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1. INTRODUCTION, GOALS

The origin of this work is a new method for the detection of exact and approximate reflective symmetries. The new algorithm is worked out for 2D case based on the fact that the symmetry axes cross the gravity centre. Accordingly the exact and approximate symmetry axes are selected from the set of the lines crossing the gravity centre. The searching algorithm is based on the definition of the so called symmetry-parameter which is a rate of the symmetry, a number between 0 and 1 without a dimension and its value does not depend on geometrical measures. The value of 1 corresponds to the exact symmetry and a value close to 1 corresponds to an approximate symmetry. A so called symmetry-diagram is determined from the symmetry-parameters computed for various lines crossing the gravity centre. The symmetry-diagram is applicable to find every exact and approximate symmetry axis. Beside this, the symmetry-diagram shows an individual shape property of the 2D figures, independently from geometrical measures and so it can be the base of pattern recognition methods being independent from geometrical measures.

Objets

During my research work I set asana aim the questions related to axial symmetries of planar (2D) configurations with optional complications:

- To work out a method applicable to examine the axial symmetries of planar configurations. To draw up such a method to be also suitable searching all symmetry axises as well as approximating symmetries.
- To create a parameter by which I can characterize numerical may the axial symmetry of won fully symmetrical planar configurations. This parameter should characterize the configuration also then if it does not include exact axial symmetry.
- To work out an algorism by which it can be examined configurations similarity. To work out a method for evaluating the configurations similarity by witch I can examine two or move configurations independently from dimensions.
- I have set as an aim the simple composition, the easy manageability and the quick suability at working out the symmetry searching algorism.
2. MATERIAL AND METHOD

My doctoral dissertation sums up the results reached in the theme concerning the searching of axial symmetries of planar configurations and examining the similarity of 2D-al configurations.

2.1 Method
I search the symmetric axis of the configuration examined that I scanning the plane with the hot direct lines passing through of the centre of gravity. During scanning I set out from that these whereas all symmetrical axes have to pass through on the centre of gravity. I carry out a calculation method for all direct line passing the centre of gravity which results I put down. By evaluating of data got this way I select the spot of approximating and exact symmetry. I display the results presenting in diagram. During evaluating the diagram I examine the local maximum values.

During my research work I have drawn up a symmetry searching algorism, (Figure 1.) (SZAKÁL, 2008a, SZAKÁL 208d) which by its known in technical literature and can be applied case of configurations with multiple complex outline, too.

![Figure 1. The algorithm (SZAKÁL, 2008a)]
2.2 Calculating the symmetry-parameter

The Z symmetry-parameter shows the approximation to the axial symmetry in numerical form (SZAKÁL, 2009b). This is a number between 0 and 1, it can be a certain grade of the symmetry characteristic. I introduce the following $Z_k$ parameter for the definition referring to the k. scanning level:

The calculation of $Z_k$ is simple in that case when on one scanning one-one intersection derives on the both sides of the axis. With the Figure Z. symbols:

$$Z_k = 1 - \frac{abs(b - j)}{b + j}$$  \hspace{1cm} (1)

Where:
- b: marks the left-hand side distance measured from symmetry axis of the perimeter section.
- j: marks the right-hand side distance measured from the symmetry axis of the perimeter section.

The $Z_k$ is designed so it the section of configuration with the measuring direct line given is exactly symmetrical to the axis supposed, then $b=j$, this $Z_k=1$. The better the configuration approximate to the symmetric the move it will be nearer the $Z_k$ to 1.

Figure 2. Explanation of measuring section
The more unfavourable situation is regarding to symmetry when the measuring section hasn’t got a match on the opposite side of the axis, that is \( b > 0 \) and \( j = 0 \), or \( b = 0 \) and \( j > 0 \), then \( Z_k = 0 \), the smallest value.

As in the (1) connection the quotient of geometric dimension occurs, \( Z_k \) is a nondimensional number, its value does not depend on geometrical size.

