41. SIMPOZIJ AKTUALNI ZADACI MEHANIZACIJE POLJOPRIVREDE

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MECHANICAL PROPERTIES OF PROFILES FROM RECYCLED AGRICULTURAL PLASTIC WASTE MIXED WITH WOOD POWDER

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SUMMARY

In recent years the concern about plastic waste from agriculture has raised significantly. A growing social and political awareness on environmental issues has led to laws and regulations aimed at controlling and reducing waste production, encouraging recycling and reuse as well.

The mechanical recycling of polymers determines a loss of some of their original chemical, physical and mechanical properties due to the role played by some of the degradation factors (UV radiation, thermal stress, agrochemicals etc.) that they were subjected to during their working life. The properties of the regenerated material can however be improved through the addition in the plastic mixture of other material, such as wood, glass, calcium etc.

In this paper, the properties of plastic profiles obtained through mechanical recycling of agricultural plastic material mixed with wood powder (70% LDPE + 30% wood powder) were analyzed. The results of the tensile, compression and bending tests here reported show that the mixture of recycled plastic from agricultural application with a suitable different material could be considered as an interesting option for the improvement of the mechanical characteristics of these new regenerated products.

Key words: *agricultural plastic waste, plastic bars, wood powder, mechanical properties*

INTRODUCTION

Current intensive and semi-intensive agricultural practices used throughout Mediterranean Countries require the use of large quantities of plastics, 615000 tons in 2004 (Briassoulis and Dejean, 2010), due to the benefit resulting in increased yield, earlier harvest, less reliance on herbicides and pesticides and less water consumption (Djevic and Dimitrijevic, 2009; Briassoulis, 2005).

In recent years the concern about plastic waste has raised significantly (Lopez et al 2007). Parallel to this, there has been a growing social and political awareness of environmental issues that has led to the passing of laws and regulations of all kinds in an attempt to control and reduce waste production, and to encourage recycling and reuse.

Recycling of plastic waste is not new (La Mantia et al, 1996). The first industrial applications in Japan date from 1973. It is well known that it is possible to manufacture rods, stakes, bars, boards, plates, etc. from mixed plastics waste but the mechanical properties of these products are worse since there are some factors having a negative influence on the quality of this “secondary raw material”, when the polymers are reprocessed, so some of their chemical, physical and mechanical properties can worsen (Scarascia-Mugnozza et al, 2006; Sica, 2000).

The mechanical properties of the recycled material may be also influenced by the presence of other factors, such as additives. For example the addition of starch to LDPE blends increases the tensile strength and the elongation at break and reduces the Melt Flow Index values (Pedroso et al, 2004). One of the possibilities to improve the properties of plastic products is using diverse fillers like talc, calcium carbonate, HDPE, densified PE (Sica et al, 2008; Scarascia-Mugnozza et al, 2010).

Previous research on some recycled PP composites with two types of wood fibres regarding their mechanical and dynamic properties carried by Liber-Knec et al (2006) showed that elasticity modulus of investigated composites improved considerably, while strength remained more or less constant, showing rather a marginal decrease. Elongation at break decreased significantly after adding wood fibres. Also modulus of elasticity was affected, which was about 15 % higher for PP composite with wood fibre BK 40/90.

In this paper, the properties of plastic profiles obtained through mechanical recycling of agricultural plastic material mixed with wood powder (70% LDPE + 30% wood powder) were analyzed.

MATERIAL AND METHOD

Recycled manufactured products were obtained through the mechanical recycling of agricultural plastic films previously used for three years as covering tunnel-greenhouses in a farm located near Lecce (Southern Italy). The plastic recycled bars were produced by an Italian manufacturer for the stockpiling, selection and mechanical recycling of heterogeneous plastic wastes (Alfa Edile, Brindisi). After the collection and transportation to the recycling factory, the plastic films were granulated, melted at about 220 °C and introduced into the extruder to produce 1.5 m long square section bars with the average side equal to 49.4 mm.

