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Properties of wheat-straw boards with FRW based on interface treatment

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Abstract

This paper explored the effect of MDI, UF and FRW content on the mechanical and fire retardant property of straw based panels with surface alkali liquor processing. In order to manufacture the straw based panel with high quality, low toxic and fire retardant, the interface of wheat-straw was treated with alkaline liquid, and the orthogonal test was carried out to optimize the technical parameters. The conductivity and diffusion coefficient K of the straw material after alkaline liquid treatment increased obviously. This indicated that alkaline liquid treatment improved the surface wet ability of straw, which is helpful for the infiltration of resin. The results of orthogonal test showed that the optimized treating condition was alkaline liquid concentration as 0.4-0.8%, alkaline dosage as 1:2.5-1:4.5, alkaline-treated time as 12h-48h.The physical and mechanical properties of wheat-straw boards after treated increased remarkably and it could satisfy the national standard. The improvement of the straw surface wet ability is helpful to the forming of chemical bond. Whereas the variance analysis of the fire retardant property of straw based panel showed that TTI, pkHRR and peak value appearance time were not affected by the MDI, UF and FRW content significantly. The results of orthogonal test showed that the optimized processing condition was MDI content as 3%, UF resin content as 6% and the FRW content as 10%.

Keywords: Wheat-straw boards; fire-retardant of wood; interface treatment; physical and mechanical properties; fire retardant property

1. Introduction

The forest resources in China are very limited. The result of sixth national forest resources investigation indicated that the forest coverage is 18.21%, only list in 130 in the world, 9.421m^3 per capita forests, less than 1/6 of the world average accumulation, ranking the 134 in the world. But the

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demand of lumber is growing. Such as in 2005, man-made board production is 6393 million m^3, which reached 74 million m^3 in 2007. The wood market consumption of China will reach more than 2.4 million m^3 in 2010. Currently the gap of China timber consumption demand is 60 million m^3, the substitute of woodiness material products is needed. As a large agricultural country, the annual crop straw residues of China can reach to 10 billion tons, of which 70% is rice straw and wheat straw, accounts for about 30% of total world [1]. Straw is kind of renewable biomass energy, which have the similar physical structure and chemical composition to wood. If use the amount of rice straw and straw 5%, can make about 20 million m^3 man-made boards, instead of 60 million m^3 wood, accounts for the total production of density board, particleboard of 2003 in China. The wood-based panels made by crop stalks can alleviate the shortage of timber resources and reduce the environment pollution.

Straw board was researched in North America and Canada from the 1980s, which had formed a complete system of industrial production now. In 1995, America's primeboard Co. in North Dakota built the first man-made straw plant, which annual production capacity of 5.3 million m^3, reached its climax in 1999. According to media reports, North America has six straw particleboard production factories at least in 1999. In 1998, the world's largest straw board factory was built in Manitoba, Canada, which has 23 million m^3 adult production capacities. In addition, Belgium, Sweden, Portugal, Russia and other countries are also made such research, and have produced various kinds of crops straw qualified man-made. In late 1970s, professors Lu renshu of China began to use crop straw manufacturing building materials. China has built six product lines which have 1.5 million m^3 biomass production capacities per year at the beginning of this century, and six product lines which have 5 million m^3 per year. .The usage of rice-straw in wood-based panels production have been put into industrialization, and the yield of rice-straw boards reach to 400,000 square meters per year in China now [2].

Now the actual production of the straw board industry also exist some problems which hinder development. The existence of silica and wax at the surface of rice-straw affect the adsorption and hydrogen bonding of adhesive which lead to the reduce of gluing property[3-5]. The MDI adhesive has merit such as water resistant, good aging performance, short thermal cycle, and no free formaldehyde release etc, but the price is high, the storage period is short. In the production process, physics, chemistry, biology and mechanical method were used to control the material removal, thus improve interfacial characteristics of agglutination performance. The physical methods including heat treatment method, chemical processing, including acid on the surface of the raw material, biological grafting method of treatment including active, mechanical method is mainly mechanical grinding. According to the statistics, 2/3 output of man-made board of China was used in furniture industry [6-9]. The release of volatile harmful gas such as formaldehyde of man-made board furniture seriously affected indoor air quality. With the environmental protection consciousness, attention was enhanced of indoor air quality and safety increasingly [10-12]. Wooden furniture and indoor decoration has become the main wood fire hazard, while woodiness material is a kind of inflammable materials. To solve these problems, it is necessary to use low-toxic adhesive and retardant materials in hot press.

