Quality loss of birch plywood logs supplied for export in Finland

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Abstract. A field-based study was performed to broaden our knowledge of Quality loss of birch plywood logs supplied for export and determine the main causes of the quality loss during harvesting and delivery and the ways to eliminate them. The total volume of studied birch plywood logs amounted to 14 281 cubic meters. Are shown the some results of the acceptance of plywood logs at the mills in Finland in terms of the types of rejects broken down by suppliers, mills and shipments. The total reject rate in the studied shipments amounted to 9.3%. The volume of birch plywood logs rejected because of mechanical damages to the log (defects) reached 39.2% of the total reject volume. Crookedness of logs was the second most non-permissible defect, which amounted to 18.9% of the total reject volume. Processing defects such as unprocessed branches amounted to 9.9% of total reject volume. Dimension incompliance, namely, undersize diameter (thinning) and short-length log (bolt) amounted to 7.7% and 3.2% correspondingly. Length incompliance was 5.2%. Thus, the high reject rate during harvesting is caused by technical, technological and management factors.

1. Introduction

For efficient development and management in logging and wood processing industries, special attention should be paid to the quality of round wood during harvesting and transportation. The most damage to the quality of timber occurs during the operations of felling, branch cutting, crosscutting, sorting, loading, skidding, storing and transportation [1].

In the Northwestern district of Russia the increased use of the fully-mechanized cut-to-length system consisting of harvester and forwarder in harvesting operations has not provided a solution to the problem of decreasing quality of various timber assortments and different species compositions. Due to non-compliance with the quality requirements for supplied timber specified in a contract between a logging company and a consumer of the timber, certain type of timber is rejected or regraded according to its quality [2].

The reject rate of valuable timber supplied for export, such as plywood logs, can account up to 10-15 % of the volume of a timber shipment. The substantive value loss of export timber is evident. The interests are balanced through pricing policy: the consumers add the volume of rejected plywood logs into the price, and the suppliers deem it possible to oversee the financial losses at this price.

To remain competitive, the logging companies have to minimize the quality loss of timber during harvesting and transportation. Consumers, on their part, should establish sample inspection of the timber production processes, specific for each timber mill and supplier.
The main objective of the study of birch plywood logs supplied for export was to determine the main causes of the quality loss during harvesting and delivery and the ways to eliminate them.

The research was conducted by researchers of the Department of Transport and Technological Machines and Equipment of the Institute of Forest, Mining and Construction Sciences of Petrozavodsk State University (PetrSU) in cooperation with the MB-EKS Lesnye ekspertisy expert organization.

In order to get representative data, the studies were conducted during harvesting and delivery of birch plywood logs performed by three logging companies of Karelia and the Vologda Region that supply timber to four UPM-Kymmene and Metsä mills in Finland. All the valuable timber was harvested using clear-cutting fully mechanized cut-to-length technology. The harvesting wood stands had not been thinned before. The harvesting areas comprised of uneven all-aged stands. Typical soils were silt loam, loam and sandy loam.

The total volume of studied birch plywood logs amounted to 14,281 cubic meters, with an average shipment of 1,298 cubic meters. The research was carried out throughout 2014 – 2018.

2. Methods and Materials

The research methods included two stages.

2.1. During harvesting birch plywood logs by the supplier

Visual observation (including photo and video recording) of technological process of harvesting system operations, felling and consequent cross-cutting of the timber by the harvester (Figure 1), loading and piling by the forwarder (Figure 2).

![Figure 1. Harvesting system operations: directing to the tree and felling, harvester John Deere 1270D.](image1)

![Figure 2. Harvesting system operations: decking (piling) by forwarder John Deere 1210E.](image2)

Evaluation of the technical condition of the machines and equipment, as well as the operators’ adherence to the operation and maintenance instructions.

Evaluation of the operators’ knowledge of technical regulations and instructions for harvesting peeler log, and their professional experience.

