



Research Article

# Investigating feasibility of interlayers in Resistance Spot Welding of low-carbon steel sheets

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## Abstract

In this study, experiments without interlayers and with interlayers of copper and stainless-steel sheets were performed. Design of Experiments based Full-Factorial Method was employed to generate experimental combinations. A total 81 samples were welded and tested in Universal Testing Machine to determine their Breaking Load. To investigate feasibility considering vehicle lightweightness, a novel LTW (Load-to-Weight) ratio has been proposed. Calculated LTW ratio for each experiment clearly showed that samples with stainless-steel interlayer outperformed over samples with copper interlayer and samples without interlayer. For feasibility in terms of machine durability, electrode corrosion has been found as the most auspicious parameter among all. Spot welding electrodes attain air oxidation above 700 °C. An FEA solver has been employed to determine time for electrodes to remain above air oxidation temperature during a single welding cycle through numerical simulation. A novel LTT (Load-to- Time) ratio has been proposed to find experimental combinations considering feasibility regarding electrode corrosion. LTT ratio, applied to experimental combinations with SS interlayer helped in selection of suitable process parameter combinations. Selected combinations through LTW and LTT ratio can be further proposed to industries. Study advocates method to calculate LTW ratio initially, following calculation of LTT ratio and eventually selecting process parameters contemplating feasibility in lightweightness and electrode corrosion.

## Article Highlights

- Study helps to decide feasibility of interlayer in RSW in terms of weight and electrode corrosion.
- Load-to-Weight (LTW) ratio is proposed to decide feasibility of interlayer in terms of weight.
- Load-to-Time (LTT) ratio is proposed to determine feasibility of interlayer against electrode corrosion.

**Keywords** Resistance Spot Welding · Interlayer · Feasibility · Tensile-Shear strength · Electrode Corrosion

## 1 Introduction

Resistance Spot Welding (RSW) has become an important process in automotive industries over years. Though, there are many other processes possessing potential of joining

metal sheets, RSW is the most preferred one because of its ease of automation and short welding time [1]. Welding current passes through stacks of sheets, heating and melting them at concentrated spot. Electrode force is applied to concentrate current at a certain area. Current is applied

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for a certain time called welding time. A solidified joint after welding is called a nugget [2].

Automotive industries are constantly putting efforts in fuel saving by reducing weight of automotive bodies by employing thinner sheets and materials of lower density. It was reported that 100 kg of vehicle weight reduced can save up to 0.3 L of fuel per 100 km [3, 4]. However, reduction in sheet thickness leads to weak joint strength of spot weld. To address this issue, researchers are employing different solutions like process parameter optimization, use of dissimilar base metals and use of interlayers in between parent sheets.

There have been efforts for Resistance Spot Welding of dissimilar metals. These studies include using low carbon steels, HSLA steels, AHSS steels and aluminum alloys [5–7]. Though, there have been successful welding in aforementioned studies; AHSS and HSLA have been given less importance owing to their high cost. Welding of aluminum with steel has a problem of intermetallic layer generation. This intermetallic layer worsens strength of weld and thus has been turned down by many experts and industries [8].

Apart from welding of dissimilar metal sheets and sheets of high strength metals, use of interlayer has also gained attention of researchers. An interlayer is a thin sheet metal component, situated in-between parent sheets or base sheets. Interlayer can be used to increase weldability or solve problem of intermetallic layer like in Al-steel welds. Interlayer, in many cases, increases tensile-shear strength of weld. Table 1 shows use of interlayer in previous studies with valuable outcomes.

From Table 2, it can be clearly concluded that use of interlayer increases tensile-shear strength significantly. Though there have been many studies supporting the use of interlayer in resistance spot welding, most studies focus on output parameters like tensile-shear strength, microstructure and microhardness. No study has been found investigating feasibility in terms of weight and electrode corrosion. Weight and electrode corrosion are two prominent factors considered by industries. In this study, this problem has been addressed by introducing two novel ratios LTW and LTT. While LTW ratio impacts feasibility considering weight, LTT ratio influences feasibility considering electrode corrosion.

First section talks about materials, sample preparation and tension-shear test. In next section, LTW ratio is proposed and defined. LTW ratio for all combinations has been tabled and illustrated in graph. Comparison of LTW ratio for all experimental combinations filtered potential combination, which were used for later calculations and others were scrapped. After LTW ratio, LTT ratio has been proposed and defined. Numerical simulation (required to calculate LTT ratio) results have been discussed after LTT ratio definition. LTT ratio for all selected combinations has been determined

and experimental combination with optimum output have been selected and proposed to industries.

## 2 Materials and methodology

Base metal sheets or parent metal sheets have been chosen as Cold-rolled closed annealed (CRCA) low-carbon steel AISI 1020 sheets. For interlayer, copper alloy UNC11000 and stainless-steel alloy SS304 have been selected. Further justification has not been given on selection of metals for brevity of space. More information can be found at Dharaiya [18] and Panchal [19].

Design of Experiments based Full-Factorial Method has been selected for experimentation. Referring to AWS D8.9 M:2012 [20], welding current, welding time and electrode force have been found as three most influential parameters on weld quality. All three parameters have been taken as 'factors' in full-factorial method. Same document mentioned above [20], suggests 'levels' for chosen factors in case of bare sheets without interlayer. 'Levels' for experiments with interlayer have been decided with pilot-experiments.

Experiments have been performed keeping in mind industrial atmosphere and efforts have been made to imitate industrial atmosphere as much as is achievable. Welded samples have been tested for their breaking load. After determining breaking load, a Load-to-Weight (LTW) ratio has been calculated, which has been taken as a base for industrial feasibility. Later, Load-to-Time ratio has been calculated with the help of numerical simulation. LTT ratio considers feasibility in terms of electrode corrosion (Fig. 1).

## 3 Experimentation

Experiments were performed on resistance spot welding machine in an industrial environment. Location of interlayer and presumed spot weld location are shown in Fig. 2, while Sample sizes are shown in Fig. 3. Sheets were marked at certain distance for overlapping as mentioned in Fig. 3. In some studies, it has been observed that, sheets were welded at edges with 'tack welds', however, in this study, with industrial consultation, this practice has been avoided. Metal sheets were cleaned off dirt; however, use of any specific chemicals for cleaning was avoided to imitate industrial conditions. Electrode tips should be clean from any corrosion layer or dirt. This has been ensured through visual inspection and proper steps (i.e. machining) were taken to meet requirements.