If on a scanning level there are more than two intersections (with Figure 3. markings \( b_1, b_2, \ldots, b_n; j_1, j_2, \ldots, j_m \)) then I place the \( b_i \) and \( j_i \) values into pairs and I form the \( Z_k \) value with (1) connection from this. If I suppose that more intersections are on the left-hand side: \( n > m \). Then the planing into pairs has to be made so, that beginning from \( b_{m+1} \) the \( b_i \) (\( i = m+1, \ldots, n \)) pair should be always \( j_i = 0 \) (\( i = m+1, \ldots, n \)). The \( Z_k \) value in general case is the average of expressions formed of pairs calculated according to (1).

\[
Z_k = \frac{1}{n} \sum_{i=1}^{n} \left( 1 - \frac{abs(b_i - j_i)}{b_i + j_i} \right) \quad (2)
\]

The \( Z \) parameter formed, of from the \( Z_k \) average of symmetry parameter

\[
Z = \frac{\sum_{k=1}^{N} Z_k}{N} \quad (3)
\]

where:

\( N \): marks the number of scanning levels from timely \( Y_{max} \) to \( Y_{min} \). As I from \( Z \) value by averaging according to (z), (3), \( Z \) keeps the original characteristic of \( Z_k \) values:

- \( Z \) can take up values in \((0,1)\) interval ,
- \( Z = 1 \) is the most favaeable (exact) case of symmetry,
- \( Z=0 \) is the most unfavaerable case regarding to symmetry,
- The values between 0 and 1 correspond to the approximate symmetry all the better the nearer is \( Z \) value to 1.
- \( Z \) is a nondimensional number and its value does not depends on the dimension of plane figure only it depends on its shape.
2.3 Evaluating the parameters calculated, the symmetry-diagram

The algorithm determines the Z symmetry-parameter in each rotation position. It fixes the timely rotation angle together with Z values after every step of rotation. The evaluation of results takes place according to the diagram taken down the changes of rotation angle of the symmetry-parameter. I call this diagram in the followings as symmetry-diagram.

Exact axial symmetry is there, where the cure shows just Z=1 value. The difference from this shows that the what approximate value is present.

A square symmetry-diagram can be seen in Figure 4. The direct lines marked with number (I, II, III, IV) mark the symmetry axises of the configuration examined on the square. It can be seen on the diagram of Figure, that the marked at Z=1 place really suit to these axises marked with number.
3. ELABORATION AND EVALUATION OF RESULTS

I show the results of symmetry searching in this chapter, where I familiarize with the individuality of parameters calculated onto various configurations and the dimension independence of symmetry-diagram, as well as I show a characteristic application to the selecting algorism.

3.1 The independence of the symmetry-diagram from size

The Z parameter is independent from geometrical dimensions because of its definition, it has only shape dependence. The result of is that planar figures with difference dimensions but with similarity have got idenfical symmetry-diagram (SZAKÁL, 2008c). I consider similar those configurations where the relative ratio is constant between the distance of two optional points from each other and the distance of the appropriate Points from each other of the configurations. I familiarize with the independence verification of size of the Z parameter in the following example:

![Figure 5. Configuration curves with similar shape but with different size in 0 – 15° range, the curves interrupted for the sake of visibility of curves to be on the other.](image)

I have selected a simple configuration during the test for the sake of easy follow ability. I have the algorism run onto squares with various dimensions. The dimension of squares were in the 40x40 mm - 600x600 mm range.
I have carried out the run with the same parameters (scanning angle $\Delta \alpha = 0.2^\circ$; the pace of horizontal scanning $\Delta L = 0.1mm$) in each case. The curves got fully cover each other it can be seen in Figure 5. I burst out the curves to be one on the other layer b layer in $0 - 15^\circ$ range for the sake of visibility, so the curves to lie on one the other can be seen in different colors.

3.2 Individual characteristic of the symmetry-diagram

I show that the symmetry-diagram is extremely sensitive to the changes of outline in the next example, parallel with this I also demonstrate that the symmetry-diagram shows the individual characteristic of planar figures. The symmetry-diagram is the shape characteristic of planar figures. The curve of symmetry-diagram also changes to effect of champing the shape of planar figure. I have deformed on the original square five times so the results got also show something else.

