Conclusion

Centuries of experience have given humanity a fairly reasonable idea of the high fire hazard of timber. Modern fire statistics only confirm this opinion about timber, which is still one of the most popular construction materials. It is no coincidence that the problem of reducing the fire hazard of timber and timber products is a major preoccupation. Successfully solving this problem depends on an understanding of the mechanisms of the onset smoldering and flaming timber combustion, fire propagation in buildings and structures with timber structures, and the conditions for preventing combustion.

Despite the vast amount of experimental work in this area, it is often difficult to compare the results, not only because different research methods were used but also because of the timber specimen used without mentioning their species and variety or any description of their characteristics. Evidently, this experimental setup of many works was due to the still-prevalent outdated approach to timber as some kind of generalized substance with properties that differed very little between them.

Rapid growth of theoretical works on pyrolysis and thermo-oxidative decomposition, flammability, and flame spread over the surface of timber and other synthetic materials with allowance for carbonization of these materials began only in recent decades.

To a certain extent, the monograph summarizes the results of the recent development of this line of timber research. The basis for this work is the concept that many properties of timber, including fire-hazardous properties, are simultaneously a function of both the physical macro- and microstructure and the chemical composition of this complex composite material created by nature itself. Therefore, the specific reaction of timber on exposure to high temperatures and fire is examined in terms of the diversity of its species and types, which should necessarily affect the physical, thermochemical and thermophysical properties, and chemical composition of the specimens.

Timber is a product of the vital activities of a living plant. The genetic basis for the diversity of this biological form of living substance on Earth, its adaptation to the habitat, and resistance to adverse impacts has still not been fully revealed.

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In the next few years of the twenty-first century, we should expect revolutionary scientific breakthroughs in knowledge of the compete genome of woody plants, the fine mechanisms of biochemical synthesis of plant tissues and the main chemical components of timber, and discovery of the genes controlling this synthesis.

The concept we have used helps us to understand the fire behavior of various timber species and the change in their fire-hazardous properties during natural and artificial aging.

An analysis of the influence of the content of main components in the chemical composition of various deciduous and coniferous timber species on the lower total combustion heat of timber, which is a thermodynamic characteristic of any specific substance, clearly confirms the correctness of this concept.

The authors have tried to organize and summarize the available results from scientific publications on pivotal experimental and theoretical works that provide insight into the relationship between the structure, composition and properties of timber, and the mechanisms of timber combustion in various conditions of heat exposure.

The authors have attempted to describe the overall status of this problem in Russia and the prospects of solving it by using their own results of long-term research and the experience of colleagues at the Academy of the State Fire Service of EMERCOM of Russia and other organizations involved in fire safety of construction projects.

It should be noted that the design and development of modern technologies for manufacturing new timber- and plant-based materials in our country are ahead of the regulatory foundation for their safe use in the construction industry. A striking example of this is the production of new types of laminated timber structures and the restriction on using them in low-rise housing construction due to the absence of the relevant construction standards and regulations in Russia.

The most economic means of legal use of new materials in the construction of medium-rise frame wooden buildings structures is probably to adapt existing international standards and regulations to this sector.

Trends toward basic study of the fire behavior and fire hazard characteristics of timber with allowance for species diversity are very clearly strengthening in world practice.

Although the combustion and fire-hazardous properties of timber are considered as an important area of timber research, it should be emphasized that many aspects of the problem of timber combustion remain unresolved.

There have been almost no studies of the long-term processes occurring in timber during low-temperature heat exposure. The conditions and factors influencing the occurrence of smoldering timber combustion and its transition to flaming combustion are unclear. An understanding of the extent to which both the content of main components in timber and the constituents of these components and their chemical nature will affect timber combustion and its critical conditions is still ahead.

In this context, an analysis of the changes in some important indicators of the fire hazard of timber when it is naturally and artificially aged is of interest. It is clear that the details of the solid phase processes are very important for the gas-phase processes of flaming combustion.

Timber charring during a fire affects the fire resistance of wooden load-bearing structures and enclosures. Data on the timber charring rate as a function only of timber density (specific weight) obtained during tests under standard fire conditions frequently disagree or are contradictory. However, a general trend emerges: all other conditions being equal, coniferous species char at a faster rate than deciduous species. If we take the significant contribution to timber charring of one component, namely, lignin, into account, the observed contradictions become more comprehensible.

We suggest concentrating on the quality of the charred surface layer that forms during the combustion of timber and timber products and the potential for targeted control of the pore structure and properties of the coke layer. This will affect its thermal properties and the temperature distribution in material in close proximity to the charring front and thus the temperature dependence of the mechanical properties of the structural member as a whole.

The optimum balance of combined fire protection methods and achieving a mutual synergistic effect among them is a way to significantly increase the fire resistance and fire safety level of wooden building structures.

The development of verifiable models of the mechanism of fire protection connecting design parameters with its composition, structure, and characteristics of its main constituents will promote the development of effective fire protection measures for timber.

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