This paper explored the effect of MDI, UF and FRW content on the mechanical and fire retardant property of straw based panels with surface alkali liquor processing. In order to manufacture the straw based panel with high quality, low toxic and fire retardant, the interface of wheat-straw was treated with alkaline liquid, and the orthogonal test was carried out to optimize the technical parameters.

2. Straw surface treatment methods

2.1. Surface wet ability of Wheat straw

Adhesive molecular and rubber wood material molecular should be full contact for the good glue. The properties of wet ability of straw are very important for glue, surface finishing and modification process. The JC2000A instrument was used to measure contact angle of water on the surface of straw.

The contact angle changes with the drop time in the surface. This study determined ten points time of 0s and 20s, 50s, 10s, 100s, 150s, 250s, 400s, 600s 900s, as shown in fig.1- fig.2.The constant K value which can evaluate diffusion - wet ability quality was measured.

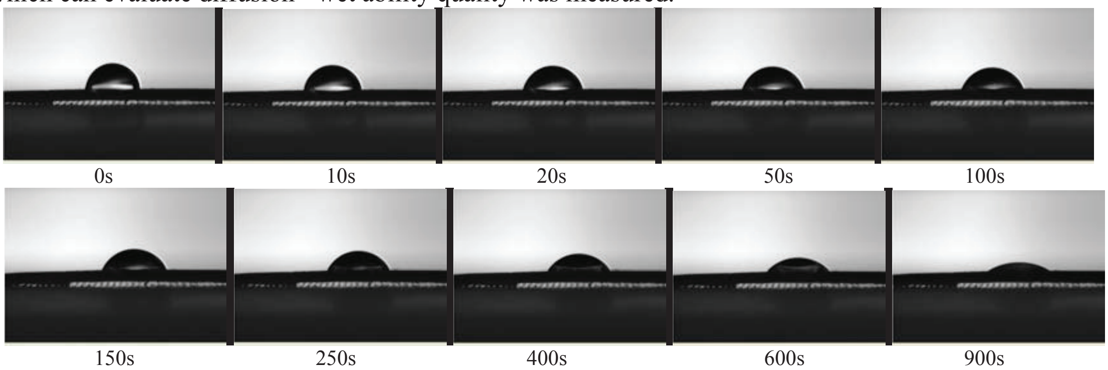

Fig.1. The contact angle of the surface of wheat straw

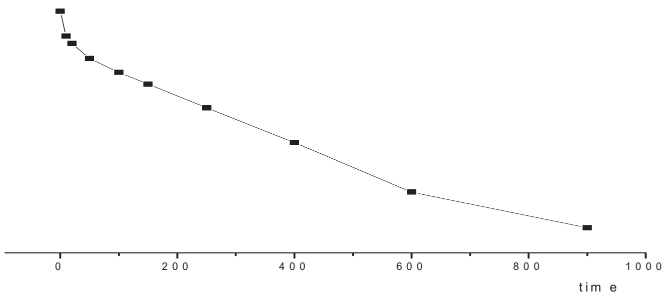

Fig.2. Change of contact angle of wheat straw with time

Contact angle decrease with time, until it reaches equilibrium. In this process, solid-liquid diffusion rate of the system was evaluated by the permeability coefficient K, as shown in fig.3.

