperature (θ) and capacitance change (C_{ij}) is negligible and it may be considered to be constant.
5) The value of the constants (a_{ij} & k_{ij}) were found to be depend on the pipeline environment temperature (θ) and the capacitance change (C_{ij}) with high correlation factors (C.F), as the pipeline environment temperature (θ) increases the value of (a_{ij} & k_{ij}) will decreases i.e. the pipeline environment temperature (θ) had a detrimental effect on the corrosion rates increases.

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