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Analysis of the Patent Activity in the Field of Racing Cars

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ABSTRACT

Motorsport is one of the fastest growing technological areas, and technical solutions related to racing cars are often subsequently implemented in civilian automobile manufacturing. Thus, development of racing cars has a direct impact on development of the entire automotive industry.

In the framework of the study, a patent search in the field of racing cars was conducted using patent databases; a patent analysis of the market was performed, and the features of patenting individual technical solutions were considered. The objective was to identify trends in development of patent activity in the field of racing car technologies. The purpose was to identify leading countries and organisations in terms of patent application and activity, and to reveal a common trend for them regarding racing car technologies. The analysis revealed the general dynamics of technology development, characterised by periods of confident growth and decline in activity, and the absolute leadership of China and Chinese organisations in terms of the number of applications and patents. The study can be applied both to determine the dynamics of technology development in the field of racing cars and to establish the level of interest of individual countries, researchers and organisations towards this area.

Keywords: *racing car, motorsport, patent analysis, automobile transport, Formula 1 car.*

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INTRODUCTION

Motorsport is one of the fastest growing technological areas, requiring constant improvement due to its competitive nature. This large industry plays an important role in the economic sector, attracting tourists and fans from all over the world. However, as the popularity of motorsport grows, so do the problems associated with, among other things, the technological side. For example, the impact of this sport threatens the environment [1]. To solve this problem, the process of modernisation of technologies is constantly taking place: e.g., hybrid power plants are integrated into motorsport. Thus, new technologies appear that require legal protection as the results of intellectual activity.

Protection of the results of intellectual activity in the field of racing cars has its own specifics. Often, inventions in this area are not limited to racing competitions but are also used in civil automotive engineering. The results of intellectual property related to racing cars describe not only the racing cars themselves, but also the devices necessary for their operation, design features, parts, control systems and much more. It can be said that motorsport is a kind of «testing ground» for automobile manufacturers wishing to test the latest technological achievements. In addition, racing competitions are a strong impetus for development of technologies, since motorsport is largely based on a technological race, forcing participants to constantly modernise and enrich their own developments. In this regard, relevant are various scientific studies, for example, concerning development of motorsport within a separate municipality [2] for which automotive industry plays the role of urban development backbone. Even more spread are research works analysing the technical side, in particular the design features of racing cars (e.g., [3–8]). It is also worth mentioning research describing various electronic systems for racing cars (e.g., [9–15]).

The *objective* of the study is the analysis of racing car technologies using patent search tools.

The patent search was carried out using the Espacenet patent database by keywords (racing AND car OR racing vehicle; bolide AND car OR bolide AND vehicle; motorsport AND car OR motorsport AND vehicle; formula AND car OR formula AND vehicle), in retrospect from 2012 to 2022, with a restriction on the IPC (International Patent Classification) (B60, B62, B65, B66, F16, G01, G05, G06, H01, H02, H08) and without restrictions on the countries of the priority application. When analysing patent activity, only patents for inventions and utility models were considered.

RESULTS

Approaches of analysis of patent indicators

The main difference in protection of intellectual property concerning racing car technologies is that it is quite difficult to keep the secret of production within the framework of racing competitions, since, according to the sports regulations, it is strictly forbidden to cover any part of the car with screens, covers and other parts that can hide the design of both the entire car and individual parts in particular (e.g., [16]). Of course, competitors do not have access to the technical side of the designs (drawings and other technical documentation), but engineers who are experts in the field are able to discern an inventive innovation even from the outside.

Most often, authors resort to fixing copyrights in relation to such developments by publishing scientific articles that describe the technical solution to one degree or another, since this is faster and easier.

