RECYCLING OF WASTE TIRES

E.A. Melnikovich
Scientific advisor associate professor I.A. Matveenko
National Research Tomsk Polytechnic University, Tomsk, Russia

Industrial progress leads to the increase in both industrial and household wastes. Waste tires make a big contribution to the global pile of waste products. The accumulation of waste tires is one of nowadays environmental challenges. It is becoming a characteristic feature of environmentally unfriendly areas. More than 1 million tons of waste tires are annually produced in Russia [2]. In Europe this figure rises to 2.5 million tons, in the United States — up to 3 million tons [14].

Naturally, the decomposition of tires exceeds 100 years with release of various chemicals hazardous for soil and groundwater. Waste tires are inflammable: if burnt, they release highly toxic substances: biphenyl, anthracene, pyrene [11]. This environmental impact could be reduced by viable alternative for the recycling of used tires by applying waste tire conversion technologies. Unfortunately, even the developed countries face the problem of burning the waste tires for fuel [12]. Therefore, waste tire recycling is a worldwide challenge nowadays.

The purpose of this work is to review and analyze existing methods of waste tire recycling, as well as to highlight particular characteristics of waste tire processing technologies.

According to the definition, recycling is a process to convert waste materials into new products to prevent waste of potentially useful materials, reduce the consumption of fresh raw materials, reduce energy usage, and environmental pollution. Thus, waste tire recycling is beneficial process because tires contain recycled materials: rubber (60%), metal (18%) and textile cord (29%) [1]. However, it is necessary to create an efficient network of collection facilities and tire processors to achieve 100% tire recycling. In the European Economic Community, disposal fee is included into the cost of tires. So, buying imported tires, a Russian consumer pays for tire recycling in the producing country. The price of Russian tire does not contain such fee [3].

At present there are about 10 ways of waste tire recycling. In Russia, the most popular way of processing is mechanical crushing, which is used by 19 companies [9]. In Tomsk there are only two enterprises, "Tomoko" and "Ekoshina", involved in tire processing. It is obvious that with a large number of waste tires, it is necessary to establish much more waste treatment enterprises.

The most accepted way of recycling of waste tires is mechanical crushing [4,5]. Bead rings are removed, and then a tire is cut into for 4 pieces and passed through rollers which destroy it. After that, large pieces are crushed to separate the rubber from the cord. The separated rubber is shredded and rubber crumb is obtained [10].However, a "shaggy" shape of the particles enhances the oxidation process, which is a weak point of the technology [3]. Steel cord cannot be completely clean, so it cannot be reused. The advantage of mechanical crushing is quite low power consumption and low cost [10].

Water-jet method [16] is an environmental friendly process. In a chamber a tire is subjected to jets of water under high pressure. Water rips chunks of rubber, which is separated from cord in the separator. The product of recycling is rubber crumb. This technology provides a high quality product and does not require large areas for production [10].

The low-temperature pyrolysis [6, 7] is a process of thermal waste decomposition in a reactor at temperatures from 500 to 600 degrees Celsius. Pyrolysis is accompanied by the release of gas, liquid and solid phases [15]. The gases discharged from the reactor, pass a capacitor where the liquid phase is released. Part of the pyrolysis products is returned to the reactor to maintain the process. The process takes place with the emission of harmful substances - flue gases. The final products are electricity, heat, metal, pyrogas, heat oil, carbon residue. Significant advantages of the method are low capital investment, and independent power supply.

The low temperature [8] (cryogenic) technology is the cooling of the tire at -69˚S to -100˚S. Liquid nitrogen is used for cooling. Being cooled the rubber cracks and is separated from the cord. Thereafter, it is ground to a rubber crumb. Liquid nitrogen is the main reason for holding back the introduction of low-temperature technology. Since nitrogen has a high cost and it is difficult for storage and transportation [3].

The product of some of the following technologies is crumb rubber. It is used for:

- the manufacture of rubber products (tires, rubber shoes);
- the manufacture of roofing materials;
- building roads.

The problem of recycling of tires is important for the environmental condition of Russia. Any of the above methods are more environmentally friendly than land filling. Recycling tires provides secondary raw materials, which may be used in many industries. Creating rubber the enterprises for recycling will help save the environment. The state should create active tire programs which provide education on tire issues, conduct waste tire collection events, and construct demonstration projects featuring practical uses for recycled tires [13].

