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Experimental and numerical investigation of spring back in compacting process of aluminum-coil waste

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Abstract: In this paper the spring back in end-aluminum-coil is studied during the compacting process. For this purpose, one coil end with the plate thickness of 0.7 mm, cylindrical diameter of 1000 mm and cylindrical length of 1300 mm has been compressed in three directions by a three axial press machine, which finally, this coil end transforms into a 800 × 600 × 200 cube. The spring back amount of this coil end has been measured experimentally. On the other hand, the entire compression process has been also simulated in ABAQUS software and the required forces for compression and also spring back amount has been also calculated numerically and the results have been compared with the experimental results which are in good agreement.

Keywords: Experimental Analysis; spring back; Finite Element Analysis

1. Introduction

The aluminum waste coils are always troublesome in metal rolling factories due to the large volume which they occupy. Meanwhile, their transportation to melting ovens in order to recycle them is also very difficult. Therefore, their compression yields to easy transportation to melt ovens while their occupancy volume would also reduce and their storage would be easier.
The required force for compressing these coils have been calculated with respect to the plastic deformation provided in the coil [1]. Noteworthy is that if the compression force would be small or in other words, if the plastic deformation provided in the material would be small, the elastic deformation of the material would get back to its initial condition after unloading which is called spring back [2]. The spring back amount can be calculated by analytical method in simple

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problems while in complex geometries, there is no analytical solution. Thus, the problem has to be solved using numerical or experimental methods.

In this paper the spring back in end-aluminum-coil is studied during the compacting process. For this purpose, one coil end with the plate thickness of 0.7 mm, cylindrical diameter of 1000 mm and cylindrical length of 1300 mm has been compressed in three directions by a three axial press machine, which finally, this coil end transforms into a 800 × 600 × 200 cube. The spring back amount of this coil end has been measured experimentally. On the other hand, the entire compression process has been also simulated in ABAQUS software and the required forces for compression and also spring back amount has been also calculated numerically and the results have been compared with the experimental results which are in good agreement.

2. Experimental study

The geometry of the tested specimen has been illustrated in Fig. 1. The coil has an outer diameter of φ=1000 mm and the thickness of the plate is 0.7 mm. The material is made of Aluminum with the mechanical properties given in Table 1.

Fig. 1. Tested specimen

Table 1. Mechanical properties of AL300

Elastic modulus	E (MPa)	70000
Poisson ratio	ν	0.33
Yield stress	Sy (MPa)	110

The test has been conducted by the press machine shown in Fig. 2. This machine is made of two upper and lower (side) cylinder, each with the pressing power of 160 tones and one main longitudinal (main) cylinder with the power of 150 tones.

Fig. 2. Machine test (Compactor machine)

For the test procedure, the studied coil is placed inside the pressing chamber and is compressed by the lower cylinder, the upper cylinder and the longitudinal cylinder, respectively. The cylinder forces have been measured by manometers during the test as shown in Fig. 3. Their values have been given in Table 2.

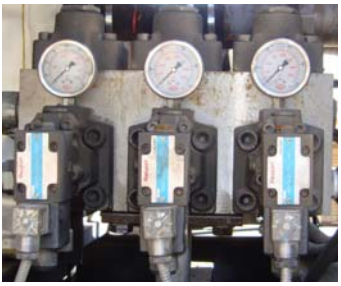

Fig. 3. manometers for measuring the force of cylinders

Table 2. Maximum force of the cylinders during the test

Upper cylinder	Fu (Tonne)	30
Side cylinder	Fs (Tonne)	112
Main cylinder	Fm (Tonne)	150

Next, in the final compression, the compressed specimen length (Fig. 4) is measured once before the unloading and once after the unloading (Fig. 5) and thereby, the spring back amount is calculated according to Table 3.

Fig. 4. Final length of the bale before and after unloading

Fig. 5. Final compacted aluminium-coil waste

Table 3. Experimental determination of spring back's amount

Final length before unloading	206.33 mm
Final length after unloading	210.44 mm
Value of spring back	4.11 mm

3. Numerical study

As it was mentioned earlier, this process has been also simulated by finite element method with the help of ABAQUS software. Fig. 6 depicts the meshed model of the studied problem. According to this figure, the pressing cylinder are modeled as rigid and the coil itself is modeled as first order S4R shell elements.

