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Investigation of formability of CRCA Steel sheet by Erichsen Cupping Test analysis

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Abstract: *The forming behaviour of cold rolled closed annealed steel sheet in Selected samples with proper annealing and chemical composition for better formability was investigated by Erichsen Cupping test method. The results showed that the formability of cold rolled closed annealed steel having lower percentage of carbon is lesser forming property and ductility. It was found that the stress distribution and the grain density of the sheet material confirm the formability. The best combination of strength and ductile properties has steel with the low carbon and better forming property.*

Key Words: *Formability; Low Carbon steel; Mechanical properties:re-crystallization; sheet metal.*

I. Introduction

Oliveira et al. (2005) explained thatSheet metal forming processes often involve high rates of deformation. Electromagnetic pulse forming (magnetic pulse forming),hydro forming and explosive forming are obvious examples, but also in more conventional sheet forming techniques, such as deep drawing, roll forming and bending, locally high strain rates occur deviating from those used in static material tests. Mala Seth et al. (2005) reported thathigh velocity deformation can be quite effective in increasing theforming limits of metal sheets as well as effectively treating some other common metal forming problems, such as wrinkling and distortion. This study examines the highvelocity formability of cold rolled sheet steel as developed in impact with a curved punch.T.B. Stoughton et al. (2000) revealed a fundamental problem in sheet metal forming is fracturing.It is therefore essential to be able to predict the risk of fracture with high accuracy.The forming limit curve (FLC) is the most commonly used fracture criterion for sheet metal forming applications.New fracture criterions have been developed but no one has yetcome to general practical use in the automotive industry

II. Experimental Details

Material and sample preparation

The materials used for research are CR1, CR2, CR3, and CR4. The chemical composition of these four samples tested by Spectro Chemical Analysis as per specification of Indian Standard 513 of 2008 Edition and the results are shown in Table 1.

Table 1: The chemical composition of CRCA steel (wt. %).

CR1	Element	C	Mn	P	S
	Atomic %	0.15	1.40	0.019	0.007
CR2	Element	C	Mn	P	S
	Atomic %	0.08	0.30	0.014	0.008
CR3	Element	C	Mn	P	S
	Atomic %	0.02	0.12	0.011	0.007
CR4	Element	C	Mn	P	S
	Atomic %	0.01	0.14	0.010	0.014

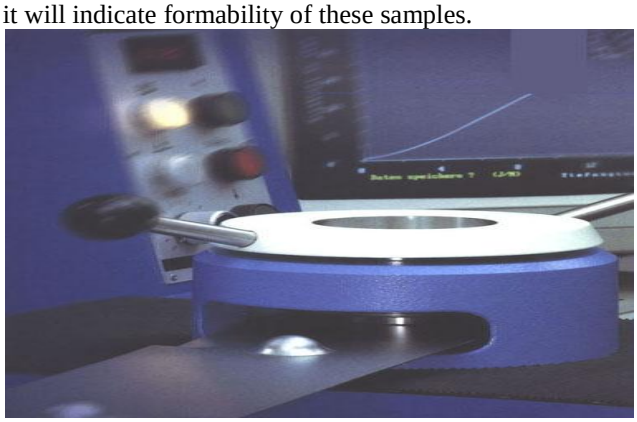
High strength cold rolled steel having low carbon is continuously annealed at the temperature of 750ºC to produce uniform strength. The holding time should be not less than 20 sec. The preferable range is 20 sec to 3min.CR1 is a commercial(ordinary) quality "O" grade as per Indian standard:513 2008 specifications. CR2 is a drawing quality "D" grade as per Indian standard: 513 2008 specifications. CR3 is a deep drawing Quality "DD" grade as per Indian standard: 513 2008 specifications.CR4 is an extra deep drawing quality "EDD" grade as per Indian standard: 513 2008 specifications.

Cupping test setup

The Cupping Testing Machine is precise technology testing machine which is used for sheet metal & strip steel rolled stock etc. It can complete test of plastic deformation and formability for sheet metal & strip steel rolled stock. It conforms to IS 513 2008. This machine is having the features like, Thickness of sheet

metal: 0.2-2mm, Width of sheet metal: 90-100mm, Stroke of punch: 40mm, Max. Clamping test load: 60kN, Max. Clamping load: 25kN, Specifications of cupping grips, Standard punch ball: φ20±0.05mm, Standard pattern hole: φ33±0.1mm etc.

The Erichsen cupping test is a ductility test, which is employed to evaluate the ability of metallic sheets and strips to undergo plastic deformation in stretch forming. The test consists of forming an indentation by pressing a punch with a spherical end against a test piece clamped between a blank holder and a die, until a through crack appears. The depth of the cup is measured. The depth of cup is proportional to the formability of sheet metal. As shown in figure1, sheet metals of selected samples are clamped between blank holder and die until a crack appears. And it will indicate formability of these samples.