Therefore, it is possible to note in advance a rather low level of patenting in the racing car industry. There are several reasons for this:

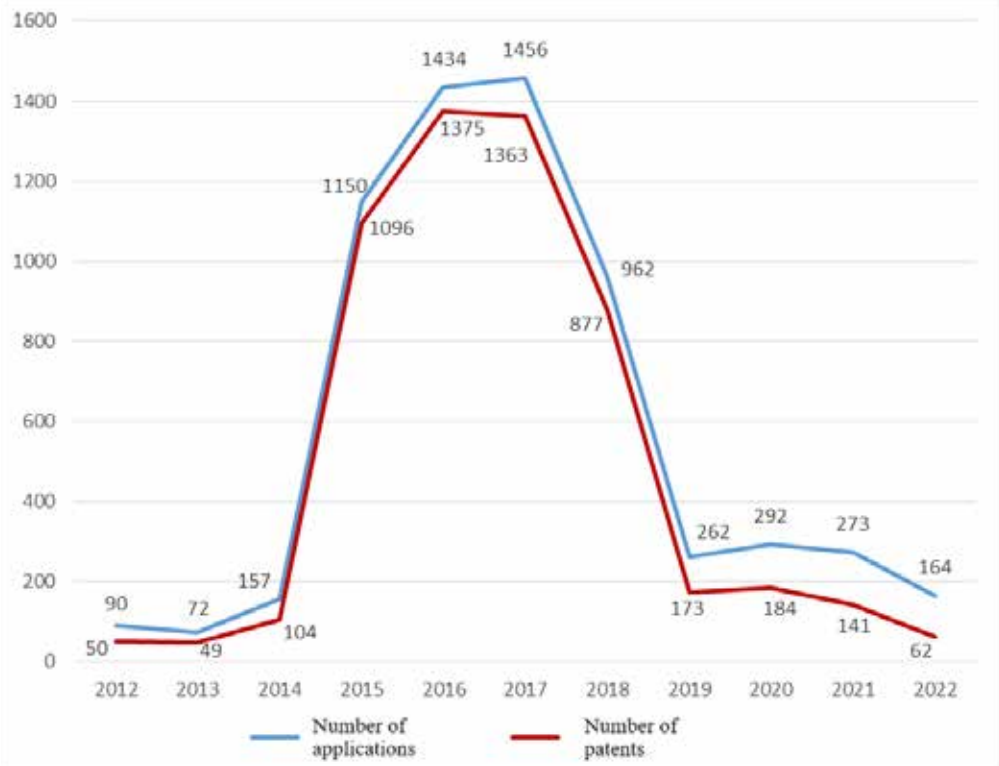
• The industry is developing so rapidly that patenting new technologies becomes meaningless. A technical solution may lose its relevance within 3–4 months, and the procedure for obtaining a patent takes an extremely long time, which is critical for such a rapidly developing industry.

• Competitors can easily spy not only on the external expression of design features, but also on the essence of the technical solution.

• Court proceedings on the results of intellectual property in this area are quite expensive and take a lot of time and effort from companies.

• Even though most technical solutions in this area are protected not by patent documents, but by a commercial secrecy regime, there is a risk of disclosure of technical solutions by competitors, for example, with the help of defector employees, etc.

These nuances create a specificity of patent activity in the racing car industry. Probably, most technical solutions remain outside the field of view of patent analysis, due to the above factors. However, the level of patenting revealed by the study is still sufficient to draw conclusions about



Pic. 1. Dynamics of applications and patents for the period 2012–2022 [according to the Espacenet patent database1].

the state of the technical industry, the pace of development and future trends. Therefore, the main purpose of the study is to demonstrate the development of patenting in the racing car industry, identify patenting features, as well as leaders among countries and companies.

ANALYSIS RESULTS

Patenting dynamics

The dynamics of applications and issued patents for the period 2012–2022 (Pic. 1) demonstrates the active growth of racing car technologies in 2014, continued until 2017. In 2014–2017, 4197 applications and 3938 patents were registered, which accounts for most of the patent activity for eleven years-long period. The number of registered applications and issued patents is approximately equal, which indicates the patentability of most of the presented technical solutions. In 2018, there was a significant decline in application and patent activity. Subsequently, the dynamics did not reach the previous peak indicators. However, this fact can be explained by the time lag of the patent database, caused by the fact that many patent documents are still undergoing examination procedures, and therefore cannot be reflected in the open access of the search engine. Nevertheless, now, the results of the patent analysis demonstrate a trend of declining interest in patenting during the period 2018–2022[1].