A pneumatic pedal operated Resistance Spot Welding machine with 120 kVA capacity and 50% duty cycle was employed for experiments. Electrodes are made of RWMA

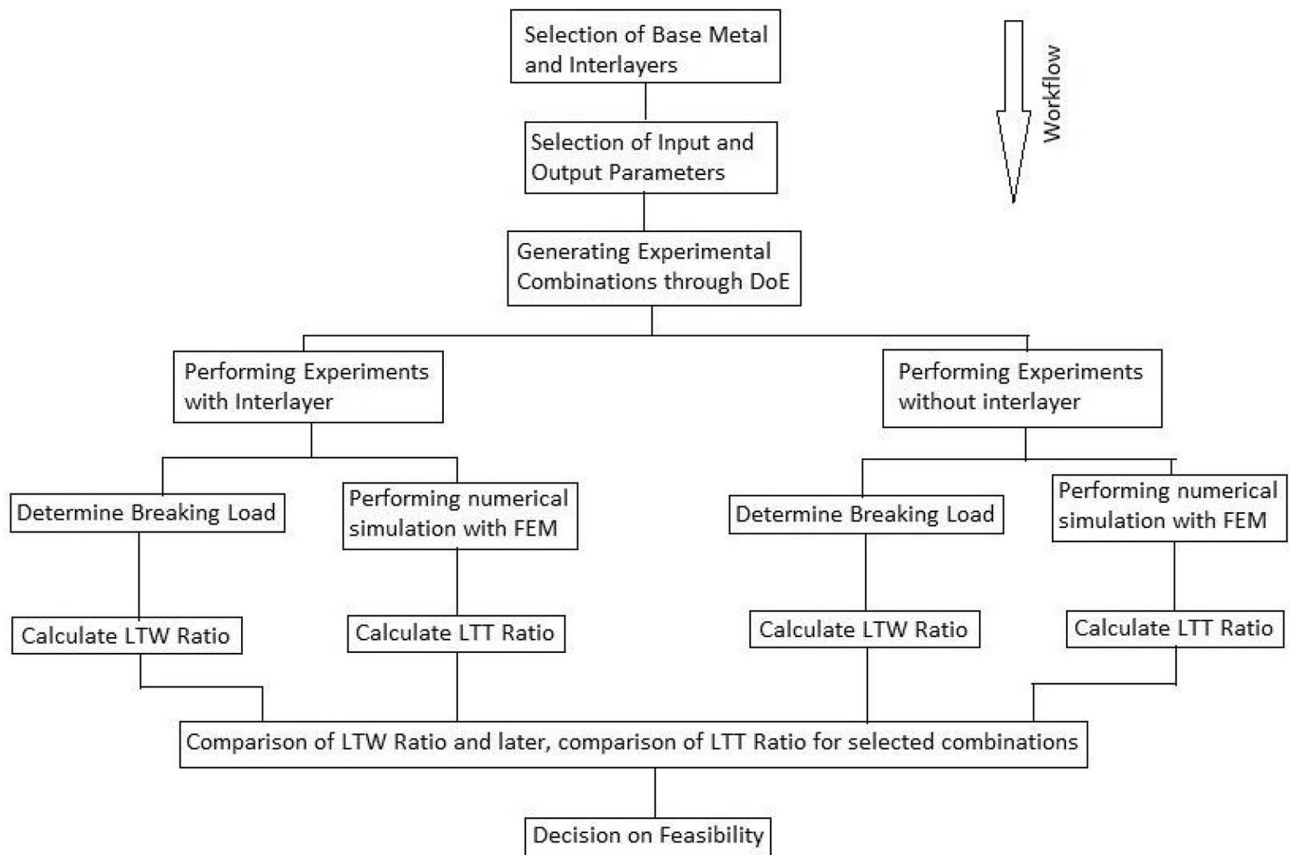
**Table 1** Previous studies of RSW with interlayer

Author	Year	Base metal sheets	Interlayer material	Input parameter(s)	Output parameter(s)	Remarks
L. Hou et. al. [9]	2014	Aluminum alloy AA6061 and low-carbon steel Q235	Alloy AlCu28	Welding Current, Welding Time, Electrode Force	Nugget Diameter, Tensile-shear strength	Use of interlayer increases spot weld strength
Zhang et. al. [10]	2014	Magnesium Alloy AZ31B and low-carbon steel Q235	Ni with 99.9% purity	Spot welding with and without Ni interlayer	Tensile-shear strength, Microstructural Characterization	Tensile-shear strength increases with interlayer
Zhang et al. [11]	2015	Magnesium Alloy AZ31B and Aluminum Alloy AA5052-H12	Pure Zn	Welding Current and Welding Time	Tensile-shear strength, Microstructural Characterization	Microstructure refinement was observed with Zn interlayer
Sun et. al. [12]	2016	Magnesium Alloy AZ31B and Aluminum Alloy AA5052-H12	Sn coated low-carbon steel	Welding Current and Downslope time	Microstructural Characterization, Tensile-shear strength, Hardness	Use of interlayer increases nugget strength, Longer downslope time contributed in avoidance of interfacial fracture mode
Muzakki et al. [13]	2018	Stainless Steel SS301 and Aluminum Alloy AA1100	Hot-dipped Zn coated low-carbon steel	Welding Current, Welding Time	Microhardness, Tensile-shear strength	Use of Zn interlayer significantly affects nugget displacement
Das et. al. [14]	2019	AISI 1008 steel	Graphene Interlayer	Welding Current, Welding Time	Tensile-Shear Strength, Microstructural Characterization, Microhardness, Nugget Diameter	Graphene interlayer increases tensile-shear strength and decreases hardness
Xu et. al. [15]	2019	Mg Alloy MB3 and Ti Alloy Ti6Al4V	Pure Al foil with 10 microns thickness	Welding Current, Welding Time, Electrode Force, Electrode Face Diameter	Tensile-Shear Strength, Microstructural Characterization, Microhardness	Al foil interlayer increases both tensile-shear strength and microhardness on weld surface
Enrique et. al. [16]	2020	Aluminum Alloy AA5052 and Galvanized Dual-Phase Steel DP600	Electrospark deposition Aluminum Alloy AA4043	Electrospark deposition coating thickness	Tensile-shear strength, Microstructural Characterization	A minimum of 30% increase in weld strength with interlayer
Iqbal et. al. [17]	2020	Stainless Steel SS316L and Titanium Alloy Ti6Al4V	Aluminum Alloy AA5754	Hold Time	Tensile-shear strength, Microstructural Characterization, Microhardness	Use of interlayer and increase in holding time significantly increases tensile-shear strength