Ten recycled bars obtained exclusively from regenerated granule of Agricultural Plastic Waste (APW) were realized in order to compare them with ten recycled bars obtained from 70% of regenerated granules of APW and 30% of wood powder.

The mechanical properties of these bars were analyzed in the Laboratory for Testing Material of the University of Basilicata (Potenza), by using a computerised universal press machine Galdabini PMA 10 type. The environmental conditions during the trial were: mean room temperature 20 °C, mean relative humidity 70%. From the recycled bars, specimens were obtained according the following dimensions:

Tensile test: strip-specimen, length 190 mm, width 49.4 mm, thickness 5.85 mm;

Compression test: cubic-specimen obtained directly by cutting the bars, side = 49.4 mm;

Bending test: bar-specimen, section 49.4 mm x 49.4 mm, span length 1,100 mm.

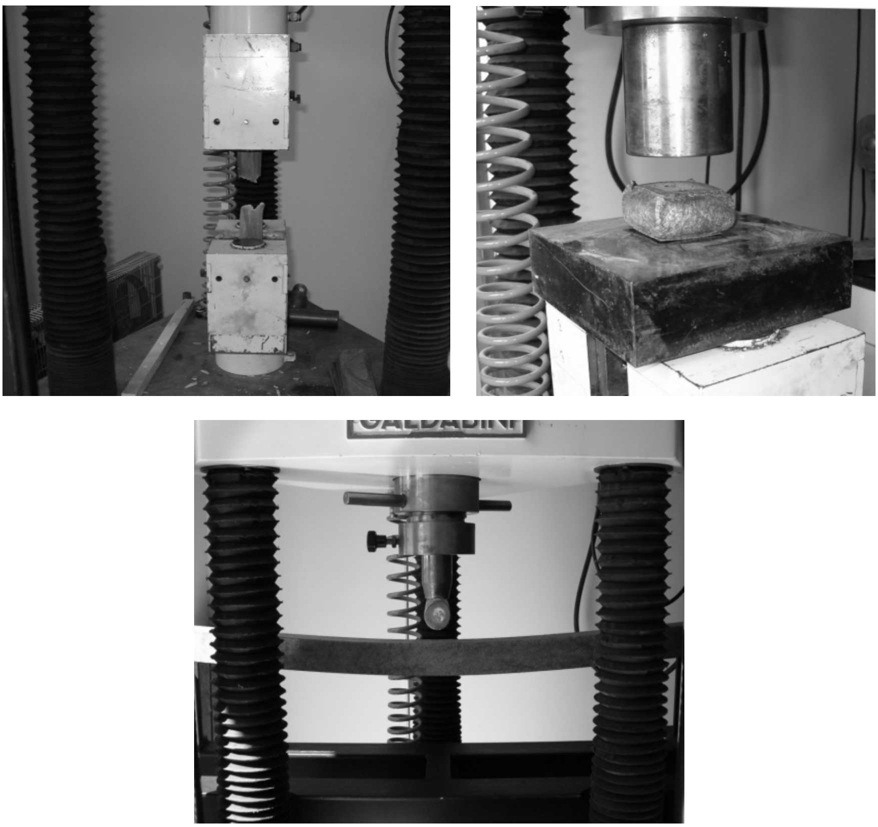

Figure 1 Tensile, compression and bending tests on the regenerated agricultural plastic waste specimens

Tensile tests were performed, according to the Italian UNI 8422 Standard (UNI, 1982), with a length between vices of 70 mm, at a constant deformation speed equal to 10 mm min^{-1}. Compression tests were performed at a constant deformation speed equal to 10 mm min^{-1}. Bending tests were performed at a strain constant speed of 70 mm min^{-1} according with the Italian Standard UNI 7219-73 (UNI, 1972), through the application of a load in the mid-span of a free length of 1.00 m between the supports.

RESULTS AND DISCUSSION

The results obtained during the tensile test (Tab. 1) show that APW has a similar maximal resistance compared to the mixture of the APW and wood powder while the situation observed for the material behavior at the end of the elastic phase is different.