Patented objects

The racing car technology market is quite diverse and includes many technical solutions aimed at achieving such technical results as safety, efficiency and other performance indicators of the car. A racing car is a complex system that requires both parts and devices as well as electronic systems. Also, depending on the type of competition, the requirements for the design of the car vary greatly. In this analysis, all technical solutions related to racing cars in general were considered, without restraints on the types of competitions.

As an example of such technical solutions, we should consider patent CN108050173B of Taiyuan University of Technology. This invention describes a bionic structure braking system for a Formula 1 racing car and as stated in the description solves the problems of low braking efficiency and short service life of existing braking systems. The described braking system includes a brake disc, a four-piston calliper,

a guide bolt, two friction blocks and a return spring. This braking system is based on the bionic principle (imitation of a rough surface), which increases the wear resistance of the system.

Also, it is worth considering the patent KR102478299B1 of Honam University Industry (University Cooperation Centre). This invention describes a suspension device of a racing car based on the rolling phenomenon, which helps to improve the stability of the car when turning. According to the description of the invention, when the vehicle makes a sharp turn, the front wheels turn in the direction opposite to the rolling, thereby improving the stability of the vehicle when turning.

Distribution of applications and patent activity by countries and organisations

In the context of application and patent activity of individual countries, it is necessary to highlight the absolute leadership of China. Chinese applications make up 93 % of the total array of technical solutions related to racing cars, and patents – 96 % (according to the patent database Espacenet[1]). Such a large gap between Chinese activity and competitors is a consequence of the fact that many foreign companies involved in racing cars outsource the development of technical solutions to Chinese research centres and universities due to lower costs and faster implementation of developments, and they, in turn, secure the results of developments for themselves with the help of patents. This is confirmed by the fact that some patent documents have a priority application from China but are published in a foreign patent office (for example, in the USA, Japan, Italy and other countries).

Among other countries, there are applications from Japan, South Korea, Germany, the USA, France, Russia and other countries but their share, compared to China, in the total array is so small that it is impossible to talk about full-fledged quantitative competition. Chinese patent documents have almost completely filled the market of racing car technologies, and not only on the national territory.

The ranking of the top 10 leading organisations by the number of filed applications and patents (Pic. 2) also demonstrates the absolute leadership of Chinese organisations. Only one organisation (TOSHIBA KK) represents Japan, while the rest of the ranking positions are represented by Chinese companies. Based on the data, it is clear that the distribution of filed applications and patents is uneven. For example, Guangdong University of Technology (UNIV GUANGDONG TECHNOLOGY in Pic. 3) ranks 3rd with 47 applications and 23 patents. However, State Grid Corporation of China (STATE GRID CORP CHINA) has fewer applications, but more patents (31 applications and 31 patents).

