Analysis of defects and their impact on the production losses using Pareto diagrams

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Abstract. The Pareto diagram is a powerful tool for identifying the significant factors influencing objects, processes, services, etc. In the production sphere, it is very suitable for analysis of defects and their impact. In this work are summarized the types of defects that occur in the production of headrest covers for car seats. Analysis was made of both the frequency of occurrence of defects and the financial losses from them. The research is done on the whole production range (all projects) proceeded in a given month, on product families and on specific products. The three defects with the highest frequency of occurrence were identified. For them, additional study was conducted to determine the impact of the type of used material on internal scrap calculated as an expense in euros.
Based on the obtained results, recommendations are made for improving the work and its results.

1 Introduction

The Pareto principle states that for many events roughly 80% of the effects come from 20% of the causes. It is named after the Italian economist Vilfredo Pareto, who has found that approximately 80% of the land in Italy was owned by 20% of the population. He has also established that the same proportion is valid for the distribution of income and wealth among the population. As a principle it is introduced by the management guru Joseph M. Juran who has proved that many natural phenomena are subordinated to the proportion 80/20 - economics, sociology, computing, sports, etc.

Widely used is the Pareto diagram, which is a cumulative curve giving the relationship between the cumulative frequency and the individual factors ranked according to the frequency of their occurrence or degree of influence. It is one of the Ishikawa's seven basic tools for quality management [1].

For example, on Fig. 1 is given a Pareto diagram presenting the most used raw materials that are dyed in Turkey [2].

As seen from the diagram, the mixture Wool/Polyester forms 42.2% of the total production, followed by pure Wool (30.8%) and Wool/Nylon (16.5%). The remaining materials constitute 10.5% of the production that is less than 20%. This means that 3 materials form over 80% of the total quantity of dyed materials.

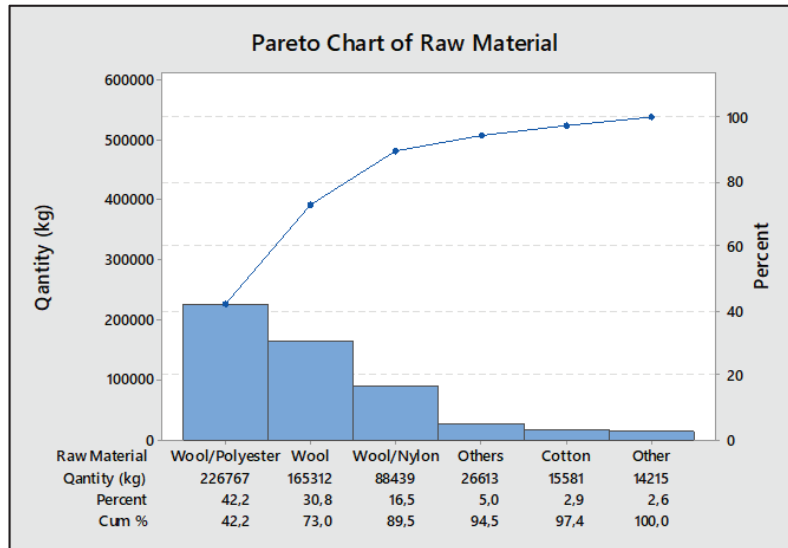* Corresponding author: dianakra@tu-sofia.bg

Fig. 1. Pareto diagram of raw material quantities [2].

In the production sphere, it is often used as a tool for quality management, especially for analysis of defects and their impact.

In [3] is carried out an investigation on the application of different techniques like Pareto chart, Ishikawa's fish bone diagram and Six Sigma for quality control of knitted fabrics. In Fig. 2 are shown the results from the Pareto analysis.
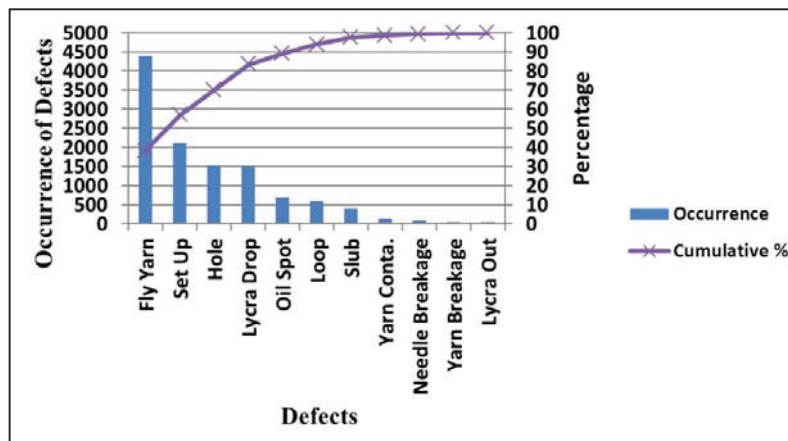