Analysis of Timbermatic system files of John Deere 1270D (E) harvesters in TimberLink-Office in order to evaluate performance and time parameters of the operations of cutting and processing of timber [3].

2.2. Upon the delivery of birch plywood logs to the timber mills

Visual control of discharge of ship, loading and uploading of motor transport (Figure 3).
Acceptance of the round-wood was carried out by volume on automatic line (Figure 4).

Acceptance by quality was carried out by sampling method employed to the whole shipment. Visual control of adherence to the technical regulations and contract specifications during the quality acceptance of the logs performed by the automatic lines operators, and the sampling done by the quality supervisors.

Acceptance of the shipments of plywood logs at the mills in Finland was performed in accordance with the contract requirements that are consistent with the specifications of the international standard GOST (All-Union State Standard) 9462-88 “Round timber of broad-leaved species. Specifications” [4], GOST 9462-2016 “Round timber of broad-leaved species. Specifications” [5] and TU 13-473-92 “Plywood logs supplied for export”.

3. Results
During harvesting operations, violations of work practices were found in performance of felling and cross-cutting by the harvester operators, as well as during loading, additional sorting and piling performed by the forwarder operators.

The harvester operators did not follow the instructions of operation and maintenance of the harvester head. There have been cases of working with dull cutting chain and delimbing knives, as well as using chains that are not recommended by the manufacturer. There have been cases of unsatisfactory sharpening of the chains while ignoring the operating instructions.

Check of the settings of Timbermatic system of the harvester head and grapple revealed that:
- The harvester head operating and measuring settings were manually controlled;
- In some cases Timbermatic system files that contain data on maintenance and repair could not be found;
- The computers of three harvesters had been virus-infected, which means that the operators had connected third-party peripheral devices.

In most cases the operators’ competence level and experience were insufficient for providing required level of performance. Operators with little work experience lack understanding of the quality requirements for plywood logs.

At the roadside landings, the log truck drivers frequently aligned a pile of assortments by hitting it on the ground.

During the mass acceptance, which is in practice at the mills, no significant violations of technical requirements and contract provisions have been recorded. There have been isolated cases of mistakes made by automatic line operator trainees when they assessed the log quality, which is attributed to their lack of work experience.
There have been isolated cases of aligning a pile of assortments by hitting it on the ground during the uploading of ships and piling the logs with consequent loading of the log trucks. The total reject rate in the studied shipments amounted to 9.3% (Table 1). This means that practically every 10\textsuperscript{th} shipment contained rejected logs that are birch pulpwood bolts.

According to the specifications of UPM-Kymmene and Mets\aa{} companies, non-permissible defects of plywood logs are mechanical damages to the log butts that occur during felling and cross-cutting. Table 1 shows that according to the results of acceptance, the abovementioned defects are the main cause of rejection. The volume of birch plywood logs rejected because of these defects reached 39.2\% of the total reject volume.

Crookedness of logs was the second most non-permissible defect, which amounted to 18.9\% of the total reject volume.

Processing defects such as unprocessed branches amounted to 9.9\% of total reject volume.

Dimension incompliance, namely, undersize diameter (thinning) and short-length log (bolt) amounted to 7.7\% and 3.2\% correspondingly. Length incompliance was 5.2\%.

Evaluation of the defects and mechanical damage to birch plywood logs was carried out on the basis of several parameters [2, 6-8] provided by applicable international standards and quality specifications in the customer contracts:

- Defects caused by improper tree-felling and cross-cutting, namely cracks (Figure 5);
- Processing defects, branches (including unprocessed branches) (Figure 6);
- Mechanical damage occurring in the course of harvesting, skidding, sorting, piling and transportation of timber;
- Crookedness of the timber (Figure 7), which depends on professional competence and experience of the machine operators, namely on their good performance of cross-cutting and sorting operations.

In addition to that, the study included monitoring of the compliance of the sizes of assortments to the quality requirements specified in the contracts: log-length allowances, as well as permissible log end and top diameters.