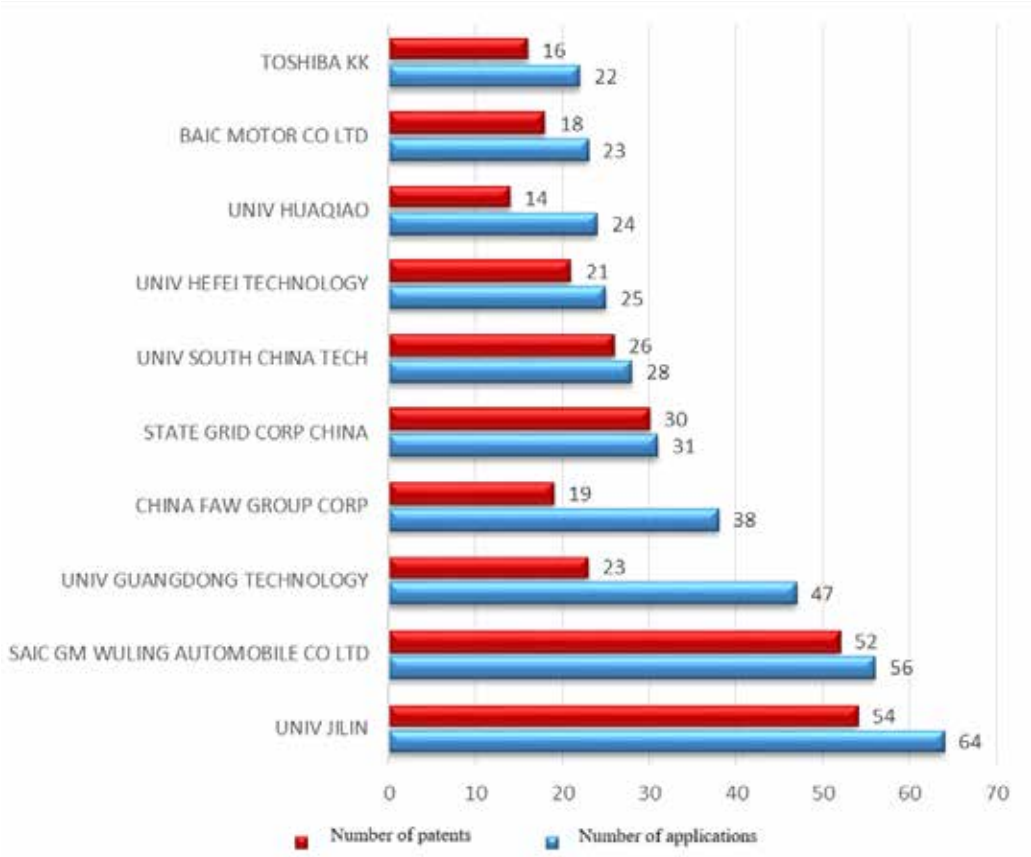
Based on the patent search data, it follows that out of the total array of applicants, universities account for 41 % of organisations, private organisations – for 56 %, and individuals – for 2 %. Private organisations form the largest part of the application and patent activity in the field of racing cars. For example, in the ranking of top organisations regarding patent activity, five out of ten organisations are private organisations, the remaining five positions are represented by universities. Among private organisations, there are both private research centres and large automobile manufacturing companies. For example, in the ranking of leading organisations (Pic. 2) there are such large automobile manufacturing companies as SAIC, FAW, BAIC.

Universities also form a large part of patent and application activity. For example, the Jilin University is the leader of application and patent activity (Pic. 2), entities affiliated with universities occupy five positions among top 10 organisations.

Individuals occupy the smallest share of the total array of application and patent activity. The identified patent documents of individuals describe technical solutions for the entire automotive industry, applicable, among other things, to racing cars, rather than specialised devices exclusively for racing cars. In this case, the value of patents increases, since their area of their application expands, but at the same time this confirms the fact that inventions to be used exclusively in racing cars are patented quite rarely, due to the rapid obsolescence of technical solutions. It is possible to extend the relevance of such a patent in the technology market only by expanding its area of application, therefore, often protected technical solutions in the field of racing cars are also applicable to general automotive engineering.

Publication activity

Special attention should be paid to the analysis of publication activity on racing car technologies. Patents and research publications together provide a complete picture of development of technologies and scientific research. Patents show which technologies are



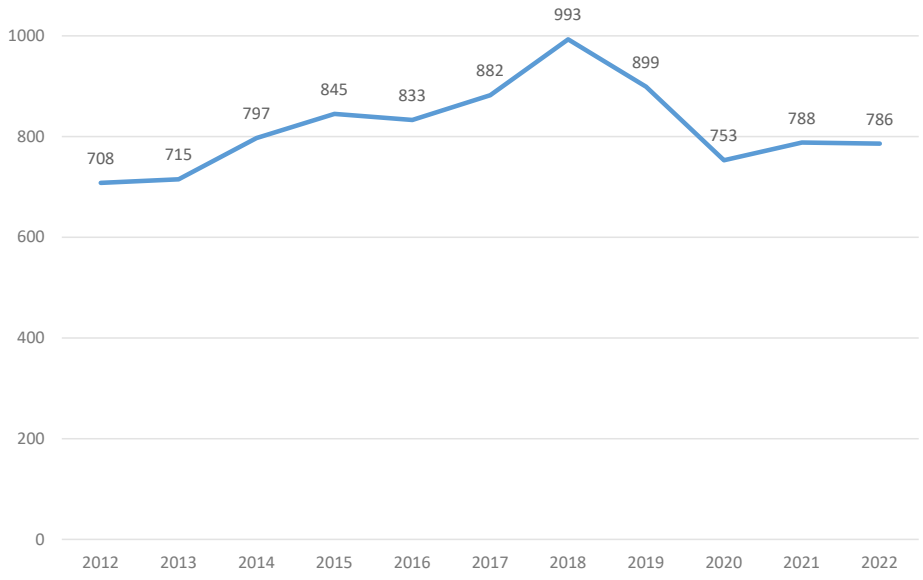
Pic. 2. Number of applications and patents by organisations for the period 2012–2022 [according to the Espacenet patent database[1]].