Fig. 2. Pareto chart for identifying major defects [3].

From 10 investigated defects 7 are responsible for 95.56% of total defects. They are arranged and included in the presented Pareto chart. Four of them form over 80% of all faults.

A lot of other examples can be given as good practices for defect analysis of different textiles and clothing [4-7].

This article presents the results of a study, which aims to analyse the defects that occur in the production of headrest covers by using the Pareto diagram (chart).

2 Experimental

The study was conducted in Grammer AD, Bulgaria. The object of investigation is the production of rear middle headrest (Fig. 3).

Fig. 3. Picture of a finished headrest G3Y for BMW.

2.1 Defects' Classification

Based on the analysis of the production technology and the identified defects, a classification was performed. The results are summarized in Table 1.

Table 1. Classification of the defects.

№	Defect	№	Defect
1	Non-compliant seam width due to wrong placed guide	16	Improperly cut salvage
2	Needle caused defect	17	Improperly positioned decorative versus functional seam
3	Seam puckering	18	Visible holes from processing
4	Technological defect	19	Improper seam width at the end hindering the next operations
5	Improperly positioned plastic border	20	Incorrect seam width when joining the central with the side details
6	Wrong plastic border (for another product)	21	Improperly performed back-tack at the beginning and end of the decorative seam
7	Wrong or wrong positioned label	22	Loose decorative seam
8	Wrong number of back-tack stitches	23	Dropped or shifted decorative stitch in the upper headrest turns Non-smooth double decorative seam
9	Uneven width of the closing seam	24	Damaged skin by joining the central and side parts
10	Non-compliant stitch length of the closing seam	25	Visible back-tack - loose or not "stitch in stitch"
11	Wrong positioned V-notches	26	Incorrect stitch length due to imprecisely executed seam in the turns
12	Uneven material distribution in the closing seam	27	Visible holes from rework

13	Improper positioning (misalignment) of the details in the closing seam	28	Improper tension of the decorative seam thread
14	Improper sewing thread tension	29	Material defect (fault of the supplier)
15	Non-smooth turn areas		

2.2 Cost Analysis of the internal scrap by projects

The first step was identifying the projects that realize the biggest losses from scrap. Initially, the research was not focused on the amount of scrap as a number of defective products, but on the projects that generate the largest financial losses.

In Table 2 is given a reference for the internal scrap for October 2019. The total amount of loses is € 40 929.

Table 2. Losses from internal scrap for October 2019.

№	Project	Internal scrap, €	Relative share (frequency), %	Cumulative frequency, %
1	Daimler BR 213 KS	12 857	31	31
2	BMW G3Y	7 969	19	50
3	JLR	7 467	18	68
4	BMW L6	3 358	8	77
5	VW 48X	1 836	4	81
6	F07	1 334	3	84
7	BMW F4x	1 047	3	87
8	BMW F10	859	2	89
9	VW WOKS I_II	535	1	90
10	VW 359	519	1	92
11	Other	3 417	8	100
	Total scrap, €	**40 929**		

A statistical analysis of the data was made and a Pareto diagram was drawn, which is presented in Fig. 4.
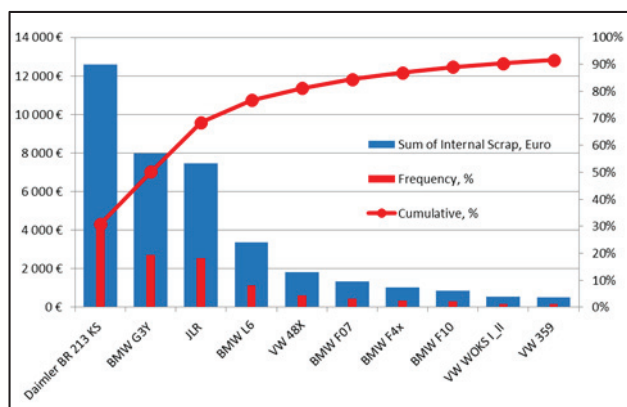

