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Electrically Assisted Augmentation of the Forming Process

Abram Pleta
Clemson University

Harshal Date
Clemson University

Dr. Durul Ulutan
Clemson University

Dr. Laine Mears
Clemson University

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Abram Pleta, Harshal Date,
Dr. Laine Mears, Dr. Durul Ulutan
Clemson University - ICAR
apleta@clemson.edu, hdate@clemson.edu,
mears@clemson.edu, dulutan@clemson.edu,

ABSTRACT:
Fuel economy standards are getting increasingly stringent over the period of time. Automotive OEMs are required to pay penalties to the government if their vehicles fail to meet the Corporate Average Fuel Economy (CAFE) standards. One of the techniques to improve fuel economy is vehicle lightweighting. Hence, OEMs demand their suppliers to individual materials with increased strength to weight ratios. Advanced high strength steels (AHSS) may serve this purpose, but they have poor formability and high springback characteristics. Advanced high strength steels such as TRIP exhibit good formability but their high alloying content adversely affects their weldability and high cost of production makes it infeasible for these materials to be put to use on a large scale. Electrically assisted forming has been proposed as a means of reducing cold stamping tonnage, improved ductility and eliminating springback. The increasing maturity of research on electrically assisted forming has developed to a point where it can be introduced onto a manufacturing scale. The objective of this project is to study various parameters related to electrically assisted forming and translate a research level idea into a production level process. This will allow introduction of AHSS like Dual Phase steels into the automobile industry and help contribute to overall lightweighting of a vehicle, which, in turn, improves sustainability.

INTRODUCTION:

- The main objective of electrically assisted augmentation of the forming process is to improve the formability of advanced high strength steels (AHSS).
- It will reduce the cold stamping tonnage and residual stresses, improve ductility and eliminate the springback effect. This is due to the increased rate of relocalization of electrons.
- Dual phase steels have excellent strength characteristics but very low ductility. Electrical augmentation would help improve this characteristic, thus helping reduce sheet thickness and contributing toward lightweighting – seats in this particular application.

EXPERIMENTAL SETUP:

It primarily consists of three tests – uniaxial tension test, air bending and wiping die. The parameters investigated for each test are as described in the table alongside.

Table: Test parameters

Parameters Investigated	*Uniaxial Tension*	*Air Bending*	*Wiping Die*
Current Density	●	●	●
Pulse Duration	●	●	●
Pulse Period	●	●	●
Stress Reduction	●	●	●
Ductility Improvement	●	●	●
Springback Reduction	○	●	●
Flow Path	○	○	●
Length of Flow Path	○	○	●

Uniaxial Testing:

- This test is used to identify baseline properties of dual phase steel such as yield point, tensile strength and failure mode.
- Current density, pulse duration and pulse period are evaluated after preliminary screening so as to find electrical threshold.
- The sample cutting is done according to ASTM standards as specified for the dual phase steel. Test is conducted on the Instron machine.
- The results of square wave input and continuous current input waveforms on DP 780 steels are shown in the figure below.

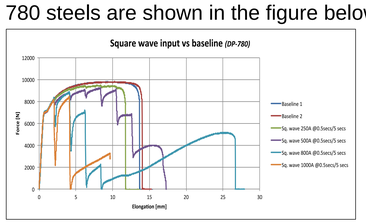


Fig: Square wave input

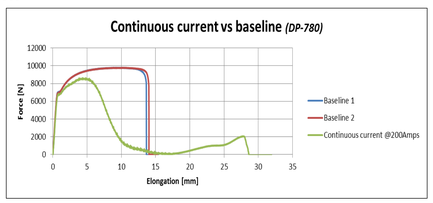
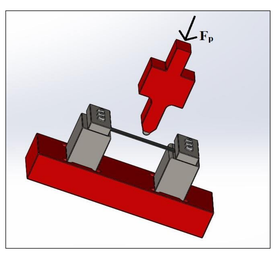
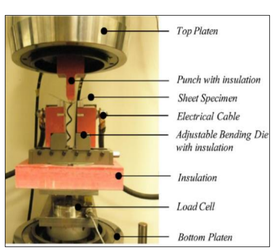


Fig: Continuous current input

Air Bending:

- The purpose of air bending test is to evaluate springback characteristics and reduction/elimination through electrical assistance in AHSS.
- 2 bending radii are used so as to assist with the wiping die design.
- The parameters to be varied include current density, pulse duration and pulse period. The analysis of variation of these parameters is used to determine optimal characteristics.
- For electrical assistance, the design has to have good insulation at both clamp ends in order to avoid dangerous situations. For this purpose, we used 'Haysite', which has excellent electrical insulation, can handle temperatures up to 200^0 C and has enough strength to withhold the ram forces.
- The overall goal for air bending is to establish a relation between electrical current, flow stress reduction and springback elimination in dual phase steels.