Table 1 Results of the tensile tests of the regenerated plastic materials

	APW	APW + wood powder
σ_e [N mm^{-2}]	6.42	8.87
E [N mm^{-2}]	111.38	557.26
A_e (%)	5.85	0.008
ν	0.46	0.44
G	104.86	496.68
σ_{max} [N mm^{-2}]	10.04	10.44
A_b (%)	374.07	8.70

It can be seen that adding of wood powder caused a significantly lower elongation at break A_b (Fig. 2, Tab. 1) causing the new recycled material to be more brittle.

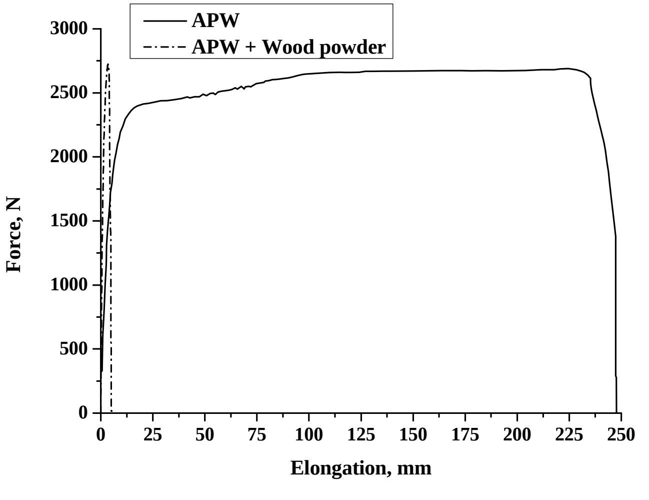

Figure 2 Force-elongation diagram of tensile tests

The analysis of the Young modulus (E) from the tensile tests (Tab. 1) showed that the recycled mixture of APW has lower values compared to its mixture with wood powder, leading to the conclusion that the adding of wood powder made this mixture much rigid compared to the APW mixture.

Conclusions about the rigidity of the mixture of APW and wood powder can be further confirmed if elongation at break for the tensile testing is analyzed. In the elastic phase the elongation of the mixture of APW and wood powder was only 0.008% while the elongation at break was 8.7%, which is significantly lower compared to the APW characteristic.

APW showed the higher value of the Poisson's ratio, that leads to the conclusion that this material is more extendible compared to the mixture of APW and wood powder. For most of metals and many other materials, values for the Poisson's ratio have a range from 0.25 – 0.35. The theoretical upper limit is 0.5 and it is characteristic for rubber.

When compression test is analyzed it can be seen (Tab. 2) that recycled mixture of the APW and wood powder showed higher strength at the end of the elastic phase. As for the area of plastic deformation before breaking of the material, none of the samples was broken under the given load of 55000 N (Fig. 3) and both materials had maximal strength equal to 20.00 N mm^{-2}.

Table 2 Results of the compression and bending tests on the regenerated plastic materials

Test	Parameter	APW	APW + wood powder
Compression	σ_e [N mm^{-2}]	4.28	8.35
	E [N mm^{-2}]	127.45	225.82
	σ_{max} [N mm^{-2}]	>20.00	>20.00
Bending	σ_e [N mm^{-2}]	1.90	3.81
	E [N mm^{-2}]	305.67	772.32
	σ_{max} [N mm^{-2}]	6.13	10.06

The analysis of the Young modulus (E) from the compression tests (Tab. 2) showed that recycled mixture of APW has lower values compared to its mixture with wood powder, leading again to the conclusion that the adding of wood powder made this mixture much rigid compared to the APW mixture in conditions of compression too.

The bending tests that were conducted showed that the recycled mixture of APW and wood powder has higher resistance at the end of the elastic phase, compared with the recycled APW material (Tab. 2, Fig. 4). During the bending tests APW materials showed so high elasticity that the maximum travel stroke of the testing machine (equal to 170 mm) was not enough to cause the breaking of the specimens. On the contrary, APW added with wood powder showed a higher resistance and a limited elasticity, so that three bars were finally broken.