Fig. 4. Losses from internal scrap by projects

The graph shows that the leading projects in terms of scrap losses are Daimler BR213KS, followed by BMW G3Y and JLR. These are the projects with the most

expensive products and even with a small amount of discarded products, the losses are high.

2.3 Cost Analysis of the internal scrap by product families

A project consists of several different product families. Although the same materials are used for their production (the products from each family are installed together in the car), they have a different design and shape. This predetermines the appearance of different defects with different frequency of occurrence. It is possible that in a specific project only one of the product families has a high level of scrap, and the rest are produced with acceptable technological scrap (≤1%).

Table 3 presents the collected data on the expenses of internal scrap by product families. In Fig. 5 they are ranked by size.

Table 3. Losses from internal scrap by product families.

№	Project	Internal scrap, €	Relative share (frequency), %	Cumulative frequency, %
1	Daimler BR 213 KS front headrest cover	6 470	16	16
2	BMW G3Y HIMI rear centre headrest cover	6 390	16	31
3	Daimler BR 213 KS Hi rear headrest covers	6 117	15	46
4	BMW G11 Vo front headrest cover	4 151	10	57
5	BMW G11 Hi rear armrest cover	3 818	9	66
6	BMW L6 front headrest cover	3 358	8	74
7	BMW F4x armrest cover	1 836	4	79
8	BMW F07 front headrest cover	1 334	3	82
9	JLR X760 Hi rear centre headrest cover	1 076	3	84
10	BMW F07 rear headrest covers	1 047	3	87
11	BMW F10 front headrest cover	859	2	89
12	VW WOKS I II front headrest cover	535	1	90
13	VW 359 front headrest cover	519	1	92
14	Other	3 417	8	100
	Total scrap, €	**40 929**		

Project BMW G3Y appears again in the first positions with one of its product families - BMW G3Y HIMI cover for rear middle headrest. It includes products made from leather (Dakota, Saddle and Merino), which are expensive materials.

2.4 Analysis of the defects by projects

For all projects an analysis of the defects with respect to their origin was made. Defects are categorized into four major groups: in decorative seam, in closing seam, from preparatory operations (overlock and plastic borders) and material based.

In Table 4 are presented the losses for product family BMW G3Y HIMI cover for rear middle headrest.

In Fig. 6 are presented the losses by the origin of the defect. The predominant defects are in decorative seam that defines the good appearance of the product.
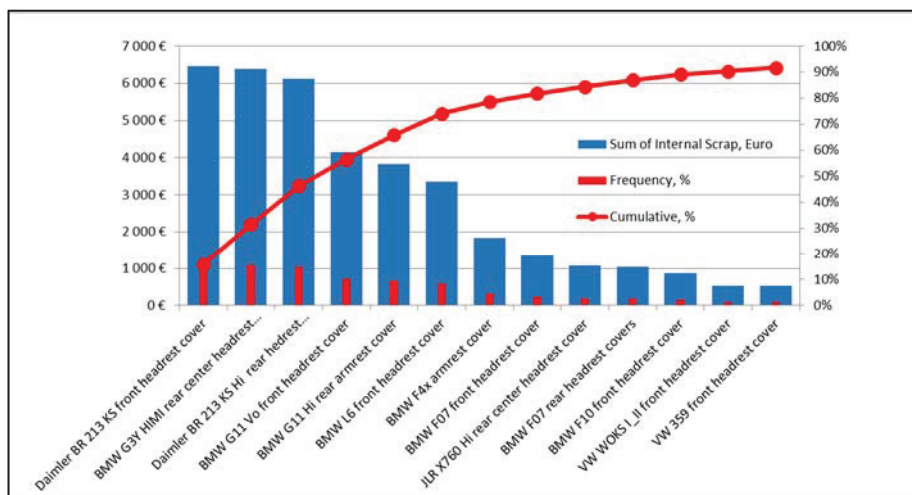
Fig. 5. Losses from internal scrap by product families.