**Figure 5.** Crack.  
**Figure 6.** Unprocessed branches.
The results of the acceptance of plywood logs at the mills in Finland in terms of the types of rejects broken down by suppliers, mills and shipments are shown in Table 1, Table 2 and Table 3.

4. Discussion and Conclusion

Thus, the high reject rate during harvesting is caused by technical [9], technological and management factors. According to this research, as well as [2, 7], waste rate can amount to 4-5% of the shipment and that fully satisfies the quality requirements for plywood logs specified in the contract.

Discovered shortcomings are systematic and lead to increased rate of avoidable plywood reject. They also decrease the yield of peeler logs and reduce the efficiency of logging operations performed by harvester and forwarder.

In order to eliminate all the discovered shortcomings in the performance of the machine operators and reduce the quality loss of birch plywood logs, the following actions are recommended:

- Machine operators should pay more attention to the quality of the logs rather than volume alone. This can be achieved by introducing a remuneration system and logging instructions that would stimulate harvesting valuable timber undamaged;
- Harvesting machine operators should not violate the processing technologies;
- Operators should service the harvester head in strict accordance to the Operations and Maintenance Manual;
- Harvesting machine operators should periodically undertake advanced training;
- Harvester and forwarder operators who have less than twelve months experience should be supervised [10].

Besides, the consumers of plywood logs are recommended to take the following actions:

- Periodic organization of advanced training for operating and engineering personnel in order to meet the requirements of the customers;
- Introduction of remunerative incentives in order to increase the quality of production and ensure absolute compliance with the process requirements set out by the customers in contract specifications;
- Taking certain measures of control during harvesting valuable assortments.

The identified deficiencies are systemic and defects reduce the quality of birch plywood logs and decrease the performance of cut-to-length system consisting of harvester and forwarder [2].

In order to solve the studied problem, given the increased demand for plywood logs, it is necessary to carry out further studies and develop proposals for reducing the quality loss of birch plywood logs.
Table 1. Results of acceptance of plywood logs at the mills in Finland