protected and can be commercialised, while scientific publications show what research is being conducted and what areas are considered promising in the academic community. The analysis of publication activity was carried out using keyword searches similar to patent searches, with a limitation on the type of scientific publications (Articles only) in the Dimensions, CORE publication databases, while the main array of scientific publications for analysis was taken from the Open Alex database.

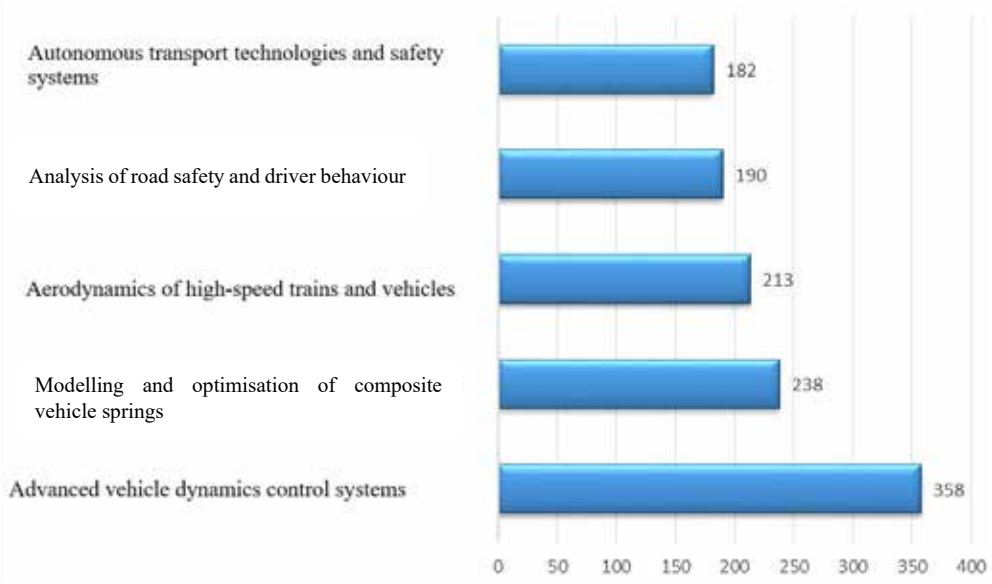
The dynamics of scientific article publications for the period 2012–2022 (Pic. 3) demonstrates a relatively uniform growth in publication activity. For the period 2012–2018, the number of annual publications increased from 708 to 993 publications, which is the peak value for the entire analysed period. However, starting from 2019 and until 2022, the dynamics begin to show downward trends. Thus, during the specified period, the number of publications decreased from 899 to 786, which, however, is not a critical drop in publication activity.

Also, the subject headings to which the mentioned publications belong were analysed (Pic. 4). The largest number of publications (358 publications) were noted in the topic referring to advanced vehicle dynamics control systems, which indicates high interest and active research in this area, possibly due to the relevance and significance of improving the controllability and safety of vehicles. Also, in this ranking were noted publications on the topic of «Modelling and optimisation of composite springs of vehicles» (238 publications), «Aerodynamics of high-speed trains and vehicles» (213 publications) and others.