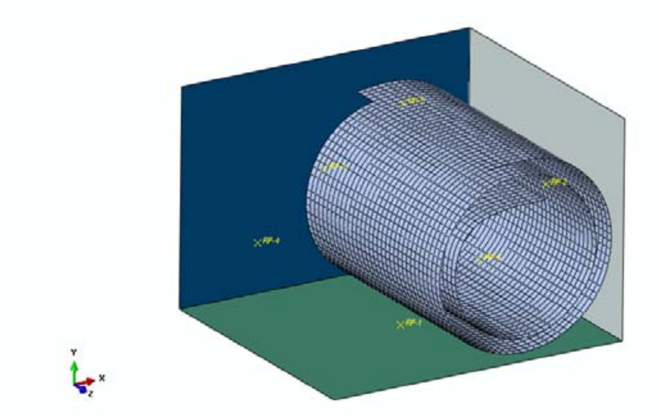

Fig. 6. Finite element model of the problem

Next, the problem is divided to three steps. In the first step, the upper cylinder has displacement of 600 mm. As a result the deformation of the specimen is depicted in Fig. 7.

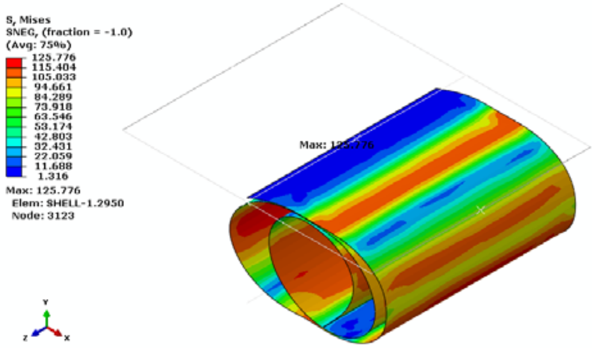

Fig. 7. Finite element result after the first step of the simulation

In the second step, the longitudinal cylinder displaces 900 mm. Therefore, the deformation of the specimen is according to Fig. 8.

In the third step the transverse cylinder displaces 1000 mm. Consequently, the final compressed specimen is shown in Fig. 9.

Afterwards, all the cylinders return to their initial conditions and the spring back amount is measured.

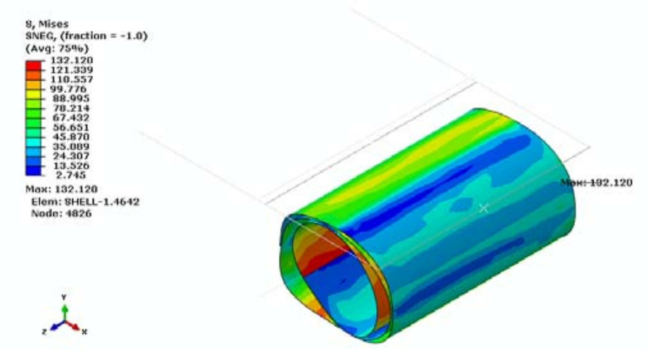

Fig. 8. Finite element result after the second step of the simulation

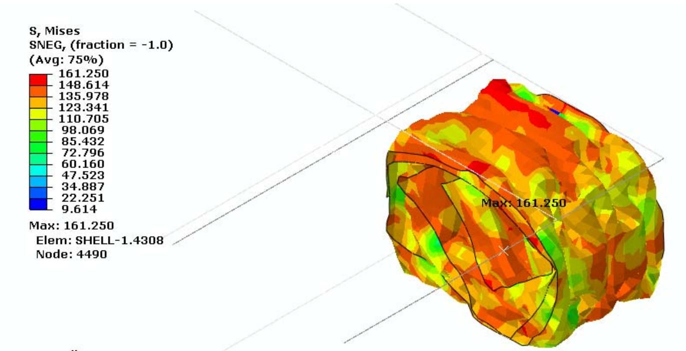

Fig. 9. Finite element result after the third step of the simulation

The maximum forces of the cylinders during the compression and the spring amount measured in this simulation have been given in Table 4.

Table 4. Numerical determination of spring back's amount and cylinder's force

Upper cylinder	Fu (Tonne)	18
Side cylinder	Fs (Tonne)	98
Main cylinder	Fm (Tonne)	143
Value of spring back		3.08 mm

4. Conclusion

Fig. 10 shows the comparison of the tested compressed specimen and the compressed specimen obtained by FEM simulation.

Fig. 10. Comparison between experimental and numerical results

The spring back amount and maximum forces of the cylinders during compression both measured in laboratory and by simulation method have been compared in Table 5, which reveals the fact that they have good coincidence.

Table 5. Comparison between experimental and numerical results

	Experimental	Numerical
Upper cylinder	18 Tonne	30 Tonne
Side cylinder	98 Tonne	112 Tonne
Main cylinder	143 Tonne	150 Tonne
Value of spring back	3.08 mm	4.11 mm

It is necessary to mention that with the increase of compression power (the amount of cylinder displacement) the spring back's amount decreases.

References

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