III. Result And Discussions

Microstructure of Sheet Metal

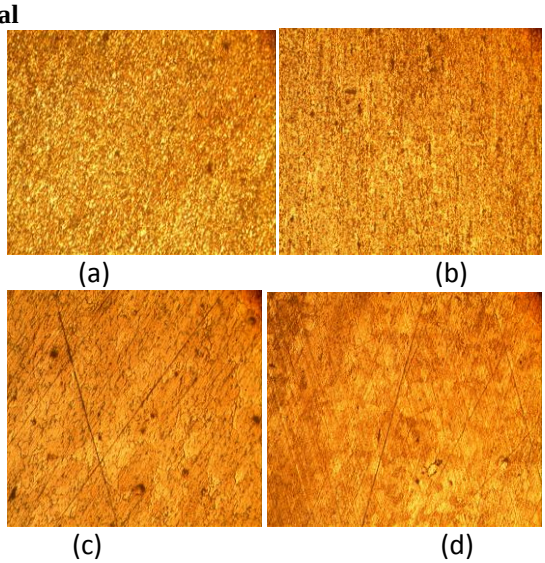


Fig. 2.Microstructure of the sample (a) CR1 (b) CR2 (c) CR3 and (d) CR4

Coarse initial grain size had a great influence on the microstructure, hardness of low carbon steel. Grain size number below ASTM number 3 represents definitely coarse grained steel and above ASTM number 6 represents reasonably fine grained steel. Fig.2 is showing microstructure related with the samples CR1, CR2, CR3 and CR4 respectively.

Table 2: Grain Size and Hardness for Selected Samples

Sr No	Sample	Grain size	Hardness(HV5)	Structure
1	CR1	6-7	201	Ferrite and pearlite
2	CR2	6-7	109	Ferrite and pearlite
3	CR3	4-5	89	Ferrite and pearlite
4	CR4	4-5	88	Ferrite and pearlite

Table 2 reveals the results related to the microstructure shown in figure 2. CR1 and CR4 are showing higher

grain size compared to other samples.The samples which are higher hardness are showing less ductility.
Fig. 1.Cupping Test Set- up.

Fine grain size is also reflection of hardness.CR3 and CR4 are showing similar grain size but CR4 is having less hardness.CR4 is having better ductility compared to other two samples. Because of less grain size, CR4 is subjected to higher ductility.
For ensuring the formability of selected samples, the cupping test was performed which showed different results for different samples as discussed under.

Forming Behaviour of CRCA Sheet Metal

With the help of cupping testing machine, forming behaviour of CRCA sheet metal of different samples is evaluated. The results obtained through this test are shown in table3.

Table 3: Cupping test results for Selected Samples

Sr.No.	samples	Depth of Cup(mm)
1	CR1	10.75
2	CR2	12.50
3	CR3	12.70
4	CR4	13.50

According to testing method of IS-10175 Part-1:1993, the sheet metal specimen in the form of strip is inserted into the test cylinder and centralized by locating diagonally. The sheet holder force of 10 kN (in accordance with the standard) is adjusted using a special regulating valve, and the actual cupping process is initiated by selecting the standardized drawing speed on the speed regulator. Since the testing machine is equipped with the function "automatic stop at specimen failure" the for- ward speed is automatically stopped when the crack occurs, so that in any case an objective test result is achieved. The cupping value is displayed with an accuracy of 0.01 mm on the digital counter.

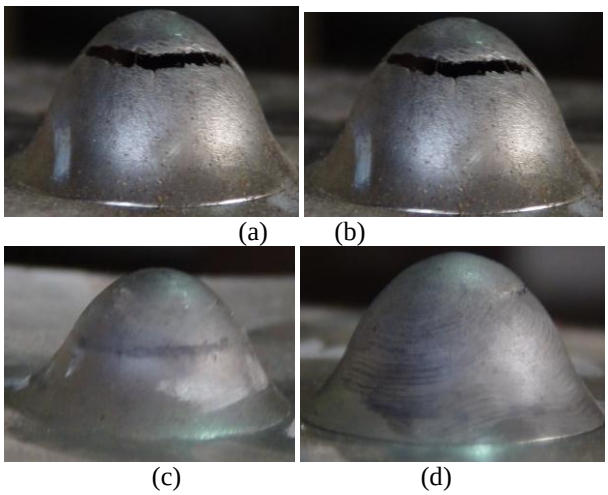


Fig. 3. Specimen after Test (a) CR1, (b) CR2, (c) CR3, (d) CR4

After performing the cupping test as shown in figure 3, the depth of cup for specimen CR4 is 13.50mm which is higher than other samples. And this is the indication of higher formability. As the material of CR1 is hard as described earlier after performing cupping test, crack appears at a depth of 10.75mm that is having less formability. CR1 is hard compared to other material as it is having high percentage of carbon.If this material is compared with all three materials, this material (CR1) is not desirable.
As CRCA material is used for transformer radiator fin sheet forming and automobile industry in which car body is manufactured. For such application formability of material is having vitalrole. Because of Enrichsen cupping, it easy to evaluate the formability of cold rolled and closed annealed sheet metal of various grads. After performing the cupping test, CR4 is showing excellent formability which will be desirable material for given application.

IV. Conclusion

1. Carbon percentage is less in CR4 other than three samples because of less grain in unit area as compared to other three samples.
2. The grain size of CR4 material is smaller than the other steels indicating bigger size of grain with low grain boundary area making the material ductile with less week spots.
3. Large surface area of grain and less boundary area confirm that CR4 is more soft and ductile in nature as compared to other three samples.
4. Fine grain structures give more grain boundaries and hence development of internal stress whereas a CR4 has better stress relief property because of less number of grains.
5. Better formability in CR4 as compared to other three samples and therefore more depth in forming can be achieved.

References

[1]. Mala Seth, Vincent J. Vohnout, Glenn S. Daehn, Formability of steel sheet in high velocity impact, Journal of Materials Processing Technology 168 (2005) 390–400.
[2]. Oliveira, D.A., Worswick, M.J., Finn, M., Newman, D., 2005. Electromagnetic forming of aluminium alloy sheet: free-form and cavity fill experiments and model. J. Mater. Process. Technol. 170, 350–362.
[3]. T.B. Stoughton, A general forming limit criterion for sheet metal forming, Int. J. Mech. Sci. 42 (2000) 1–27.)