![symmetry-diagram](image)

Figure 6. 90x90 mm square and its symmetry-diagram (SZAKÁL, 2008c)

The following “original” square is 90x90 mm I have modified this examining the individuality of the symmetry-parameter of configurations. I, II, III, IV marks the symmetry axis and their places in the Figure 6. The smallest parameter $Z=0.58$ can be seen on the symmetry-diagram.

I broke down the square curves in the Figure 7. I made 1x1 mm – breakdown in the corner points the square. The deformation is $\approx 2\%$ concerning the change of length of the square sides, concerning the change of area is $\approx 0.00025\%$. The axial symmetries number remained from this change (with the Figure marks: I, II, III, IV). The smallest parameter is $Z=0.595$ that can be seen in the symmetry-diagram. This means that the symmetry axises of the configurations haven’t changed to the effect of modifying, however the value of the smallest parameter has increased.
I have made a more important match in Figure 8., the match is 3x6 mm. It can be seen in the Figure that have already the number of exact symmetry axises reduced to one (in the Figure I – mark direct line), as well as three approximate symmetry axises can be found (in the Figure II, III, and IV-mark). If the configuration deforms so that the real symmetry axises deform considering the formers then those are sensible immediately in the parameters calculated. Four symmetry axises can be seen in Figure 5. and 6. (the symmetry curve I, II, III, IV points also reach the Z=1 value), contrary to this only in the I-mark point reaches the curve the Z=1 value in the Figure 8. there on the other places it is only Z=0.98, the local maximum value, because of this it is already approximate symmetry axis.
I have made the match deeper (6x6 mm) in the Figure 9. This behaves already otherwise because of this than the configuration shown in the previous Figure. The difference looks in that greater Difference which can be experienced in the diagram. Already in the previous case also can be experienced difference from the parameters calculated to basic geometry, here however the difference of diagrams is still more significant. Approximate symmetry can be seen at the III-mark point in the Figure, while at the II and IV points the value is only already $Z=0.845$, which approximates the symmetry less.

![Figure 9. Test configuration with 6x6 mm match and the symmetry-diagram. (SZAKÁL, 2008c)](image)

I made a narrow but deeps match on the basic geometry in Figure 10. In this case it also can be seen from the results that it causes a result deformation with noticeable degree comparing to the original configuration. I made again the match so, that the I-mark axial symmetry remained approximate symmetry is present in the symmetry-diagram at the III-mark place with $Z=0.98$ value, thus this axis is not sensible to match with such type. The symmetry-parameter at II- and IV-mark places shows already significant difference, have symmetry is present only with $Z=0.805$ value, this it can be spoken about only approximate symmetry.
ELABORATION and EVALUATION OF RESULTS

Figure 10. Test configuration with 2x10 mm match and the symmetry-diagram (SZAKÁL, 2008c)

I have changed the basic outline I the Figure 11. that I made the match a liking general place with 2x5 mm dimension. In this case it is evident from the results got that now the configuration is neither symmetrical at the I-mark place. The best approximate symmetry is only $Z=0.75$ value in the III-mark point. In case of II and IV-mark axis the degree of approximation is $Z=0.88$.

Figure 11. Test configuration with asymmetrical 2x5 mm match and the symmetry-diagram (SZAKÁL, 2008c)

I show the elements of Figures 6-11 summed up in the Figure 12. It can be seen in this Figure the difference from the basic geometry results well detected differences during examination.
ELABORATION and EVALUATION OF RESULTS

It can be seen with red colour the results of calculation carried out out to the original outline then also showing the others in turn. I can be seen from the diagram that breaking down the corner points of the 90x90 mm square by 1x1 mm (approximating with this to the perfect circle) it shows greater Z value in the curve all points than the original square applied as origin.

In the other cases when I have changed the certain sides of the square (by pinching a side with a small section) then the curves got show significant differences however the “area of defects” applied by me is only 0.45% of the area of initial configuration in the worst case, too.