**Table 2** Levels for DoE factors

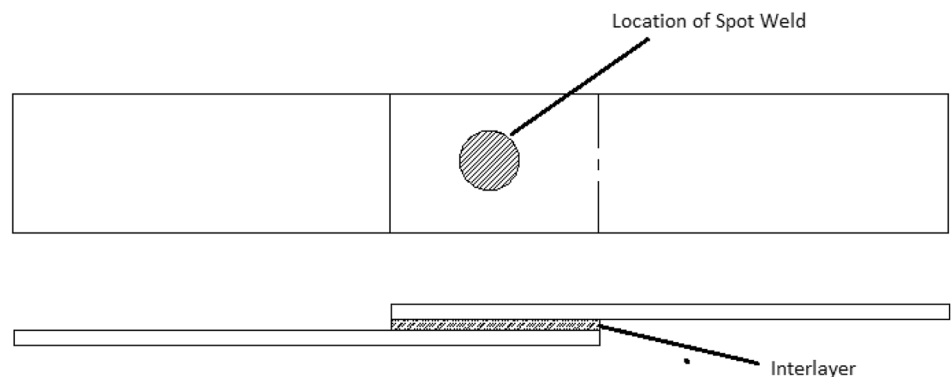
Type	Welding current (kA)	Welding time (cycles)	Electrode force (kN)
Bare sheets	5–5.5–6	6–7–8	3–3.4–3.8
With Interlayer	8.25–9.35–10.45	7–8–9	4.2–4.6–5.0

Class-2 (Copper-Chromium alloy) with truncated cone shape and 10 mm face diameter. Analog controls include welding current, welding time and hold time. Welding was performed manually with dimensions and approximate spot location as shown in Figs. 2 and 3. Table 2 shows factors and levels for spot welding. Hold time has been kept constant at 0.4 s. All other factors are assumed constant.

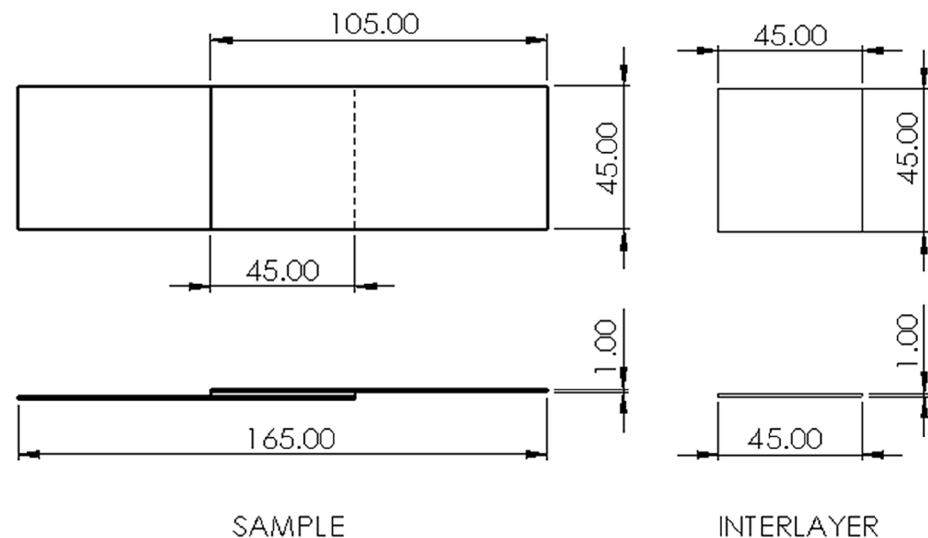


**Fig. 1** Methodology

**Fig. 2** Presumed location of Spot Weld and location of interlayer



**Fig. 3** Dimension of sheets and interlayer (in mm)



**Fig. 4** Breaking load determination in Universal Testing Machine

### 3.1 Evaluation of breaking load

Resistance Spot Welding of AISI 1020 low-carbon steel sheets was performed. For interlayer copper (UNS C11000) and stainless steel (SS304) were used. A total of 81 experiments were performed. All instructions from AWS D8.9 M:2012 [20] standard was followed. Universal Testing Machine (UTM) with strain rate of 0.1–5 mm/s was used to obtain breaking load or load of Ultimate Tensile Strength. Specimens were fixed from both ends in jaws as shown in Fig. 4. Maximum depth of sheet in each jaw is 50 mm. It should be noted that authors are interested in peak load or breaking load and hence only breaking load value has been recorded.

Figure 5a, b and c follows a certain pattern. From figures, a sudden decrease in Breaking Load from sample no. 9 to 10 and from sample no. 18 to 19 can be noticed.

However, calculating reduction in breaking load is 0.6 kN for bare sheets, around 1kN for copper interlayer and around 2 kN for Stainless Steel Interlayer. Experiment no. 9 to 10 shows an increase in welding current but decrease in welding time and electrode force. This shows dominance of welding time and electrode force over increase in welding current. Maximum welding current generates maximum nugget strength in case of bare sheets and copper interlayer. In case of stainless-steel interlayer, minimum welding current generates maximum strength. It shows that welding current plays principal role in copper interlayer and bare sheets, while welding time is predominant in stainless steel interlayer.

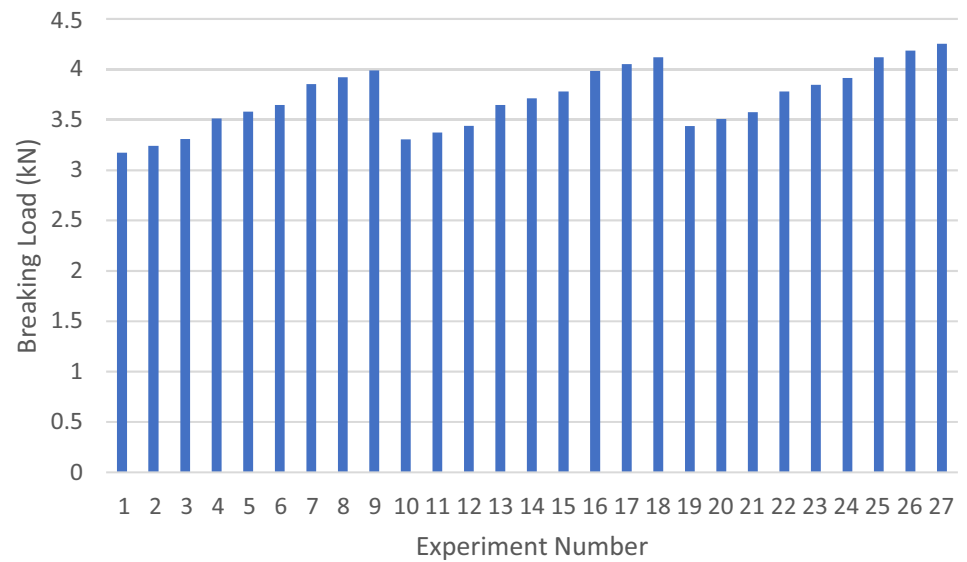
### 3.2 LTW ratio

The question for industries is feasibility. Welding with interlayer improves strength, that can be understood from comparison of Tables 2 and 3. industries would like to implement interlayers in case of a significant amount of increase in strength against increase in weight owing to interlayer. This issue can be addressed with an LTW (Load-to-Weight) ratio.