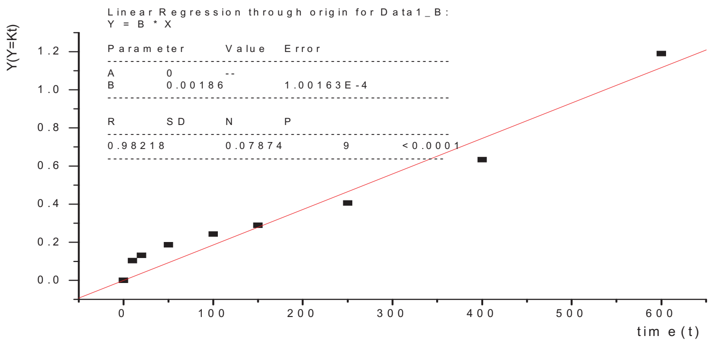

Fig.3. Linear regression of Y and time of wheat straw

The experimental results of coefficient K value were shown in table1. According to the poor analysis we can know, the biggest influence the quality of raw material is alkali concentration, and the volume ratio and processing time according to the same extent influence. The optimal solution is alkali density 0.6%, handling the dosage of alkali liquid materials for 1:3.5, the alkali processing time for 12h considering the actual production of raw materials.

Table 1. Result of orthogonal experiment of wheat straw

Number	A	B	C	Blank	K
1	1(0.3)	1(1 : 3.5)	1(12)	1	0.00127
2	1(0.3)	2(1 : 1.5)	2(24)	2	0.00155
3	1(0.3)	3(1 : 2.5)	3(48)	3	0.002
4	2(1.5)	1(1 : 3.5)	2(24)	3	0.00419
5	2(1.5)	2(1 : 1.5)	3(48)	1	0.00269
6	2(1.5)	3(1 : 2.5)	1(12)	2	0.0022
7	3(0.6)	1(1 : 3.5)	3(48)	2	0.00548
8	3(0.6)	2(1 :1.5)	1(12)	3	0.00186
9	3(0.6)	3(1 : 2.5)	2(24)	1	0.00323
K_1	0.00482	0.01094	0.00533		
K_2	0.00908	0.0061	0.00897		
K_3	0.01057	0.00743	0.01017		
k_1	0.001606667	0.003646667	0.001776667		
k_2	0.003026667	0.002033333	0.00299		
k_3	0.003523333	0.002476667	0.00339		
R_i	0.001916667	0.001613333	0.001613333		

2.2. The buffer capacity of straw

Wheat straw buffer capacity refers buffer action for foreign acid or alkali of the water extraction liquid straw, which can token balance or resist for external acid or alkali in storage processing and use. The increasing of buffer capacity and pH make against the solidified of urea-formaldehyde glue which solidified on the condition of acidity. The solidified time of urea-formaldehyde becomes shorter when acid buffer capacity bigger and smaller Ph, which can improve the glue strength.

This study was referring to the determination method of wood buffer capacity (GB/T17660-1999), the results are acid buffer capacity of raw is 10.90 ml, alkali buffer capacity for 39.48 ml, raw material buffer capacity for 50.38 ml, acid buffer capacity after the alkali handling is 25.56 ml, and alkali buffer capacity for 31.13 ml, raw material buffer capacity for 56.69 ml. According to the experimental results, the wheat straw acid buffer capacity rise from 10.90 ml to 25.56 ml after treatment. The alkali buffer capacity reduced from 39.48 ml to 31.13 ml, which illustrates the wheat straw after treatment is more advantageous for urea-formaldehyde, more conducive to improving adhesive strength of wheat straw board.

2.3. Adjustable pH of wheat straw

The determination of pH of the wood was referred to the determination method of wood of China (GB6043-85) in this paper. The pH value of the raw materials is 6.10, when pH value is 7.86 after alkali treatment. The solidified environment of urea-formaldehyde glue which was made in experiments is pH

=5- 6, so adjust pH value of the end is pH =5- 6. The volume of hydrochloric consumed for adjustment of pH value by the end of 1%. The alkali treatment straw can get better urea-formaldehyde glue solidified environment after treatment the 1.5 ml of concentrate of hydrochloric, as shown in table 2.

Table 2. The use of HCl quantity of adjust pH

Number	Quality（g）	pH	The use of HCl quantity	
			pH=6	pH=5
1	3.00	7.85	3.62ml	4.70ml
2	3.00	7.88	3.76ml	5.1ml

2.4. Mechanical properties of wheat straw board

According to the test results obtained earlier research, mechanical properties was compare between wheat straw without surface chemical modification of the board and after wheat straw surface chemical modification of the board in the same conditions, the test results was shown in table 3.