References

1. Garin, V.M. Disposing of solid waste: instruction medium / V.M. Garin –Rostov-on-Don:The Rostov State Transport University, 2004. – 146p.
2. Information - analytical agency Cleandex. URL: http://www.cleandex.ru/
3. Moskvin, A.A. Pecycling of waste tires in Russia / A.A. Moskvin //Recycling of waste. – 2009. – № 3. – P. 2-5.
4. Pat.2139188 Russian Federation, IPC B29B17/00, B02C19/18. The device for discharge destruction of tires with metal cord / Bedyukh A.R., Parubochaya T.V., Butko V.G.; applicant and patentee Bedyukh A.R.. – №98123180/12; applicantion 03.04.1998; publ.10.10.1999.
5. Pat.2050287 Russian Federation, IPC B26F3/06. The device for structuring tires with metal cord / Bedyukh A.R., Lutsenko A.L., Parubocha T.V., Butko V.G., Odinets S.I.; applicants and patentees Bedyukh A.R., Lutsenko A.L., Parubocha T.V., Butko V.G., Odinets S.I.– №5055859/28; application 22.07.1992; publ. 20.12.1995.
6. Pat.2399488 Russian Federation, IPC B29B17/00. The device for low-temperature pyrolysis of waste tires continuous method without pretreatment / Rozhin V.V.: applicant and patentee Rozhin V.V. – №2009109698/12; application 20.01.2010.; publ. 20.09.2010.
7. Pat.2211086 Russian Federation, IPC B01J023/755, B01J023/74, C08J011/20. The catalyst of low-temperature pyrolysis of hydrocarbon-containing polymer materials and its production method / Prilutskiy E.V., Prilutskiy O.V.; applicants and patentees Prilutskiy E.V., Prilutskiy O.V. – №2001106616/04: application 25.08.25.; publ. 27.08.2003.
8. Pat.2299804 Russian Federation, IPC B29B17/00. Integrated production line of tire recycling / Kutsemelov B.A.; applicant and patentee Kutsemelov B.A. – №2005123216/12; application 22.07.2005; publ. 27.05.2007.

9. «SIBUR Corporate». – URL: http://www.sibur.ru/
10. Solid waste. – URL: http://www.solidwaste.ru/
11. International Power Ecology Company. URL: http://i-pec.ru/en/
12. Myhre, Marvin; MacKillop, Duncan A (2002). "Rubber recycling". Rubber Chemistry and Technology 75 (3): 429–474. http://rubberchemtechnol.org/doi/abs/10.5254/1.3547678
13. Waste tire recycling. URL: https://dpw.lacounty.gov/epd/TireRecycling/index.cfm
14. Waste tires treatment technologies. URL: http://tdplant.com/news/waste-tires-conversion-technologies
15. Recycling and utilization of scrap tires. URL: http://www.tkomplex.ru/en/equipment/equipment-application/recycling-and-utilization-of-scrap-tires
16. Method of recovery of rubber from used car tyres and installation for its application. URL:http://worldwide.espacenet.com/publicationDetails/biblio?CC=EP&NR=2420371A1&KC=A1&FT=D

PELLET IMPACT DRILLING DEVELOPMENT: PROSPECTS AND TRENDS

D.A. Nechaev, D.G. Dubinsky
Scientific advisors senior lecturer A.V. Kovalev, associate professor D.A. Terre
National Research Tomsk Polytechnic University, Tomsk, Russia

Nowadays, there is a trend of increasing amounts of operations in hard and tough rocks in world's drilling practice. Drilling in such types of rocks is characterized by low values of mechanical speed and bit pressure. In this regard, development of alternative ways of hard-rock destruction and new design solutions for rock cutting tool becomes topical. Pellet impact boring method which implies destruction of rocks by blows of metal pellets continuously circulating in a bottom-hole area is one of the most prospective techniques. Circulation is carried out by means of an ejector pellet impact tool string. Potentially, this method can give a considerable gain of penetration rate within the range of hard and tough rocks, reduce costs of a well construction by cutting round-trip time down. Moreover, as pellet impact method can easily fit the existing well technology which involves cutting transport by drilling fluid it will not demand considerable re-equipment of the drilling rig.

For the first time the method of rock destruction by pellet impact was offered in 1955 by a group of scientists from American company «Carter Oil». A jet pump was chosen by them as a device which can cause acceleration and recirculation of pellets. As a result of their laboratory research it was established that the greatest mechanical cutting speed is observed using the pellets of the greatest possible diameter which do not get jammed in mixing chamber. However, in 1961 one of participants of this project L. U. Ledgerwood noted that pellet impact drilling has no practical application and, despite the possibility of destroying rocks, this method is less cost-effective than usual rotary drilling. These conclusions have been brought about owing to a procedure error: while making experiments the American scientists put emphasis on pellet impact physics rather than rock destruction issues. Consequently, the researchers drilled rocks of different hardness at identical pellet launching speed which was equal to 22,8 m/s. Besides, the tool string which was called "gravity-aspirator" had a number of shortcomings. The special