Thus, publication activity demonstrates a relatively uniform development trend. It is worth noting that the noted decline in the period 2019–2022 is not critical and does not demonstrate a rapid rate of decline in publication activity, however, it should be considered in the long-term analysis of the industry. When comparing patent and publication activity indicators, it is noticeable that the peak values of publication activity are



Pic. 3. Dynamics of publications of scientific articles for the period 2012–2022 [according to the Open Alex database].



Pic. 4. Number of publications of scientific articles by subject topics for the period 2012–2022 [according to the Open Alex database].

much lower than similar values of patent activity. Nevertheless, the rate of development of publication activity demonstrates a more stable nature.

CONCLUSIONS

The patent activity analysis data shows that, in general, the level of patent activity in the racing car field has experienced both a steady rise and a significant decline. Even though most of the technical solutions are probably protected as know-how and are not available for open patent analysis, it was possible to trace a continuous increase in patent activity over the period 2014–2017. The bulk of the application and patent activity occurred during the above-mentioned period, after which a decline in activity was observed.

Regarding the application and patent activity of individual countries, the undisputed primacy of the world leader – China – was revealed, both in the number of applications related to racing cars and in the number of patents issued. China also leads in the number of the most active organisations and is unlikely to give up its position in the coming years. The leading role in application and patent activity for racing car technologies is played by private organisations and universities, providing most of the technical solutions.

REFERENCES

1. Ekanem, I., Ikpe, A., Abia, E. Evolution of formula one (F1) motorsports and its top-notch advancement in engineering innovations across the racing industry. In: Atlas. 11th International Congress on Advanced Scientific Studies and Interdisciplinary Research, Marrakesh, Morocco, January 16–18, 2024. Proceedings Book. Eds. Prof. Abuharris, A., Kidiryüz, M. Liberty Academic Publishers, 2024, pp. 107–127. ISBN: 978–1–955094–94–8.

2. Doronkin, V. G., Lyamin, A. S. Development of automobile sports in Togliatti city: 1966–2016 [*Razvitie avtomobilnogo sporta v gorode Tolyatti:1966–2016*]. *Baltic Humanitarian Journal*, 2017, Vol. 6, Iss. 1 (18), pp. 90–93. [Electronic resource]: https://elibrary.ru/item.asp?id=28921917. EDN: YIXJAF. Last accessed 15.05.2023.

3. Bernatsky, V. V., Krasavin, P. A., Martin, G. K. To the question of investigation of the hardness characteristics of the rams of racing vehicles [*K voprosu issledovaniya zhestkostnykh kharakteristik ram gonochnykh*]. *Car. Road. Infrastructure*, 2019, Iss. 3(21), P. 11. [Electronic resource]: https://elibrary.ru/item.asp?id=41152477. EDN: UQTIYI. Last accessed 15.05.2023

4. Degtev, D. N., Lavrenov, S. V., Osipov, A. A. [*et al.*] Static analysis of the front steering knuckle for Formula Student racing car [*Staticheskiy analiz perednego povorotnogo kulaka gonochnogo avtomobilya klassa «Formula Student»*]. *High technologies in the construction complex*, 2021, Iss. 1, pp. 61–67. [Electronic resource]: https://elibrary.ru/item.asp?id=46141472. EDN: WZOEVH. Last accessed.

5. Sorokin, P. A., Khryakov, K. S., Mishin, A. V. Spectral analysis of «Dallara T12» race car front wing vibrations [*Spektralniy analiz vibratsii perednego antikryla gonochnogo avtomobilya «Dallara T12»*]. *Bulletin of Tula State University. Technical sciences*, 2015, Iss. 7–1, pp. 221–226. [Electronic resource]: https://elibrary.ru/item.asp?id=25070439. EDN: VCQAMN. Last accessed 15.05.2023.

6. Khryakov, K. S. Issues of performance in aerodynamic elements of racing cars [*Problemy effektivnoi raboty aerodinamicheskikh elementov gonochnykh avtomobilei*]. *Bulletin of Tula State University. Technical sciences*, 2014, Iss. 11–2, pp. 193–196. [Electronic resource]: https://elibrary.ru/item.asp?id=23050864. EDN: TKKZCX. Last accessed 15.05.2023.