Table 3. Mechanical properties comparing of wheat straw board

Content	D(g/cm^3)	W(%)	MOR(MPa)	MOE(MPa)	IB(MPa)	2hTS(%)
Indisposed	0.65	5	23.13	2459.44	0.34	13.0
Disposed	0.70	5	21.03	2325.68	0.45	7.5
Standard	0.50-0.85	5-11	≥14	≥1800	≥0.40	≤8.0

The MOE and MOR of the treated board decline slight, but can meet the national standard of China. The alkali treatment of wheat straw destroyed the raw materials, reduce the fiber structure stiffness, and thus affect the MOE and MOR of wheat straw board at a certain extent. The IB of treated wheat straw board has greatly improved, the main reason is alkaline destroy the waxy of wheat straw surface, improved wet ability in a certain extent, in favor of glue and bond. The 2hTS of treated wheat straw board increase, can meet the national standard, therefore, alkali treatment on wheat straw board has important influence.

3. Manufacture of fire- retardant wheat-straw boards

3.1. Materials and Methods

The air-dried rice-straw used in this study were obtained from Harbin, Heilongjiang China. Solid NaOH content not less than 96%. Urea-formaldehyde resin (UF): was made by professor GuJiYou group of northeast forestry university of China, solid content as 64%, viscosity as 47s, PH 8.0-8.5, the storage period for 2 months, free formaldehyde content as 0.35%; Isocyanate resin (MDI): bright plastic Harbin Industry Co., Ltd., solid content as 32%; FRW, Ammonium chloride, Paraffin.

Based on the previous research results, the content of MDI, UF and FRW were selected to investigate the effect of addition content on the physical and mechanical property and fire retardant properties of boards. The orthogonal theories L_9 (3^4) were carried out in this paper (table 4-table 5).

Table 4. Factors and levels of orthogonal test

Level	MDI (%)	UF (%)	FRW (%)
1	2	8	4
2	3	7	7
3	4	6	10

Table 5. The table of orthogonal experiment

Number	MDI	UF	FRW	Blank
1	1 (2)	1 (8)	1 (4)	1
2	1 (2)	2 (7)	2 (7)	2
3	1 (2)	3 (6)	3 (10)	3
4	2 (3)	1 (8)	2 (7)	3
5	2 (3)	2 (7)	3 (10)	1
6	2 (3)	3 (6)	1 (4)	2
7	3 (4)	1 (8)	3 (10)	2
8	3 (4)	2 (7)	1 (4)	3
9	3 (4)	3 (6)	2 (7)	1

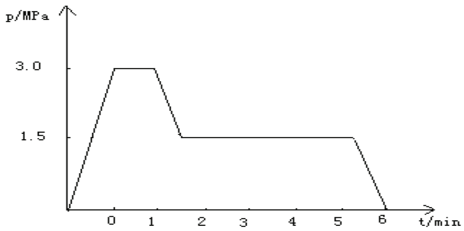

Fig. 4. The graph of hot press technique of fire- retardant straw based panel

UF and MDI resin were applied to the rice-straw and FRW in a drum blender by using a compressed air spray head. After blending, all straws were formed by hand in a 340mm by 320mm deckle box. The mats were pressed in the hot-press at the 160 ℃ for 4 min as shown in Fig.4. The pressure was set at 3MPa. The target size of rice-straw board was 340 by 320 by 10 mm. The physical and mechanical property measurements of rice-straw boards were conducted according to GB/T4897.3-2003 and fire-retardant performance test was conducted in accordance with the ISO5660-2002, the peak heat release (pk HRR), time to peak heat release, ignition time (TTI) were chosen to evaluate the flame retardant effect. The thermal radiation power was set to 50Kw/m^2, the corresponding temperature was 780℃ in the CONE experiment.

3.2. Effect of technological factors on physical and mechanical property

The physical and mechanical property of rice-straw boards was shown in table 6. The analyze of influencing of technique factor on mechanics performance was shown in table 7。The trend table of influencing of technique factor on mechanics performance was shown in fig.5.