- The results of springback and load characteristics for air bending on DP 780 steels are as shown below.

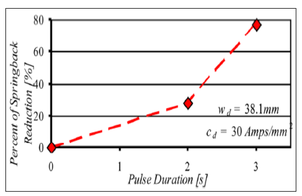


Fig: Springback reduction

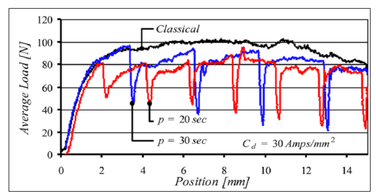
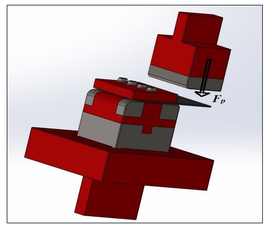
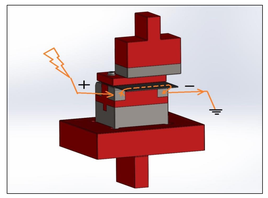


Fig: Load characteristics

Wiping die design and test:

- Wiping die test will allow us to investigate effects of varying electrical flow paths and path lengths in addition to the parameters already investigated in the above tests. This will allow for improvement in existing EA models and can potentially establish new models which will depend also on length of plastic deformation zone and thickness
- The test will be conducted on two DP 980 sheets 1 mm and 1.2 mm thick respectively.
- The figures alongside show the wiping die design and experimental plan; and the table shows an initial calculation of load reduction (non experimental)
- The table right below shows die force calculations based on the wiping die force formula by Kalpakjian - $F_{max} = k\frac{(UTS)Lt^2}{W}$
- The results in the table are a rough estimate of what to expect when the experiments are conducted.





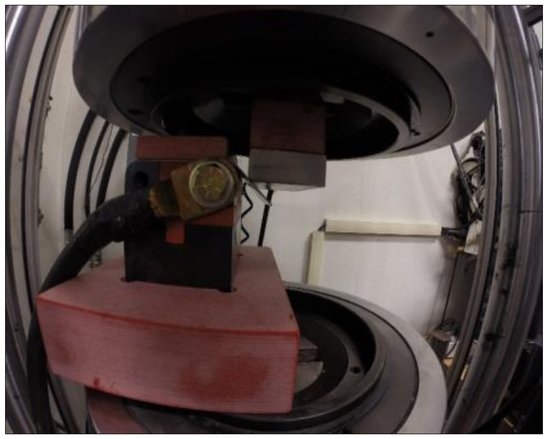


Fig: Wiping die design

Quantity	Symbol	DP 780 Steel				DP 980 Steel			
		1.2 mm thickness sheet		*1 mm thickness sheet*		*1.2 mm thickness sheet*		*1 mm thickness sheet*	
k-Factor	k	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33
Sheet Thickness	t	1.2 mm	1.2 mm	1 mm	1 mm	1.2 mm	1.2 mm	1 mm	1 mm
Die Radius	R	5 mm	10 mm	5 mm	10 mm	5 mm	10 mm	5 mm	10 mm
Punch Radius	r	5 mm	5 mm	5 mm	5 mm	5 mm	5 mm	5 mm	5 mm
Ultimate Tensile Strength	UTS	780 MPa	780 MPa	780 MPa	780 MPa	980 MPa	980 MPa	980 MPa	980 MPa
Part Length	L	50 mm	50 mm	50 mm	50 mm	50 mm	50 mm	50 mm	50 mm
t + R + r	W	11.2 mm	16.2 mm	11 mm	16 mm	11.2 mm	16.2 mm	11 mm	16 mm
Wiping Force (N)		*1655*	*1144*	*1170*	*804*	*2079*	*1437*	*1470*	*1011*
20% Reduction		*1324*	*915*	*936*	*643*	*1663*	*1150*	*1176*	*809*
70% Reduction		*497*	*343*	*351*	*241*	*624*	*431*	*441*	*303*

Table: Bending force calculations

CONCLUSION AND FUTURE SCOPE:

The results of wiping die test will help us further improvise on electrical assistance in forming, which, in turn will contribute toward vehicle lightweighting. Also, with optimized process parameters based on results, total energy consumption can be reduced and hence the cost of manufacturing, if put to use on a wide scale. This research can be extended to components other than seating assembly and will eventually contribute towards better sustainability in the industry.

ACKNOWLEDGEMENTS:

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