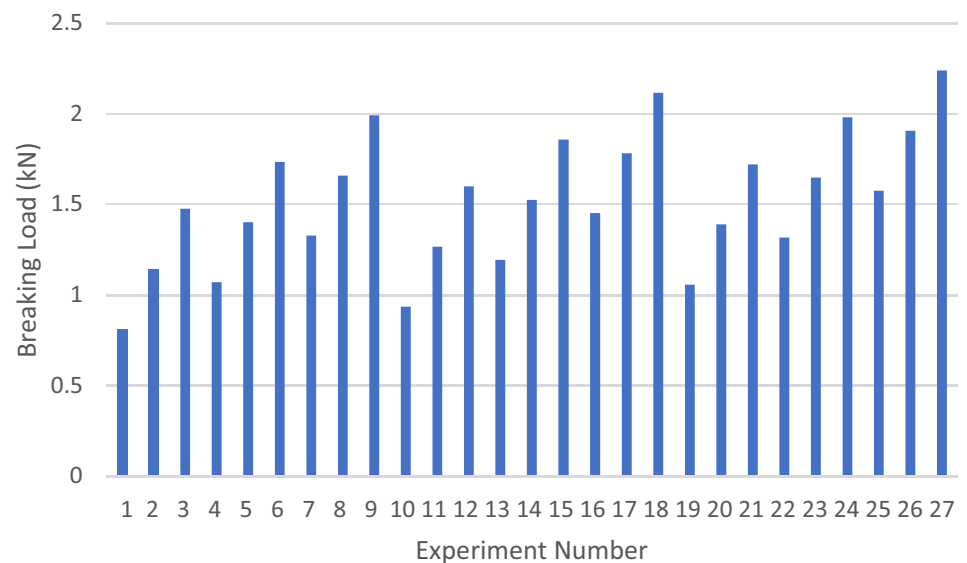
$$\text{LWT ratio} = \frac{\text{Breaking Load of Welded Joint(kN)}}{\text{Total Weight of welded joint(kg)}}$$

Total weight of bare sheet welded joint without interlayer is 0.0737 kg, 0.0918 kg for joint with copper interlayer and 0.09 kg for joint with aluminum interlayer.

**Fig. 5** Breaking load for **a** Bare Sheets **b** Copper Interlayer **c** SS Interlayer **d** combined



**(a)**



**(b)**

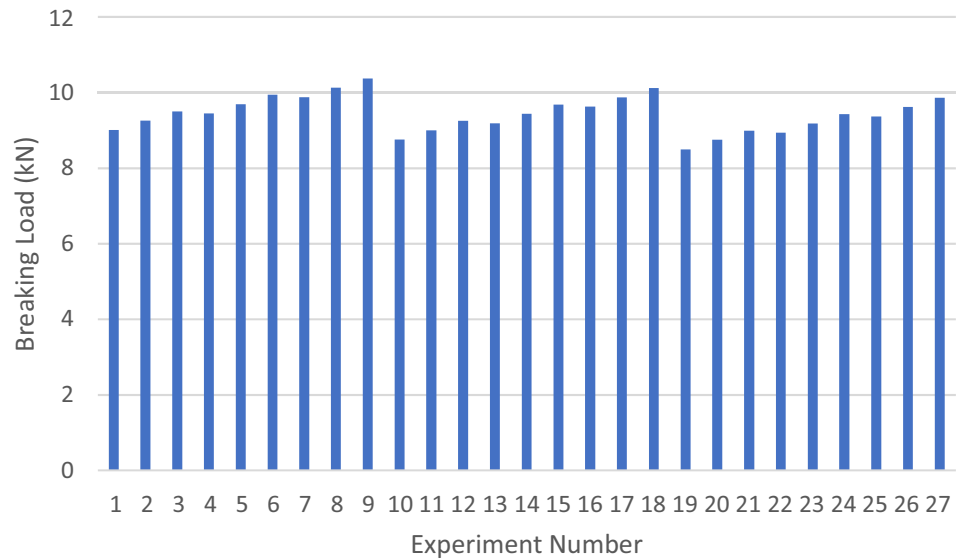
From Table 4, it is evident that, welded joints with SS interlayers outperform bare sheets and copper interlayer in terms of LTT ratio. Before proceeding further, it is important to note that, as welded joints with SS interlayer outperformed significantly, they possess eligibility to be selected for implementation in automotive body. Welded joints with copper interlayer and with bare sheets have been rejected for implementation. Further in this study,

only welded joints with SS interlayer have been considered (Fig. 6).

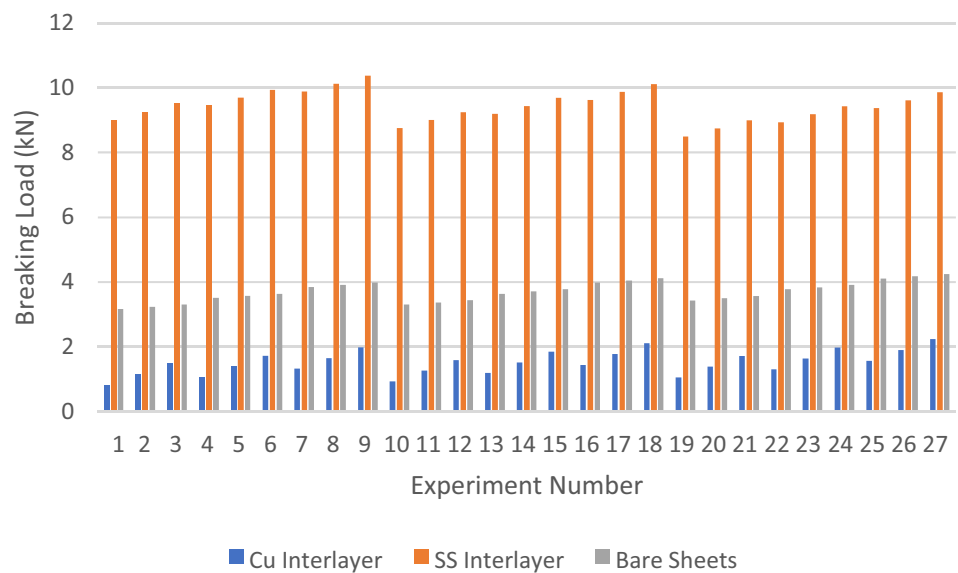
### 3.3 LTT ratio

Temperature above 700 °C invites oxidation layer in Cu-Cr alloys [15] and leads to electrode face corrosion. Oxidation layer on electrode face obstructs clear travel of welding current following overheated electrodes and weak weld

Fig. 5 (continued)



(c)



(d)

nugget. This common problem is faced by each industry and the most practiced remedy is removal of oxidation layer through electrode face machining at time intervals. Figure 7 shows microstructure of oxide layer on Cu-Cr alloy above 700 °C.