Table 4. Losses from internal scrap for product family BMW G3Y HIMI cover for rear middle headrest.

№	Project	Internal scrap, €	Relative share (frequency), %	Cumulative frequency, %
1	Decorative seam	3 392	53	51
2	Material	2 000	31	84
3	Closing seam	805	13	97
4	Preparatory operations	193	3	100
	Total scrap, €	6 390		

Significant is the share of losses caused by defect materials. In this case, the supplier is notified in a timely manner and bears the cost of the scrap. It is his commitment to take actions to ensure that the subsequent deliveries will meet customer requirements and quality standards.

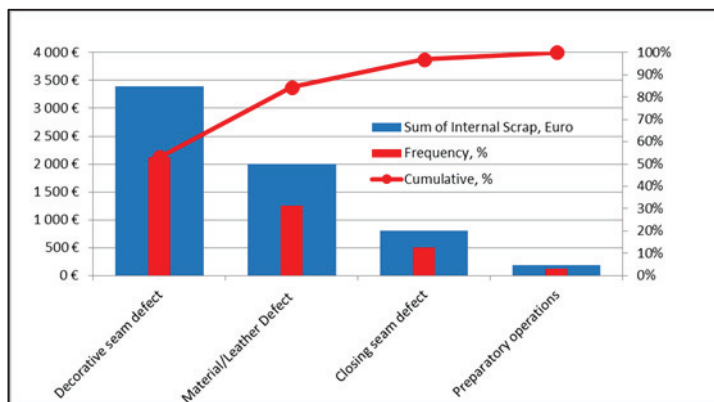The other two groups of defects have less impact, as can be seen in Fig. 6.

Fig. 6. Losses from internal scrap depending on the origin of the defect.

The analysis of the financial losses specifies these projects and product families to which efforts for quality improving should be directed.

2.5 Analysis of the defects for the product family generating the largest losses from scrap

As a next step, a Pareto analysis of the product family with the biggest losses (BMW G3Y HIMI cover for rear middle headrest) was performed.

A control card has been developed, in which for each defect from Table 1 the number of discarded details per day is recorded and a summary for a month was made.

After processing the results, the Pareto diagram is drawn, presented in Fig. 7.
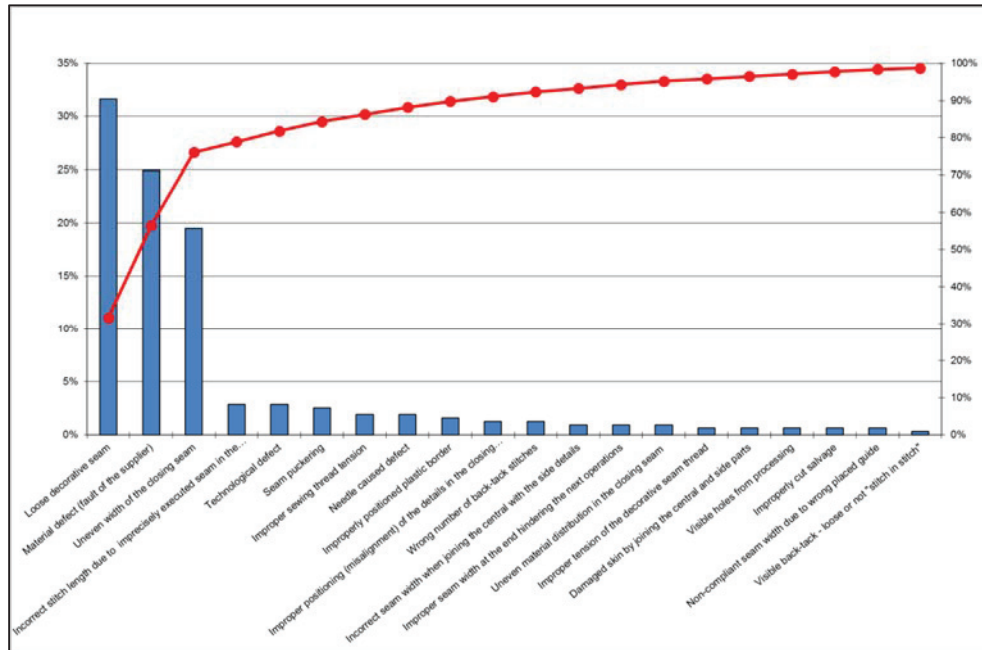

Fig. 7. Pareto diagram of defects in a product family BMW G3Y HIMI cover for rear middle headrest.