Table 6. The test result of mechanics performance of fire- retardant wheat straw based panel

Number	MOE/MPa	MOR/MPa	IB/MPa	2hTS /%
1	3324	29.5	0.46	9.93
2	4702	36.3	0.53	7.44
3	3745	26.6	0.42	9.02
4	4643	31.4	0.68	6.99
5	4338	34.1	0.83	7.01
6	4320	39.8	0.87	9.39
7	3546	28.3	0.92	7.31
8	2683	32.2	1.45	8.76
9	4333	35.9	1.17	7.54
Standard	≥1800	≥14	≥0.40	≤8.0

Table 7. The analyze of influencing of technique factor on mechanics performance

Average	MOE/MPa			MOR/MPa			IB/MPa			2hTS /%		
	MDI	UF	FRW	MDI	UF	FRW	MDI	UF	FRW	MDI	UF	FRW
k1	3924	3838	3443	30.8	29.8	33.9	0.47	0.69	0.93	8.8	8.1	9.4
k2	4434	3908	4560	35.1	34.2	34.6	0.79	0.94	0.79	7.8	7.7	7.3
k3	3521	4133	3877	32.2	34.1	29.7	1.18	0.82	0.72	7.9	8.6	7.7
Range	913	295	1117	4.3	4.4	4.9	0.25	0.25	0.21	1	0.9	2.1

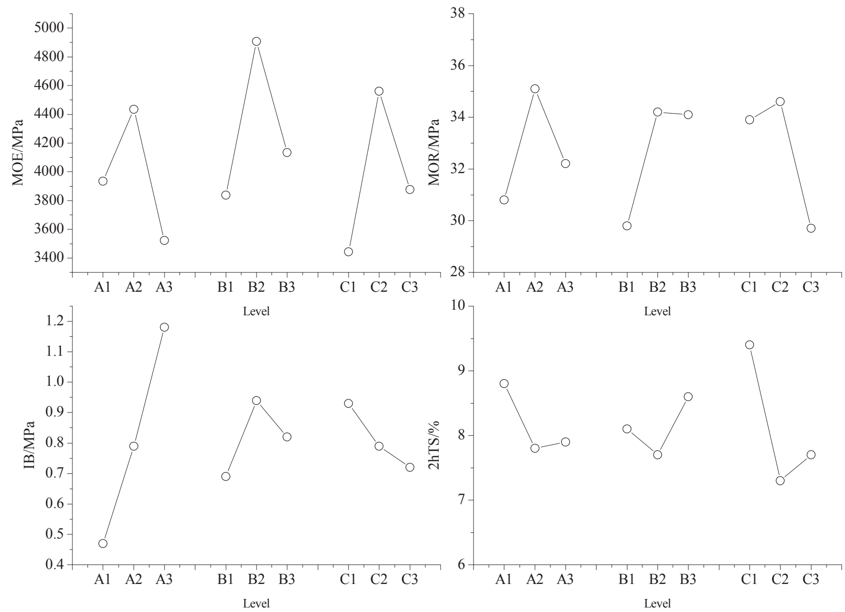

Fig.5. The trend table of influencing of technique factor on mechanics performance

3.2.1 Effect of technological factors on modulus of elastic (MOE)

The maximum of MOE reached 4702MPa, minimum reached 2683MPa, average reached 3959MPa in nine groups of fire-retardant straw board, which far higher than 1800MPa of the national standard, as shown in fig.6.

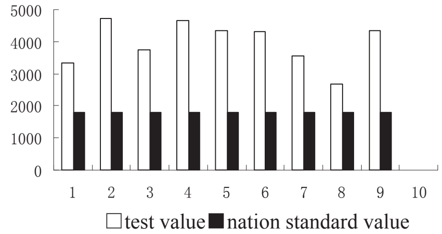

Fig .6. The compare of test value and nation standard value of MOE

The variance analyze and notability verify of influencing of technique factor on MOE was shown in table 8. The biggest influence factor on MOE is FRW, when the least influence factor is UF. The optimum technological conditions are MDI 3%, UF resin 7%, FRW additives 7%.