From LTW ratio, use of SS layer has been finalized. However, when it comes to feasibility and cost; maintenance time and productivity should also be considered.

As claimed from [15], Cu-Cr alloy starts to gain oxidation layer above 700 °C. It is important to find optimized parameters considering results obtained through LTW ratio along with minimized electrode face machining time.

It is clear that oxide layer starts to form once electrodes exceed 700 °C temperature. Oxide layer continues to form above this temperature. This leads to a proposal

**Table 3** Breaking load for welded joints without interlayer

No.	Current (kA)	Time (cycles)	Electrode force (kN)	Breaking load (kN)
1	5	6	3	3.172
2	5	6	3.4	3.239
3	5	6	3.8	3.307
4	5	7	3	3.512
5	5	7	3.4	3.579
6	5	7	3.8	3.647
7	5	8	3	3.852
8	5	8	3.4	3.919
9	5	8	3.8	3.987
10	5.5	6	3	3.305
11	5.5	6	3.4	3.372
12	5.5	6	3.8	3.439
13	5.5	7	3	3.645
14	5.5	7	3.4	3.712
15	5.5	7	3.8	3.779
16	5.5	8	3	3.985
17	5.5	8	3.4	4.052
18	5.5	8	3.8	4.119
19	6	6	3	3.437
20	6	6	3.4	3.505
21	6	6	3.8	3.572
22	6	7	3	3.777
23	6	7	3.4	3.845
24	6	7	3.8	3.912
25	6	8	3	4.117
26	6	8	3.4	4.185
27	6	8	3.8	4.252

to minimize time for electrode to remain above 700 °C. Another proposal is to find process parameter combinations producing weld nugget strong enough to circumvent electrode corrosion. To address this approach, a novel LTT (Load-to-Time) ratio has been proposed.

LTT ratio considers Breaking Load along with oxidation time for electrodes (i.e. how much time an electrode remains above its oxidation temperature).

$$\text{LTT ratio} = \frac{\text{Breaking load}}{\text{Time for electrode to remain above corrosion temperature} \times K} \text{ (N/s)}$$

While Breaking load is in 10<sup>3</sup> Newton and time is in fraction of a second, denominator doesn't have a significant impact on numerator value. This leads to insensitivity of LTT ratio. To solve this, in denominator of LTT ratio equation, a constant K is multiplied. Value of K is fixed at 1000.

### 3.4 Application of LTT ratio

From LTW ratio, it is evident that welded components with Stainless Steel interlayers outperforms every other combination. This leads to a strong rationale to avoid welded joints without interlayer and with copper interlayer for further consideration in LTT ratio. LTT ratio with SS interlayer helps to discover suitable parameters considering both breaking load and electrode corrosion. To figure out oxidation time with SS interlayer, numerical simulation has been employed.

Commercial FEA solver Simufact.Welding® has been employed and all combinations of DoE for SS interlayer have been simulated. Sheet and electrode dimensions are taken as per Fig. 3. Figure 9a shows bearings, upper and lower sheets, interlayer and direction vector. Both sheets are fixed at far ends with bearings having 0 degree of freedom in all translational and 3 rotational directions. Bearing sizes are decided by inbuilt settings in software and does not affect function of bearing or spot-welding process. Direction vector shows direction of electrode imposition. Pink point beneath direction vector guides electrode imposition such that, center point of electrode face coincides with it. Air-cooling has been enabled for electrodes and their alloy is taken as RWMA 2 Copper alloy class. Mesh size is fixed at 1 mm. As one can see in Fig. 9b, sheets are not parallel. That is because of static behavior of bearings and thrust of electrode force. Material Properties are shown in Table 5. Contact Resistance follows model by Bay and Wanheim [22]. FEA solver has capability to calculate nugget diameter. Nugget diameter value provided by FEA solver has been compared with measured nugget diameter for validation with experimental data. Figure 8 shows measurement procedure of Nugget Diameter (Fig. 9) (Table 6).

From data in Table 7, one can conclude that, in each weld combination, lower electrode has higher time above oxidation temperature. That is why, time for lower electrode is considered in equation of LTT for each experimental combination. It is advised to always use maximum time in LTT equation. Figure 11 shows maximum temperature

vs time curve for both electrodes. It should be noted that maximum temperature node keeps changing with time and not fixed at any point. However, during simulation, maximum temperature node is always attached with electrode face (Fig. 10).

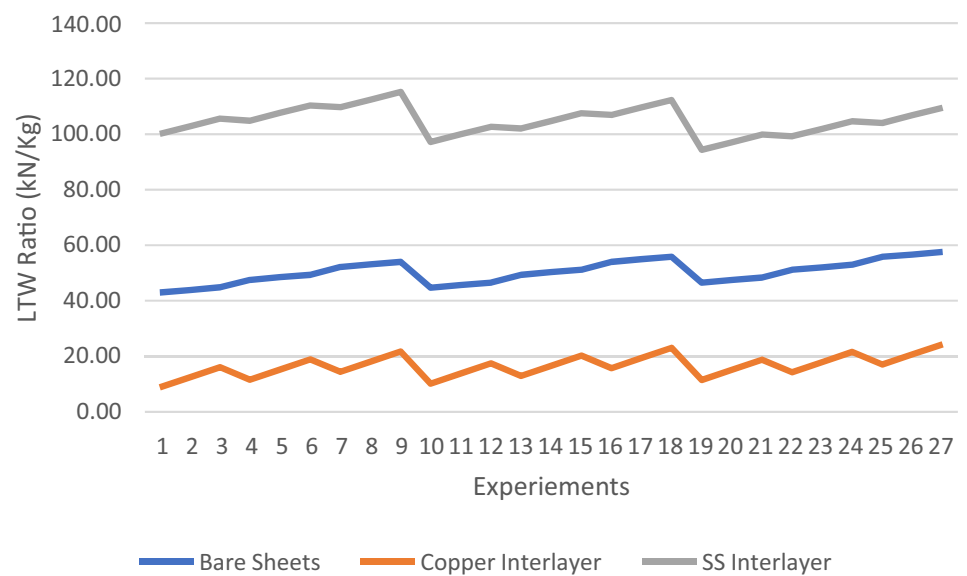
Figure 11 illustrates that LTT Ratio is highest for sample no. 3 and lowest for sample no. 19 Breaking load for