The diagram shows that the first three defects stand out sharply: Loose decorative seam - 32% of the total number of all rejected products, Material defect (defect not found on Incoming control and admitted to the production line) - 25% and Uneven width of the closing seam - 19%.

These three defects form 76% of the product family's scrap.

2.6 Analysis of products discarded due to Loose decorative seam

This defect was found in eleven products. The Pareto chart with the number of defects in each material is shown in Fig. 8.

The first three materials form over 50% of the total number of detected defects. The first commodity number is made of leather Saddle, followed by covers made of artificial leather and leather Merino. The behaviour of all three materials during the sewing process was analysed. The feedback of the operators who sew a double decorative seam

was taken into account; the qualitative criteria for a decorative seam and the admissible tolerances were discussed. On the recommendation of the technologist, additional training was made for certain operators who make the most mistakes in the sewing process.
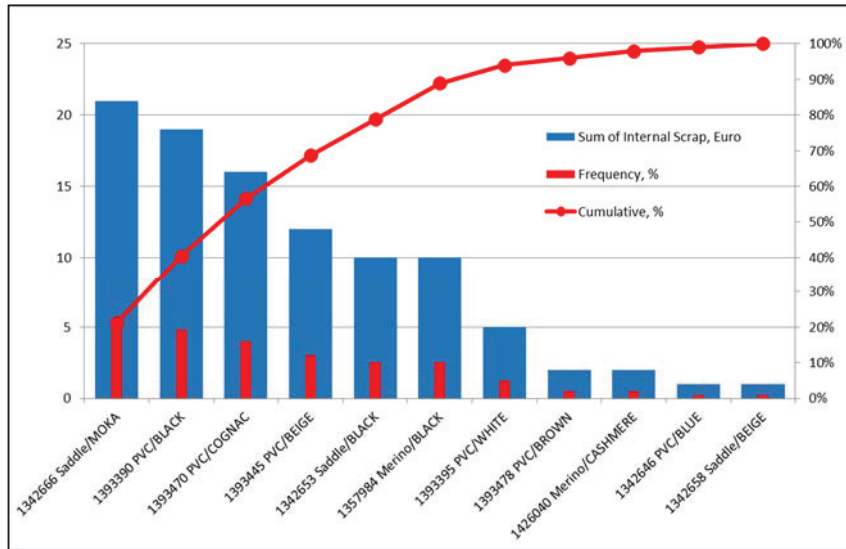

Fig. 8. Pareto diagram by product due to Loose decorative seam

2.7 Analysis of products discarded due to Material defect

Four products have shown such a defect. 64% of all discarded products belong to only one product number (Fig. 9). This information was sent to the supplier in order to take measures and strengthen the Outgoing quality control. As an internal measure, Grammer AD has appointed a 100% inspection of each item of this commodity number.
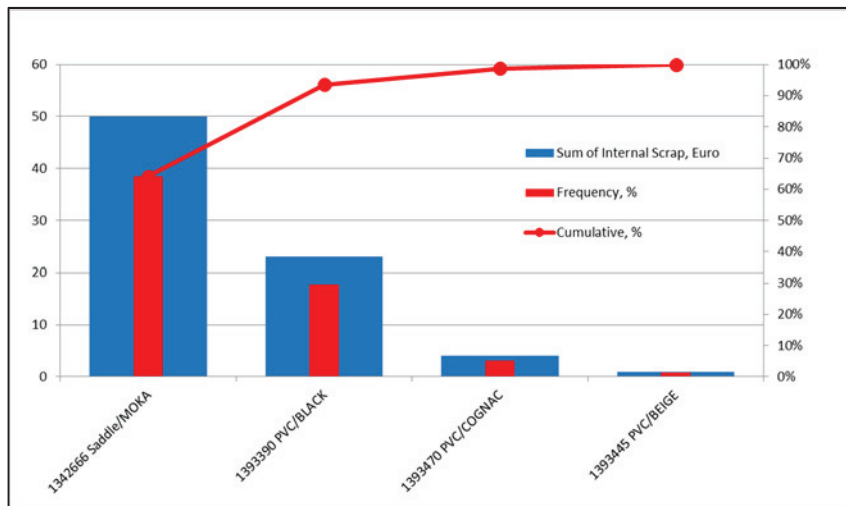

Fig. 9. Pareto diagram by product due to Material defect.