Significant differences can be observed on the symmetry curves got as an effect also of very small modification, deformation carried out on configuration.

3.3 Examining multiple complex configuration

It can be happen in engineering practice such case when the outline of a certain configuration can not be described with a single closed curve. Undercuts, holes can be found in it. In this case it is spoken of complex geometry regarding to symmetry examination. I show an example for this case in the followings. The geometry examined is a disc with two holes in it. (Figure 13.)
If the objects of examination would be a circular arc then the parameter got would take up $Z=1$ value in the whole angular range. As I have placed also two holes inside the outer outline because of this I got the result corresponding to Figure 13. during examination. $Z=1$ in the I and II mark points, thus the configuration is symmetrical. Outside of this two points the geometry examined $Z<<1$ neither shows approximate symmetry yet.

### 3.4 Searching the best approximate total symmetry-axis

I search the maximum $Z$ parameter concerning to the configuration given during determining the best total symmetry-axis.

During my research work I have set out from that thought that the symmetry axis of a configuration pass undoubtedley over its centre of gravity. This statement is true in every such case when the configuration has got at least one symmetry axis. However if there is not exact symmetry it is not sure that the symmetry axis with the best approximation can be found among the direct line passing through the centre of gravity. Because of this it is suitable to examine also those direct lines passing around the centre of gravity concerning the axial symmetry. It can be happen that the $Z$ parameter value calculated to a direct line passing beside the centre of gravity will be higher. I examine with moving away of the centre gravity every such configuration by the symmetry searching algorism which has not got complete symmetry axis ($Z \neq 1$).

I show the results of moving away the centre of gravity on a simple configuration. Its centre of gravity is outside of the configuration outline. The surface of the lower and upper part of the configuration does not agree with each other and the side proportions are also different by this I have guaranteed the general character of the configuration. Matching a square-grid net to the surroundings of the configuration centre of gravity and to the grid points as to modified centre of gravity ($S'$) carrying out the symmetry searching I examine whether there is a better approximate symmetry axis, than as that passing through the centre of gravity. That area which includes the centres of gravity modified possibly I choose in the function of the greatest dimension of configuration. Taking as a base the distance of the farthest points of the configuration examined I carry out a primary examination in the 20% surroundings of the centre of gravity. During the primary run on the examination area indicated I carry out 20 run in every case. In Figure 14. the 1-20 numbers mark the $S'$ centres gravity moved away.
Among the results got during run I also the $S'$ surroundings giving the greatest $Z$ parameter with the algorism with a second calculating series. During the second approximation I indicate the surroundings of $S'_{\text{max}}$ value to a never examination.

The primary examination gives a raw approximation to search the best total symmetry. During the second approximation I carry out never 36 run in the $S'_{\text{max}}$ surroundings of the first approximation according to show in the Figure 16. By recalculating $S'_{\text{max}}$ surroundings established during the first examination with grater resolution the result got suits the expectations of engineering practice.
I choose the second examination area so, if I take up to each $S'_i$ points a same size area then there just should be no overlappings yet, so I examine every possible area with greater resolution. By this method I apply 0.490 resolution as compared to the greatest dimension of the original configuration during searching the best symmetry-axis.

The algorism results run to the points taken up to the $S'_{\text{max}}$ surroundings can be seen in Figure 17. The curves got characterize at this $S'_{\text{max}}$ surroundings. Due to the small centre of gravity shift the curves the symmetry-diagram have got similar characters. Among the symmetry-diagrams calculated I choose the centre of gravity ($S'_{\text{max}}$) shifted curve showing the greatest $Z_{\text{max}}$ parameter. Due to modifying centre of gravity I can that point to the configuration examined where the greatest Z parameter value can be calculated to those direct lines passing through that point. This symmetry-diagram will contain the $Z_{\text{max}}$ parameter characterizing the configuration to be runs do not cause trouble. The run time of the program does not effect significantly marking-out never examination domain.
3.5 Method for evaluating part selection