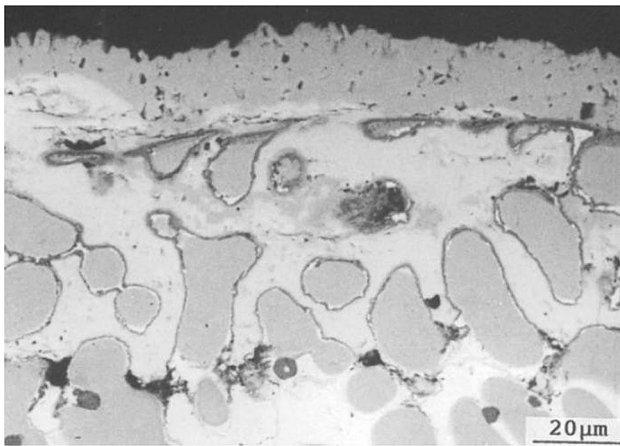


**Table 4** Breaking Load for welded joints with Interlayer

No	Current (kA)	Time (Cycles)	Electrode force (kN)	Breaking load (Cu Interlayer) (kN)	Breaking load (SS Interlayer) (kN)
1	8.25	7	4.2	0.812	9.012
2	8.25	7	4.6	1.143	9.258
3	8.25	7	5	1.475	9.505
4	8.25	8	4.2	1.070	9.447
5	8.25	8	4.6	1.401	9.693
6	8.25	8	5	1.733	9.940
7	8.25	9	4.2	1.328	9.882
8	8.25	9	4.6	1.659	10.128
9	8.25	9	5	1.991	10.375
10	9.35	7	4.2	0.935	8.755
11	9.35	7	4.6	1.267	9.002
12	9.35	7	5	1.598	9.249
13	9.35	8	4.2	1.193	9.190
14	9.35	8	4.6	1.525	9.437
15	9.35	8	5	1.856	9.684
16	9.35	9	4.2	1.451	9.625
17	9.35	9	4.6	1.783	9.872
18	9.35	9	5	2.114	10.119
19	10.45	7	4.2	1.058	8.498
20	10.45	7	4.6	1.390	8.745
21	10.45	7	5	1.721	8.992
22	10.45	8	4.2	1.316	8.933
23	10.45	8	4.6	1.648	9.180
24	10.45	8	5	1.979	9.427
25	10.45	9	4.2	1.574	9.368
26	10.45	9	4.6	1.906	9.615
27	10.45	9	5	2.237	9.862

**Fig. 6** LTW Ratio





**Fig. 7** Microstructure with oxidation on surface of Cu-Cr alloy above 700 °C [21]

**Table 5** LTW Ratio values (kN/Kg)

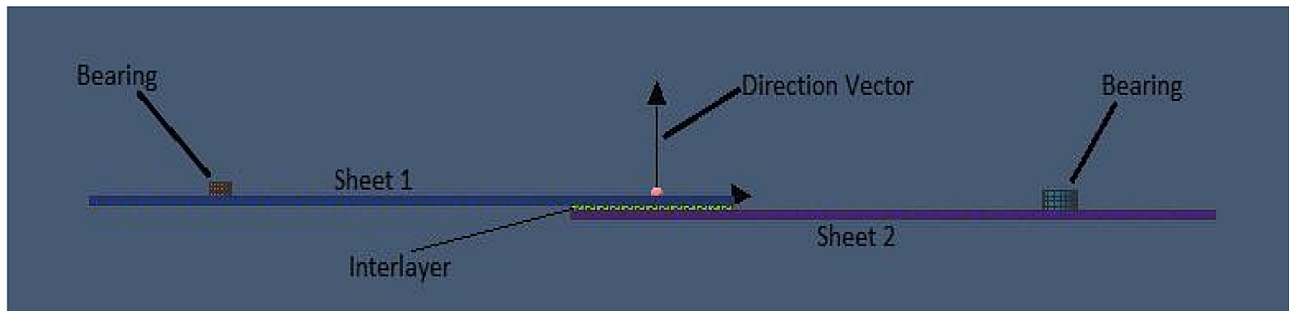
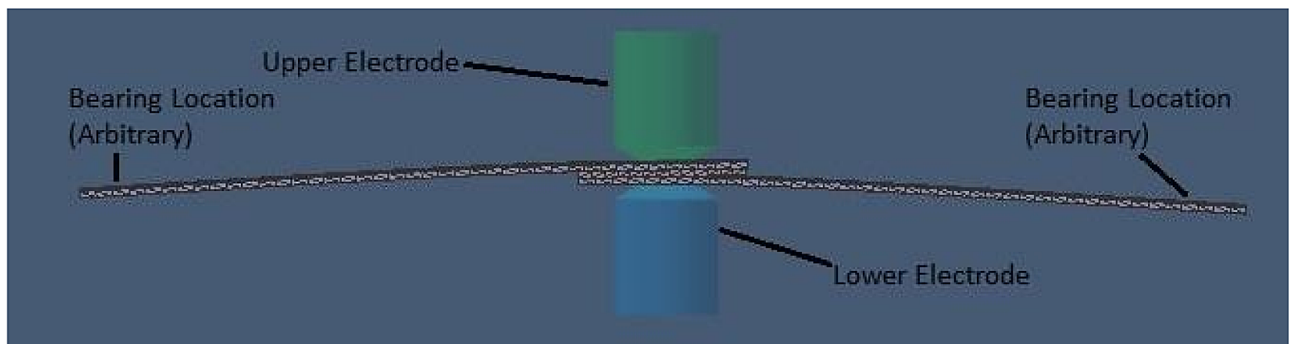
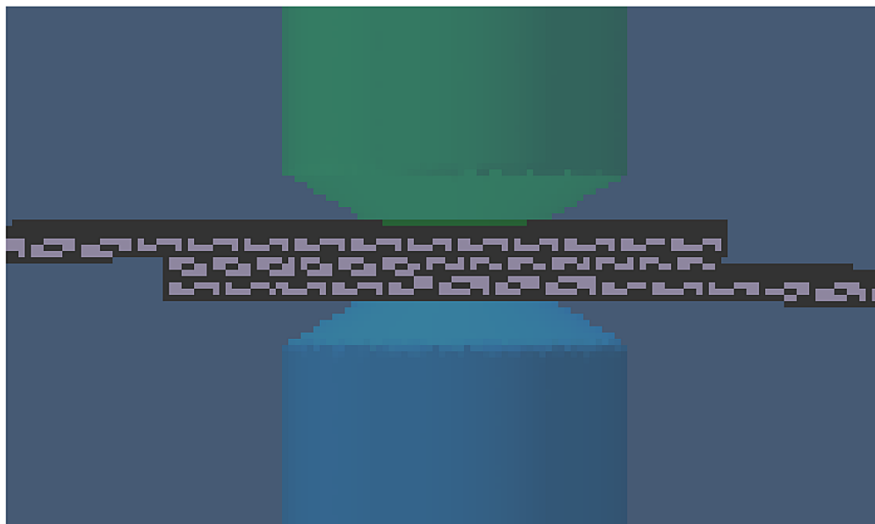
No	Bare sheets	Copper inter-layer	SS interlayer
1	43.04	8.84	100.13
2	43.95	12.46	102.87
3	44.87	16.07	105.61
4	47.65	11.65	104.96
5	48.56	15.27	107.71
6	49.48	18.88	110.45
7	52.27	14.46	109.80
8	53.18	18.08	112.54
9	54.10	21.69	115.28
10	44.84	10.19	97.28
11	45.75	13.80	100.02
12	46.66	17.41	102.76
13	49.46	13.00	102.11
14	50.37	16.61	104.85
15	51.28	20.22	107.60
16	54.07	15.81	106.94
17	54.98	19.42	109.69
18	55.89	23.03	112.43
19	46.64	11.53	94.43
20	47.56	15.14	97.17
21	48.47	18.75	99.91
22	51.25	14.34	99.26
23	52.17	17.95	102.00
24	53.08	21.56	104.74
25	55.86	17.15	104.09
26	56.78	20.76	106.84
27	57.69	24.37	109.58



