DEVELOPMENT OF WOOD FIBER REINFORCED POLYMER COMPOSITES

PHD DISSERTATION
(WRITTEN BY: ZOLTÁN KOCSIS)

THESES

Theses 1:

I developed a complex evaluation method whereby I compared the results (tensile- and bending strength and modulus, impact strength and MFI) of the tests (tensile, bending, bend impact tests and MFI) on wood fiber reinforced polypropylene hybrid composites containing coupling agent, talc, plasticizer, nanofiller and basalt fiber besides the wood fibers. According to this method I determined that the composite with 40 wt% wood and 15 wt% basalt fiber content showed the best complex properties with equal weighted parameters, which is the optimum composition based on the considered properties.

Theses 2:

According to analysis of wood fiber reinforced PP composites with different wood fiber length and fiber length distribution I stated the following:

a.) The value of the shrinkage measured in different directions of the flat specimens is independent of the length of the wood fibers.

b.) I described with the following relation how shrinkage proceeds as a function of time in the duration of t_1=0,083 h to t_2=168h:

$$S(t) = S_t + (-ax + m_0)\lg(t) \; [\%], \qquad t_1 \leq t \leq t_2$$

where *S(t)* is the shrinkage, S_t is a – technological – shrinkage that can be measured in one hour after injection molding, *t* denotes time, *a* is constant that depends on the material, *x* is wood fiber content, m_0 is the time-dependent coefficient of the neat matrix material.

Based on measurements I concluded that the parameters of this relation are the following in case of using wood fiber reinforced PP (TVK, H116F): SH0: a=0,0003, m_0=0232, SHSZ: a=0,0004, m_0=0,0275, SKE: a=0,0002 , m_0=0,0248, és SKH: a=0,0004 , m_0=0,0231.

Thesis 3:

According to the acoustic emission measurements under tensile load of the wood fiber reinforced composites with and without coupling agent and talc content I showed that the deformation process of the composites can be followed by the supervening of the acoustic events in function of the time. I stated that the wood fiber reinforced composites without coupling agent emit numerous acoustic events yet in the early section of the deformation process because of the weak adhesion between wood fibers a matrix material. I assessed that the friction between wood fibers and matrix and the deformation of the gap around the fibers cause a rapid increment in the acoustic event number. I showed that with the use of coupling agent the better adhesion on the fiber-matrix interface causes only a small number of acoustic events during the deformation process, a rapid increment occurs at the rupture caused primarily by the fiber splits. I pointed out that talc causes a large number of acoustic events during the entire deformation process caused by the weak adhesion between talc and matrix, and these delamination.

Thesis 4:

I worked out a statistical acoustic emission model to analytical describe the number of acoustic events in function of time during tensile load of wood fiber reinforced polypropylene composites. With the use of this model based on the structural failures of the fiber bundles the $\Lambda_i(t)$ expected event number, the $Q_i(t)$ life-span distribution of the elements and the statistical parameter of them (prospective value, quadratic mean and standard deviation) can be evaluate according the measured $n_i(t)$ event numbers and the parameters of the acoustic emission events (a_{ik}, τ_{ik}, $i=1,\ldots,r$; $k=1,\ldots,n_i(T)$), where a_{ik} is the amplitude and τ_{ik} ist the time.

Thesis 5:

In terms of the statistical acoustic emission model which analytical describes the number of acoustic events in function of time during tensile load of wood fiber reinforced polypropylene composites I made the following statements:

a.) According to the statistical acoustic emission model I showed that the supervening of the acoustic events in function of the time can be approached with the four parametric Weibull-function in case of the 40 wt% wood fiber reinforced composites without coupling agent and the 40 wt% wood fiber reinforced composites with coupling agent and 8 wt% talc content with the following function:

$$d<0,\ a=0: \qquad \Lambda(t) = bQ(t) = \begin{cases} be^{-\frac{1}{(kt)^{|d|}}}, & t > 0 \\ 0, & otherwise \end{cases},$$

where a and b are tresholds, k is the scale factor, d is the modulus factor.

I calculated the function's parameters, which are in case of the 40 wt% wood fiber reinforced composites without coupling agent: b_{mean}=2088,23; $b_{dev.}$=364,84; d_{mean}=-3,0325; $d_{dev.}$=0,2365; k_{mean}=0,0504; $k_{dev.}$=0,0018.

In case of the 40 wt% wood fiber reinforced composites with coupling agent the following function can be used:

$$d>0,\ b=0: \qquad \Lambda(t) = aQ(t) = \begin{cases} a(1 - e^{-(kt)^{d}}), & t > 0 \\ 0, & otherwise \end{cases},$$

where a and b are tresholds, k is the scale factor, d is the modulus factor.

I calculated the function's parameters, which are in this case: a_{mean}=422,50; $a_{dev.}$=33,04; d_{mean}=-7,7541; $d_{dev.}$=1,2006; k_{mean}=0,0103; $k_{dev.}$=0,0004.

b.) According to the statistic acoustic model and with the help of the Weibull-function's parameters I determined the average theoretical lifetime of the structural components of wood fiber reinforced polypropylene composites during tensile load, which was in case of the 40 wt% wood fiber reinforced composites without coupling agent 26,74 s, in case of the 40 wt% wood fiber reinforced composites with coupling agent 91,29 s, and in case of the 40 wt% wood fiber, and 8 wt% basalt fiber reinforced composites with coupling agent 44,21 s.