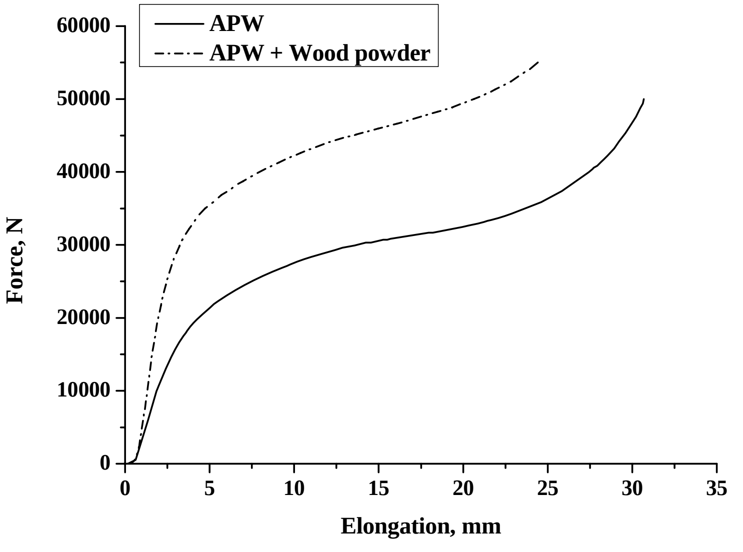

Figure 3 Force-elongation diagram of compression tests

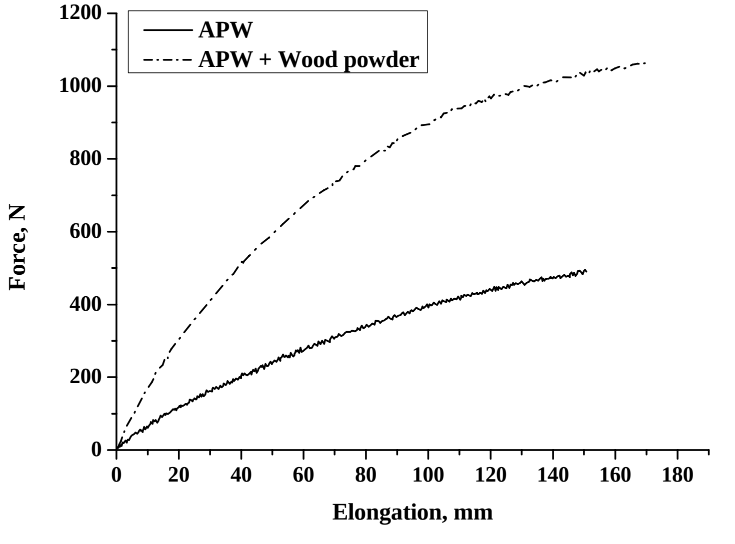

Figure 4 Force-elongation diagram of bending tests

The values of the Young modulus obtained by the bending tests show a significantly higher value in the case of mixture of APW and wood powder, so confirming that this mixture is more rigid.

CONCLUSIONS

In this research adding of wood powder into the APW and recycling such material was analyzed in the sense on how does this mixture behave in conditions of tensile, compression and bending stress. The recycled APW showed good tensile and compression characteristics. The addition of the wood powder, in terms of tensile stress, has lowered the APW elasticity causing the new recycled material to be more brittle. Concerning the compression test recycled mixture of the APW and wood powder showed higher strength at the end of the elastic phase. In conditions of bending stress mixture of APW and wood powder showed itself as more rigid. It can be concluded that the mixture of APW and wood powder in ratio 70% and 30% causes new material to be more brittle and sensitive to tensile and compression loads. Other possibility to improve the mechanical properties of the recycled APW is to investigate using some other additives or the same with different percentages in order to improve further the properties of the “secondary raw material”.

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