**Fig. 8** Measurement of Nugget Diameter

run no. 3 is 9.5 kN and time for oxidation temperature is 1.06 s. For run no.19, breaking load is 8.5 kN and time for oxidation temperature is 1.38 s. Other two worthy candidates are sample no. 6 and sample no. 9. Oxidation time for sample 6 is 0.92 s and 0.96 s for sample 9. One can clearly notice slim oxidation time difference among sample 3,6 and 9. They can be proclaimed as suitable combinations for implementation in industrial practices (Table 8).

It is recommended to industries that first LTW ratio should be calculated for all available and feasible parameters according to industrial conditions and machine configurations. Later LTT ratio should be calculated considering welding electrode corrosion. LTT ratio also provides information about maintenance of welding electrodes. An industry can easily schedule its maintenance with LTT ratio.

**(a)****(b)****(c)****Fig. 9** **a** Geometry setup **b** Welding Procedure Simulation **c** Enlarged view of welding location

**Table 6** Material Properties for numerical simulation

Material Property	Copper Electrodes [24]	AISI 1020 [23]	SS304 [23]
Thermal conductivity (W/m.K)	324	48.9	14
Electrical resistivity ( $\mu\Omega\cdot\text{m}$ )	0.0216	0.292	0.72
Coefficient of thermal expansion (Linear) ( $\mu\text{m}/\text{m}\cdot\text{K}$ )	17.6	14.8	18.7
Melting point (K)	1348	1789	1723
Density (Kg/m <sup>3</sup> )	8890	7870	8000
Specific Heat (KJ/Kg.K)	0.385	0.599	0.500

**Table 7** Nugget diameter (Predicted and measured)

Exp. No	Nugget diameter (Numerical simulation) (mm)	Nugget diameter (Experimental) (mm)	Difference (mm)
1	4.25	4.46	0.21
2	4.62	4.39	0.23
3	4.50	4.32	0.18
4	4.76	4.89	0.13
5	4.94	4.83	0.11
6	5.02	4.76	0.26
7	4.98	5.33	0.35
8	5.09	5.26	0.17
9	5.39	5.20	0.19
10	4.95	4.69	0.26
11	4.38	4.62	0.24
12	4.78	4.55	0.23
13	5.43	5.13	0.30
14	5.36	5.06	0.30
15	5.28	4.99	0.29
16	5.17	5.56	0.39
17	5.06	5.51	0.45
18	4.87	5.43	0.56
19	4.59	4.92	0.33
20	5.26	4.85	0.41
21	5.02	4.79	0.23
22	5.18	5.36	0.18
23	5.65	5.29	0.36
24	4.75	5.22	0.47
25	5.36	5.79	0.43
26	5.52	5.73	0.21
27	5.39	5.66	0.27

## 4 Conclusion

Resistance Spot Welding of low-carbon steel AISI 1020 sheets with interlayer (copper and stainless steel) and without interlayer were spot welded and their Breaking Load was determined. An attempt to justify use of interlayer considering weight and electrode corrosion has been made.

- For feasible use of interlayer considering weight, a novel LTW (Load-to-Weight) ratio has been proposed. Samples with stainless steel interlayers outperformed every other experimental combination regarding LTW ratio.
- For electrode corrosion, oxidation temperature for electrodes has been found from previous studies. Oxidation time (i.e. how much time an electrode remains above oxidation temperature) during one welding cycle has been calculated through numerical simulation.
- From breaking load and oxidation time, a novel LTT (Load-to-Time) ratio has been proposed. Calculated LTT ratio for all experimental combinations of stainless-steel interlayer showed some experimental combinations outperforming others.
- Suitable experimental combinations of stainless-steel interlayer selected through LTT ratio can be implemented in automotive industries.
- This method of primarily calculating LTW ratio followed by LTT ratio is recommended to industries for ensuring feasibility of using interlayer in terms of lightweightness and electrode corrosion.

In any automotive body, nearly 1500 locations are spot welded. Use of interlayer at all these locations increase weight of an automotive body significantly and affects industries monetarily. It is advised to run some studies before implementation of interlayer to figure out critical locations for use of interlayer instead of entire automotive body.