Table 8. The variance analyze and notability verify of influencing of technique factor on MOE

Source	df	Sum of squares	Mean square	F value	Sig.
MDI	2	1256585.128	628292.564	3.302	.232
UF	2	142608.357	71304.179	.375	.727
FRW	2	1902351.964	951175.982	4.999	.167
Error	2	380535.729	190267.865	-	-
Total	8	144798582.547	-	-	-

3.2.2 Effect of technological factors on modulus of elastic (MOR)

The maximum of MOR reached 39.8 MPa, minimum reached 26.6MPa in nine groups of fire-retardant straw board, which far higher than 14MPa of the national standard, as shown in Fig.7.

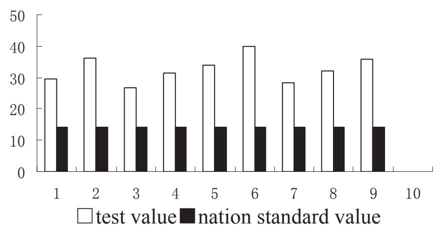

Fig .7. The compare of test value and nation standard value of MOR

The variance analyze and notability verify of influencing of technique factor on MOR was shown in table 9. The biggest influence factor on MOR is FRW, when the least influence factor is MDI. The optimum technological conditions are MDI 3%, UF resin 7%, FRW additives 7%.

Table 9. The difference analyze and notability verify of influencing of technique factor on MOR

Source	df	Sum of squares	Mean square	F value	Sig.
MDI	2	28.914	14.457	.837	.544
UF	2	38.418	19.209	1.112	.474
FRW	2	41.786	20.893	1.209	.453
Error	2	34.558	17.279	-	-
Total	8	9773.828	-	-	-

3.2.3 Effect of technological factors on IB

The maximum of IB reached 1.45 MPa, minimum reached 0.42MPa ,average reached 0.81MPa in nine groups of fire-retardant straw board, which far higher than 0.4MPa of the national standard, as shown in fig.8.

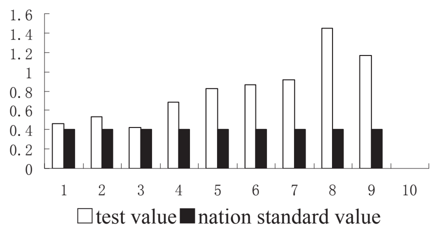

Fig.8. The compare of test value and nation standard value of IB

The variance analyze and notability verify of influencing of technique factor on MOE was shown in table 10. The biggest influence factor on IB is MDI, when the least influence factor is FRW. The optimum technological conditions are MDI 4%, UF resin 7%, FRW additives 4%.

Table 10. The difference analyze and notability verify of influencing of technique factor on IB

Source	df	Sum of squares	Mean square	F value	Sig.
MDI	2	0.758	0.379	84.658	0.012
UF	2	0.094	0.047	10.484	0.087
FRW	2	0.064	0.032	7.149	0.123
Error	2	0.009	0.004	-	-
Total	8	6.895	-	-	-

3.2.4 Effect of technological factors on 2hTS

The 2hTS refers to the rate of rises of specimen thickness after absorbing water and the thickness of the former, which has an important influence on the stability of the furniture structure. The maximum of

IB reached 9.93%, minimum reached 6.99%, and average reached 8.15% in nine groups of fire-retardant straw board, as shown in fig.9.

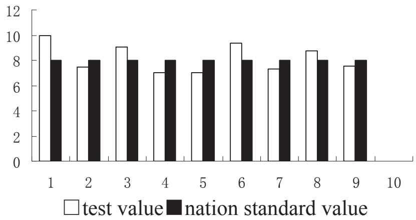

Fig.9. The compare of test value and nation standard value of TS

The variance analyze and notability verify of influencing of technique factor on MOE was shown in table 11. The biggest influence factor on 2hTS is FRW, when the least influence factor is UF. The optimum technological conditions are MDI 3%, UF resin 7%, FRW additives 3%.