| No. | Customer          | Place of acceptance | Number of ships | Length/length code | Acceptance volume Upon delivery (Cm) | first class/grade | Reject Cm | % |
|-----|-------------------|---------------------|-----------------|--------------------|---------------------------------------|------------------|-----------|---|
|     |                   |                     |                 |                    |                                       |                  |           |   |
|     | total             | 11                  | 14281.6         | 12948.0            | 90.7                                  | 1333.5           | 9.3       |   |
| 1   | Supplier No.1     | Timber mill No.1    | 1               | 4.0                | 1633.1                                | 1560.6           | 95.6      | 72.5 | 4.4 |
| 2   | Supplier No.2     | Timber mill No.2    | 1               | 3.3; 4.0           | 1555.0                                | 1461.7           | 94.0      | 93.3 | 6.0 |
| 3   | Supplier No.1     | Timber mill No.2    | 1               | 4.0                | 1452.6                                | 1345.1           | 92.6      | 107.5 | 7.4 |
| 4   | Supplier No.1     | Timber mill No.3    | 1               | 3.3; 4.0           | 1502.4                                | 1323.5           | 88.1      | 178.8 | 11.9 |
| 5   | Supplier No.2     | Timber mill No.2    | 1               | 4.0                | 1573.0                                | 1388.5           | 88.3      | 184.5 | 11.7 |
| 6   | Supplier No.1     | Timber mill No.2    | 1               | 4.0                | 1691.6                                | 1497.0           | 88.5      | 194.6 | 11.5 |
| 7   | Supplier No.1     | Timber mill No.2    | 1               | 4.0                | 482.7                                 | 450.4            | 93.3      | 32.3  | 6.7 |
| 8   | Supplier No.2     | Timber mill No.2    | 1               | 3.3; 4.0           | 737.3                                 | 701.9            | 95.2      | 35.4  | 4.8 |
| 9   | Supplier No.3     | Timber mill No.3    | 1               | 3.3; 5.0; 4.1      | 1545.6                                | 1417.3           | 91.7      | 128.3 | 8.3 |
| 10  | Supplier No.3     | Timber mill No.4    | 1               | 4.0                | 1602.0                                | 1321.6           | 82.5      | 280.4 | 17.5 |
| 11  | Supplier No.2     | Timber mill No.2    | 1               | 4.0                | 506.3                                 | 480.4            | 94.9      | 25.9  | 5.1 |
| No. | Customer     | Place of acceptance | Deductions (incl. nominal length deductios) | Undersize diameter (thinning) | Short-length log (bolt) | Branches | Crookedness |
|-----|--------------|----------------------|---------------------------------------------|-------------------------------|-------------------------|----------|-------------|
| 1   | Supplier No.1| Timber mill No.1     | -                                           | 10.9                          | 15.0                    | 27.6     | 38.1        | 3.6         | 5.0         |
| 2   | Supplier No.2| Timber mill No.2     | -                                           | 12.4                          | 13.3                    | 21.2     | 22.7        | 7.8         | 8.4         | 20.1       | 21.5       |
| 3   | Supplier No.1| Timber mill No.1     | -                                           | 4.4                           | 4.1                     | 11.7     | 10.9        | -           | -           | 35.2       | 32.7       |
| 4   | Supplier No.3| Timber mill No.3     | 28.50                                       | 15.9                          | 12.0                    | 6.7      | 7.5         | 4.2         | 13.5        | 7.6        | 85.8       | 48.0       |
| 5   | Supplier No.2| Timber mill No.2     | -                                           | 37.9                          | 20.5                    | -        | 9.6         | 5.2         | 16.7        | 9.1        |
| 6   | Supplier No.1| Timber mill No.2     | -                                           | 8.6                           | 4.4                     | -        | 9.4         | 4.8         | 18.9        | 9.7        |
| 7   | Supplier No.1| Timber mill No.2     | -                                           | 5.6                           | 17.3                    | -        | 0.8         | 2.5         | 1.6         | 5.0        |
| 8   | Supplier No.2| Timber mill No.2     | -                                           | 2.4                           | 6.8                     | 2.4      | 6.8         | 6.0         | 16.9        | 9.6        | 27.1       |
| 9   | Supplier No.3| Timber mill No.3     | 20.10                                       | 15.7                          | 6.2                     | 4.8      | -           | -           | 12.4        | 9.7        | 32.5       | 25.3       |
| 10  | Supplier No.3| Timber mill No.4     | 20.50                                       | 7.3                           | -                       | -        | -           | 37.9        | 13.5        | 26.0       | 9.3        |
| 11  | Supplier No.2| Timber mill No.2     | -                                           | 2.6                           | 10.0                    | -        | 6.5         | 25.1        | 1.0         | 3.9        |
### Table 3. Results of acceptance of plywood logs at the mills in Finland by the type of reject: Cracks, mechanical damage

| No. | Supplier | Place of acceptance/Timber mill | Cracks, mechanical damage, cm | %  |
|-----|----------|---------------------------------|-----------------------------|----|
| 1   | No.1     | No.1                            | 23.1                        | 31.9 |
| 2   | No.2     | No.2                            | 22.5                        | 24.1 |
| 3   | No.1     | No.2                            | 30.2                        | 28.1 |
| 4   | No.1     | No.3                            | 10.5                        | 5.9  |
| 5   | No.2     | No.2                            | 86.2                        | 46.7 |
| 6   | No.1     | No.2                            | 110.6                       | 56.8 |
| 7   | No.1     | No.2                            | 23.7                        | 73.4 |
| 8   | No.1     | No.3                            | 7.7                         | 21.8 |
| 9   | No.3     | No.2                            | 17.0                        | 13.3 |
| 10  | No.3     | No.4                            | 180.2                       | 64.3 |
| 11  | No.2     | No.2                            | 180.2                       | 42.1 |

Total: 522.6 %; 39.2 %

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