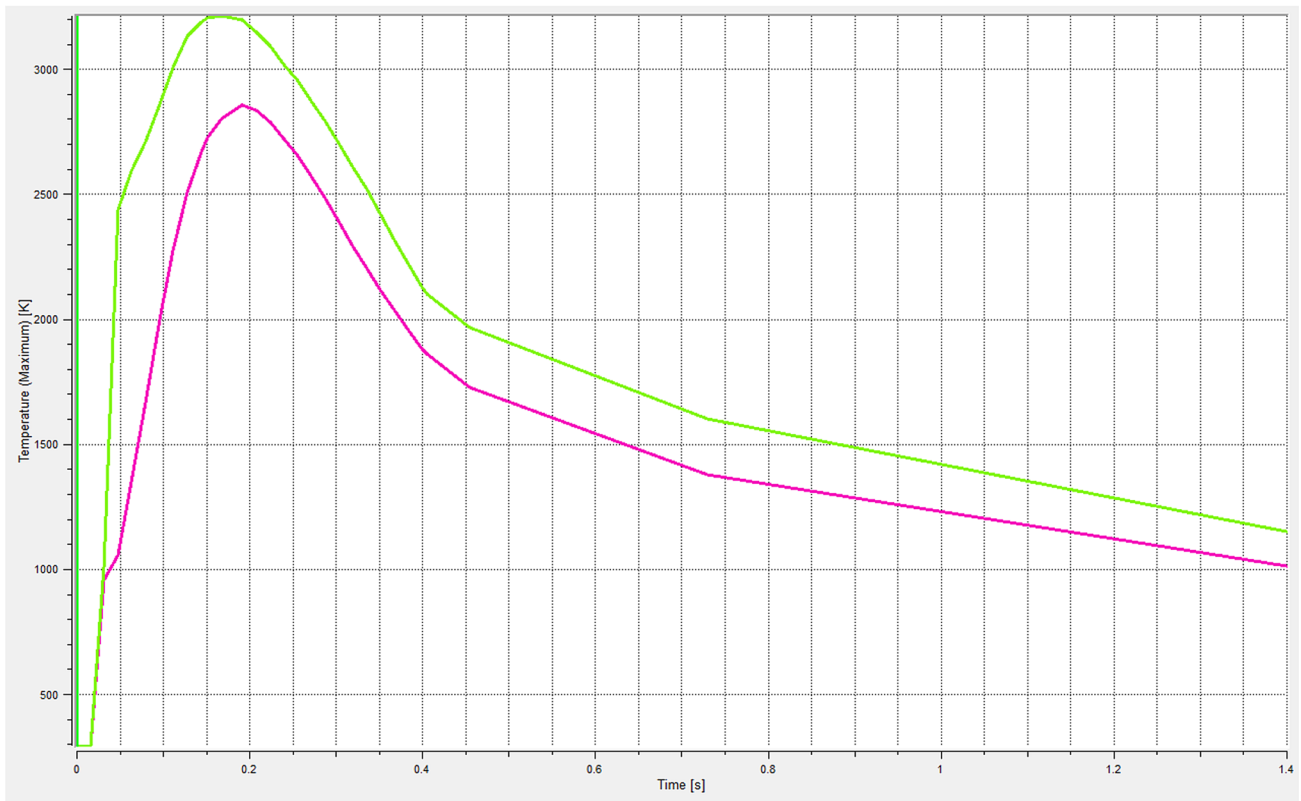
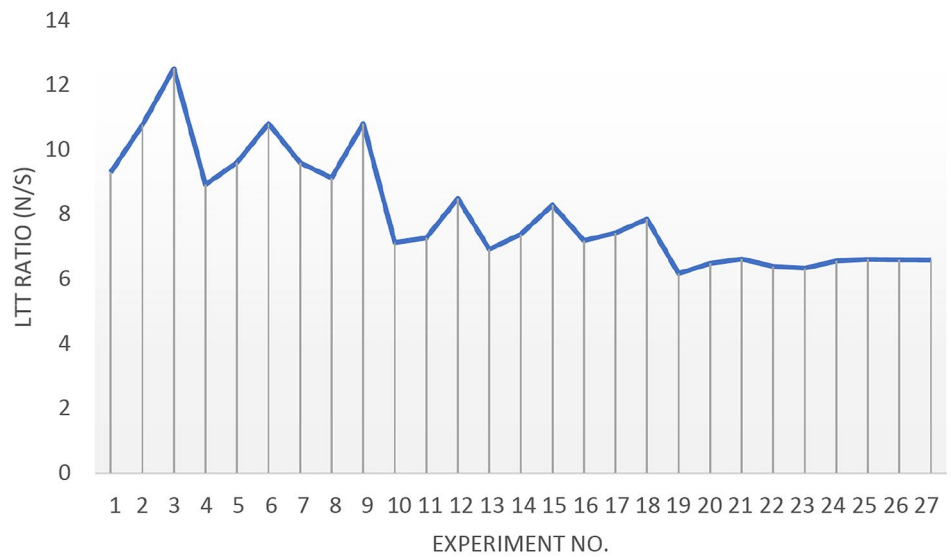


Fig. 10 Maximum temperature vs time for run no.3 at lower electrode (green), upper electrode (pink)

Fig. 11 LTT ratio for SS inter-layer



**Table 8** Time for electrodes prone to corrosion

No	Parameters			Time above 700 °C (s)	
	Current	Time	Electrode Force	Upper electrode	Lower Electrode
1	8.25	7	4.2	0.79	0.97
2	8.25	7	4.6	0.71	0.86
3	8.25	7	5	0.74	0.76
4	8.25	8	4.2	0.85	1.06
5	8.25	8	4.6	0.82	1.01
6	8.25	8	5	0.76	0.92
7	8.25	9	4.2	1.07	1.03
8	8.25	9	4.6	0.9	1.11
9	8.25	9	5	0.81	0.96
10	9.35	7	4.2	1.08	1.23
11	9.35	7	4.6	1.03	1.24
12	9.35	7	5	0.87	1.09
13	9.35	8	4.2	1.05	1.33
14	9.35	8	4.6	1.06	1.28
15	9.35	8	5	0.93	1.17
16	9.35	9	4.2	1.14	1.34
17	9.35	9	4.6	1.11	1.33
18	9.35	9	5	1.03	1.29
19	10.45	7	4.2	1.23	1.38
20	10.45	7	4.6	1.22	1.35
21	10.45	7	5	1.16	1.36
22	10.45	8	4.2	1.36	1.4
23	10.45	8	4.6	1.37	1.45
24	10.45	8	5	1.3	1.44
25	10.45	9	4.2	1.41	1.42
26	10.45	9	4.6	1.38	1.46
27	10.45	9	5	1.36	1.5

## Declarations

**Conflict of interest** On behalf of all authors, the corresponding author states that there is no conflict of interest.

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