Table 11. The difference analyze and notability verify of influencing of technique factor on TS

Source	df	Sum of squares	Mean square	F value	Sig.
MDI	2	1.864	0.932	28.121	0.034
UF	2	1.278	0.639	19.287	0.049
FRW	2	6.853	3.426	103.380	0.010
Error	2	.066	0.033	-	-
Total	8	608.517	-	-	-

3.3. Effect of technological factors on fire-retardant properties

FRW fire-retardant is also applicable to straw and have the same panels of fire retardant mechanism and good performance, because of the straw structure and chemical composition similar to wood. Smoke suppression performance parameters, the combustion heat release parameters and quality parameters can be measured by Tapered calorimeter. According to the relationship between the parameters of the following several parameters to evaluate specimens of flame retardant performance: the heat release peak (pk HRR), heat release peak time, light time, test results were shown in table 12.

Table 12. The test result of fire-retardant performance of fire-retardant wheat straw based panel

Number	TTI (s)	pk HRR (KJ/m^2)	peak times (s)
1	23	174.41	35
2	20	164.63	35
3	23	163.98	35
4	20	177.01	35
5	27	147.40	35
6	23	187.26	49
7	19	142.80	35

8	21	161.46	40
9	23	164.82	49

The variance analysis results of the effects of the addition of MDI, UF and FRW on fire-retardant performance were shown in table.13-14. The effects of FRW on the heat release peak significant, while UF and MDI not significant. When adding 10% of the FRW, the TTI and the longest peak time, respectively 23s and 49s. Through analysis, in favor of lighted straw board time and time to peak heat release process for the optimal amount of MDI Sizing 4%, UF sizing the volume of 7%, FRW add 10 percent capacity. FRW when 7% of its adding, the straw board a minimum of heat release peak 132.6 KJ/m^2, with the addition of FRW increases, the peak heat release there was a downward trend, flame retardant material in the presence of boric acid to reduce the material the straw of the heat release rate, flame retardant to achieve the purpose of this is the most important reason. Straw from the board in favor of lower heat release rate of the point of view, optimization of process parameters for MDI production capacity sizing 4%, UF sizing the volume of 7%, FRW add 10 percent capacity. The test result was shown in table 13.

Table 13. Analyze of influencing of technique factor on fire-retardant performance of wheat straw based panel

Mean	TTI			pk HRR			peak times (s)		
	MDI	UF	FRW	MDI	UF	FRW	MDI	UF	FRW
k1	22	20.67	22.33	167.67	164.74	174.38	35	35	188.33
k2	23.33	22.67	21	170.56	157.83	168.82	186.67	36.67	186.67
k3	21	23	23	156.36	172.02	151.39	188.33	338.3	35
Range	2.33	2.33	2	14.2	14.19	22.99	153.33	303.3	153.33

Table 14. The difference analyze and notability verify of influencing of technique factor on fire-retardant performance wheat straw based panel

TTI					
Source	df	Sum of squares	Mean square	F	Sig.
MDI	2	8.222	4.111	.359	.736
UF	2	9.556	4.778	.417	.705
FRW	2	6.222	3.111	.272	.786
Error	2	22.889	11.444		
Total	8	46.889			
pk HRR					
Source	df	Sum of squares	Mean square	F	Sig.
MDI	2	337.850	168.925	8.099	.110
UF	2	302.103	151.051	7.242	.121
FRW	2	862.799	431.399	20.682	.046
Error	2	41.717	20.859		
Total	8	1544.469			
peak times (s)					
Source	df	Sum of squares	Mean square	F	Sig.

MDI	2	46516.667	23258.333	1.034	.492
UF	2	183016.667	91508.333	4.067	.197
FRW	2	46516.667	23258.333	1.034	.492
Error	2	45000.000	22500.000		
Total	8	321050.000			

3.4. Determine the optimum process factor

Analysis of different technological factors level of physical and mechanical properties of wheat straw board and fire retardant performance can helps to understand the key effect factors of physical mechanics properties of wheat straw board and fire redundancy of the. The optimum process conditions are selected by the influencing factors of wheat straw board mechanics and fire retardant properties of poor analysis and significant analysis. The ultimate goal is to test fire retardant properties of wheat straw board production process, through comprehensive consideration of the influencing factors on physical and mechanical properties of wheat straw board and flame resistance mechanism, poor comprehensive analysis results to determine the optimal technological factors.