2.8 Analysis of products discarded due to Uneven width of the closing seam

The correct execution and observance of the closing seam parameters is extremely important, because the double decorative seam passes along its contour. Its production is a challenge, as the rear middle headrest covers are made of small details with a complex design. They have four "turns" that follow the shape of the headrest.

The information for items discarded due to a defect in the closing seam has been taken from the database. The data was processed and the obtained Pareto diagram can be seen in Fig. 10.
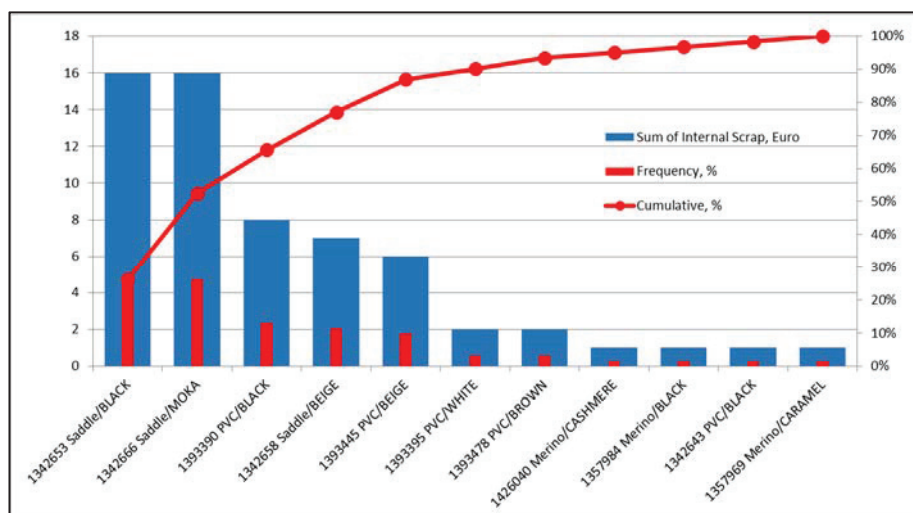

Fig. 10. Pareto diagram by products due to defects in the closing seam.

The Pareto diagram shows that most mistakes in performing the closing seam operation are made when processing Saddle leather. 63% of all discarded cases for the month are made of this material, which requires immediate corrective action. For performing this operation have to be chosen good operators. It is possible even to be revised the standard time for executing this operation.

3 Conclusions

Based on the performed research, the following conclusions can be made:
- ✓ The possible defects in the production of headrest covers for car seats are systematized.
- ✓ The data on internal scrap for all "projects" worked in a given month at Grammer AD is collected and summarized. Based on the Pareto diagram, an analysis was made of the projects that generate the largest losses from scrap.
- ✓ All projects consist of several different product families. Pareto diagram was developed and the losses caused by production of scrap were analysed. The differentiation by product families reflects the design influence on the various defects and the frequency of their occurrence. The groups that form the highest expenses are identified.

✓ Pareto diagram of the defects for all projects according to their origin is made and analysed. Defects are categorized into four main groups: decorative seam, closing seam, preliminary operations and material.

✓ Statistics on the number of defects by type in the production of the product family generated the highest losses have been collected. Pareto diagram is drawn for the relative and cumulative frequency of defects, identifying the significant and insignificant defects according to their number.

✓ The main defects of the studied product family are:
• Non-smooth/loose double decorative seam with a relative share of 32%;
• Material defects not detected during Incoming control, with a relative share of 25%;
• Uneven width of the closing seam - 19%.

✓ For these three defects, diagrams and in-depth analyses have been made of the impact of the type of material used on the internal marriage, calculated as costs in euro.

✓ Based on the obtained results, recommendations for necessary measures have been made.

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