Summary

According to the principles of the circular economy, it is necessary to increase the use of secondary waste materials by the industry. This requires the improvement of separate waste collection systems and the building or reorganization of mechanical-biological treatment plant (MBP) into recycling centers. Currently operating MBT plants assure the separation of secondary waste materials and the pre-RDF for the production of fuel from the mixed municipal solid waste (MSW). Moreover, at MBT plants, the remaining waste after stabilization are prepared for landfilling. The reorganization of MBT plants into regional recycling centers requires the adjustment of the sorting technological line for effective material recycling. The aim of this study was to determine the sorting efficiency of separately collected waste of metal and plastic (SMT) and paper waste (SP) depending on the waste mass loading in time (OLT) of an automatic-manual sorting line designed for sorting of mixed municipal solid waste. The used OLTs were 2.8, 4.3 and 6.4 Mg SMT/h and 3.8, 7.7 and 11.0 Mg SP/h; the difference in used OLTs was due to the different bulk density of SMT and SP. About 85 tons of SMT and about 140 tons of SP were sorted.

Analysis of the morphological composition showed that the secondary waste materials for the recycling, which were separated from SMT, accounted for 42.64%, the remains were the impurities. The share of packaging of PET_b was the largest and accounted for 9.01% of SMT. The secondary waste materials for recycling from SP constituted 76.56%, with the largest share being soft paper (47.20% SP) and cardboard (29.36% SP).

The sorting efficiency on the automatic-manual sorting line was determined on the basis of the degree of automatic separation (S_A) and homogeneity of automatically separated (J_A) and manually sorted (J_M) secondary waste materials, pre-RDF and ballast.

At OLT of 2.8 Mg SMT/h, the S_A and J_A of secondary waste materials were 76.25-98.43%, and the efficiency of manual sorting was 98-100%. With an increase in OLT to 4.3 Mg SMT/h, the efficiency of automatic sorting and the S_A and J_A of secondary waste materials decreased to 65.00-96.82%. The efficiency of manual sorting remained unchanged. At the highest OLT, 6.4 Mg SMT/h, despite high S_A (74.38-95.63%), the J_A of secondary waste materials was merely 41.31-78.14%. After manual sorting, homogeneity decreased to 51.00%. This meant that the required homogeneity of the secondary waste materials for recycling has not been achieved. Overloading of the automatic-manual sorting line with the mass of waste caused inappropriate distribution of size fractions on the sieve and overloading of the separators. Compared with the results obtained at OLT of 2.8 Mg SMT h, at OLT of 4.3 Mg SMT/h, mass of pre-RDF increased from 11.78 to 17.22% SMT, and the share of

secondary waste materials in pre-RDF increased from 1.12 to 2.67% SMT. At OLT of 6.8 Mg SMT/h, the share of pre-RDF increased to 27.05% SMT, and the share of secondary waste materials in pre-RDF increased to 6.36% SMT. The content of ballast was lower, 13.74% SMT.

For paper waste, at OLT of 3.8 Mg SP/h, the efficiency of automatic and manual sorting was high of 91.25-100% and 98.50-100%, respectively. An increase in OLT to 7.7 Mg SP/h decreased the efficiency of automatic sorting to 80.22-100.00%, while the efficiency of manual sorting was still high (89.00-100.00%). At OLT of 11.0 Mg SP/h, the J_A of soft paper was 75.02%, with the S_A of 89.70%. The J_A of cardboard was 80.22%, with the S_A of 40.73%. At OLTs of 7.7 and 11.0 Mg SP/h, the mass of pre-RDF increased to 4.64 and 5.31%, and the mass of ballast increased to 3.85 and 13.79%. At OLT of 11.0 Mg SP/h, the share of secondary waste materials in the ballast was 7.66% SP.

The results shows that the automatic-manual sorting line of the MBP designed for processing of mixed MSW can be used for SMT sorting at OLTs of 2.8 and 4.3 Mg/h. Sorting at OLT of 4.3 Mg SMT h is recommended, because at higher loading, the quality requirements of secondary waste materials from SMT for recycling are obtained. According to the requirements, the homogeneity cannot be lower than 90%.

In the case of SP sorting, due to the higher loading of the sorting line, the use of OLT of 7.7 Mg/h is recommended. The homogeneity of secondary waste materials from SP was higher than 90%, and the quality of secondary waste materials from SP for recycling met the requirements. Despite the high homogeneity of secondary waste materials from SP, the optopneumatic separators were unequally loaded during sorting, which indicates their inefficient use. The sorting line for SP should be modernized. The separator of SO_plastics should be equipped with sensors of identification of different types of paper waste. Leaving the separator of SO_plastic in its current configuration requires changing the direction of flow of the waste stream separated by this separator and directing it to the beginning of the automatic-manual sorting line and sorting this stream with SMT waste.