According to physics and mechanics index requirements of GB/T4897.3-2003 of China, MOR should bigger than1800MPa, MOE bigger than 14 MPa, IB bigger than 0.40 MPa, 2hTS not bigger than 8.0%. Therefore, improve the straw board fire-retardant is the optimal selection of technological parameters. From the three parameters of fire retardant properties, choose light and heat release peak time appear for a long time, lower peak heat release of process conditions. Secondly, selection optimized conditions of lower cost of production process. Based on the above principles, choice MDI 4%, UF resin 7%, FRW 10% for the optimum process conditions based on satisfy the physical and mechanical properties of wheat straw board.

3.5. Validation of the optimum process factor

3.5.1 Testing analysis of physical and mechanical property

The result of validate experiment of physics mechanics and fire-retardant performance were shown in table 15.

Table 15. The result of validate experiment of physics mechanics and fire-retardant performance

Content	MOR (MPa)	MOE (MPa)	IB (MPa)	2hTS (%)	pk HRR (KJ/m^2)	peak times (s)
Blank sample	37.92	3702	0.76	9.2	189.77	22
Best sample	32.03	3461	0.73	10.4	161.23	24
Standard	≥14	≥1800	≥0.40	≤8.0	—	—

The MOE, MOR, IB, 2hTS of straw board treated by FRW fire-retardant declined. Except 2hTS, others property were higher than nation standard of China. Using MDI - UF mixed glue method, enhances the permeate diffusion capacity of wheat straw fiber, improved agglutination point of the plate. But the MOE and MOR declined when FRW fire- retardants joining. Because FRW fire-retardant hampering the glue between the fiber, and the existence of boric acid reduce the pH value of adhesive, lead glue curing in advance, thus affect the straw board strength, increase hygroscopic and the 2hTS.

3.5.2 Testing analysis of on fire-retardant properties

The thermal power of CONE experiment was 50Kw/m^2, temperature was 780 degrees for near the actual fire temperature. The heat release rate (HRR) is one of the most important parameters of combustion, also called the fire intensity. The HRR peak of straw board after treatment reduced 26KW compare that of untreated straw board, and extend the time of peak appeared, curve tends to gently. The combustible volatile generated speed and heat release rate of fire-retardant straw board decrease, which in favour of fire-retardant.

Total heat release (THR) of is sum of heat release in the burning process of material in the unit area. With the increasing of THR value, more quantity of heat release and more fire danger occurred. Total quantity of heat release of fire-retardant straw board reduced to 85% of un-treated straw board. Glowing combustion started when flame combustion closed, the quantity of heat release of fire-retardant straw board increased slowly. The Glowing combustion was prolonged with the fire-retardant treatment

EHC reflects the burning extent of combustible volatile produced from pyrogenation of materials. The EHC of FRW straw board changes smoothly, and slightly lower than un-treated board. Fire-retardant inhibit the pyrogenation process of straw board.

The quality of the fire-radiation straw board and un-treated sample diminishes quickly with the extension of spoke time. The quality of giblets of un-treated sample was lower than that of the fire-radiation straw board in a flame combustion and glowing combustion stage. The burning debris of Straw board is mainly charcoal, the FRW fire-retardant promoted the carbonization of straw board, and this is an important factor of fire-retardant. The smoke ratio (SR) of fire-retardant straw board obviously was lower than that of un-treated sample in a flame combustion stage. The relationship between SR and time similar to heat release rate and basic synchronization. The yield of smoke reducing significantly under FRW fire-retardant treatment, and have prominence influence on the suppression smoke release in the prophase of flame combustion.

4. Conclusion

(1) The coefficient K of straw raw material improved through the alkali treatment, which improve surface wet ability and increase the glue strength of straw board.

(2)The optimization alkali treatment method: alkali density0.6%, the ratio of raw and alkali 1:3.5, alkali processing time for 12h.

(3)The MOE and MOR of straw board treated by FRW fire-retardant declined. Except 2hTS, others property were higher than nation standard of China. FRW fire-retardant hampering the glue between the fiber, and the existence of boric acid reduce the pH value of adhesive, lead glue curing in advance, thus affect the straw board strength, increase hygroscopic and the 2hTS.

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