7. Pletin, D. A. Design features of Formula racing cars [*Osobennosti konstruktsii gonochnykh avtomobilei klassa Formula*]. *Izvestia MGTU «MAMI»*, 2014, Vol. 1, Iss. 1 (19), pp. 63–66. [Electronic resource]: https://elibrary.ru/item.asp?id=21834415. EDN: SJUWHX. Last accessed 15.05.2023.

8. Evseev, K. B. Analysis of mechanical properties of carbon fiber suspension guide elements of a Formula Student car [*Analiz mekhanicheskikh svoistv ugleplastikovykh napravlyayushchikh elementov podveski avtomobilya klassa «Formula student»*]. *Youth Scientific and Technical Bulletin,* 2013, Iss. 10, P. 11.

9. Bikbulatov, R. I., Fedorov, S. V. Telemetry system of a racing car [*Sistema telemetrii gonochnogo avtomobilya*]. *Achievements of science and education,* 2019, Iss. 5(46), pp. 14–21. [Electronic resource]: https://elibrary.ru/item.asp?id=37347336. EDN: YLSVOG. Last accessed 15.05.2023.

10. Krasin, P. S., Volchenko, N. A. Experimental calibration of racing car [*Eksperimentalnaya kalibrovka datchikov gonochnogo avtomobilya*]. *Electronic online polythematic journal «Scientific Works of KubSTU»*, 2015, Iss. 2, pp. 205–212. [Electronic resource]: https://elibrary.ru/item.asp?id=23028910. EDN: TJYMJB. Last accessed 15.05.2023.

11. Turenko, A. N., Uzhva, A. V., Lukashov. I. V. [*et al.*] Use of GPS navigation satellite system for trajectory playback of a racing vehicle [*Ispolzovanie navigatsionnoi sputnikovoi sistemy GPS dlya vosproizvedeniya traektorii dvizheniya gonochnogo avtomobilya*]. *Bulletin of Kharkiv National Automobile and Highway University*, 2013, Iss. 60, pp. 083–089. [Electronic resource]: https://elibrary.ru/item.asp?id=21120196. EDN: RUEMYH. Last accessed 15.05.2023.

12. Suranovich, D. I., Korukhova, Yu. S. A System for Automated Driver's Errors Detection in Motor Racing [*Sistema avtomatizirovannogo vyyavleniya oshibok voditelya v avtogonkakh*]. *Scientific service on the Internet*, 2018, Iss. 20, pp. 454–458. [Electronic resource]: https://keldysh.ru/abrau/2018/theses/51.pdf. EDN: YPOHCX. Last accessed 15.05.2023.

13. Shinde, T., Chavan, R., Savadekar, P. [*et al.*] Failure Analysis of a Wheel Hub of Formula Student Racing Car. *Journal of The Institution of Engineers* (India): Series D, 2021, Vol. 102, Iss. 1, pp. 73–78. DOI: 10.1007/s40033-020-00244-z.

14. Susca, L., Mandorli, F., Rizzi, C., Cugini, U. Racing car design using knowledge aided engineering. Artificial Intelligence for Engineering Design, Analysis and Manufacturing (AI EDAM), 2000, Vol. 14, Iss. 3, pp. 235–249. DOI: https://doi.org/10.1017/S0890060400143057 [Access limited for subscribers].

15. Manaf, M. Z. A., Latif, M. F. A., Razak, M. S. A. [*et al.*] Suspension kinematic analysis of UTeM's FV Malaysia electric vehicle racing car. International Review of Mechanical Engineering. 2016, Vol. 10, Iss. 4, pp. 294–300. DOI: 10.15866/ireme.v10i4.8626.

16. Kamalyan, A. M. Protection of Scientific Research Results and Scientific Information in Elite Sports («Formula 1» Case Study). *Actual Problems of Russian Law*, 2021, Vol. 16, Iss. 2 (123), pp. 175–182. DOI: 10.17803/1994-1471.2021.123.2.175-182.

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