In case of selection tasks the work begins with picture processing. A digital picture is being made from the aggregation at this time, then I complete with the help algorithm in MATLAB the table of picture points forming the outline of configurations. I examine with an algorithm produced in the Visual FoxPro surroundings used to select configuration the picture points got as a result of picture analyzing. Maybe the several thousand picture points describing the configuration do not make it possible the quick selection. I search straight section with the algorithm on the outline inasmuch I can describe the picture-point series with straight sections so the claim to time of run decreases. In case of machine-parts as for example in the case of hexagon nuts the outline confined by sides describing with straight section six co-ordinate-points has to be stored instead of several thousand picture-points (depending on the picture resolution). I approximate the threaded hole also with straight section in this care I produce the inner perimeter sections using every fifth picture-point of the hole outline (in case of picture with 1600x1200 picture-point dimension).

I show a digital shot made from pass taken from engineering practice in Figure 18. I make it known the method of selecting parts in case of nuts with various dimensions and types. Among the nuts the number 3, 4, 6 mark nuts are undamaged. The number 2 nut for corners has got slightly damaged during assembling, I have filed off one corner of the number 1 nut in such a way that this already disturbs its further adaptability.

Figure 18. Nuts with various dimensions and types
I have got the symmetry-diagram in Figure 19. the selecting algorism based on characteristics run tom parts. I examine in the diagram that the curves got how many local extreme values have got. I also take into account the values and numbers of maximum and minimum. This is the first step of decision mechanism of the selecting algorism. Based on this I shift out the diagrams to be similar considering with the markings of Figure 18 the symmetry-diagrams of configurations marked with number 5 and 7 considering characteristic differ from the results of configurations marked wit number 1. 2. 3. 4. 6 in Figure 19.

![Figure 19. The symmetry-diagram in case of nuts shown in Figure 18.](image)

Examing with a greater resolution the symmetry-diagrams of configurations shifted in the step it can be seen the result of Z parameter is between 0.9 and 1.

The result showing six local maximum corresponding to configuration with hexagon outline can be seen in Figure 20. The symmetry-diagram of 1. 2. 3. 4. 6. configurations are shown in the diagram corresponding to Figure 18. markings. I produce an arrange diagram characterizing to the configurations examined from the average of the results of symmetry-parameter belonging to identical angular value of diagrams. I produce a 3% error-zone accepted for engineering practice in the surroundings of this diagram. I have marked with green colour the curves (average + 1.5% and average -1.5%) which mark out the error-zone. During analysing the symmetry-diagram I examine in the second steps whether the diagrams are within in this zone. The symmetry-diagram of configuration number 1 (marked with red) emerges from the error-zone in many places therefore probably it contains too great error. I have deformed one corner of the configuration number 1. in Figure 18. such degree that makes not possible its further application, in this case error causes the deformation of the symmetry-diagram.
ELABORATION and EVALUATION OF RESULTS

Figure 20. Symmetry-diagrams of hexagon nuts and their 3% error-zone

By eliminating the configuration believed faulty those parts come to selection from the aggregation examined which symmetry-diagrams are within the 3% error-zone. In case of symmetry-diagrams of parts selected I search that smallest error-zone in which every diagram still can go in. The symmetry-diagrams of parts 2. 3. 4. 6. selected are in the 2,3% error-zone.

Figure 21. Symmetry-diagrams of parts qualified to be uniform and their error-zone
The strictness of selection determines the grade of the error-zone. I reduce the amount of zone to 1% in case when the application of damaged parts can not at all allowed. The zone decided so is that in which I consider the parts with similar shape. I accept 3% difference in case of general selecting machine-parts. It can not be experience yet such damages on the parts whics influence the application.

3.6 Sorting bulk parts

The symmetry searching algorism is capable to sort parts (SZAKÁL, 2009). The algorism searches the symmetry-axises of configuration outlines. The symmetry-diagram is individual for all configurations taking down from Z-parameters got to possible symmetry-axises to examined independently from the fact that whether the configuration contains symmetry-axis or not. By using this characteristic of the symmetry searching algorism it can be used for sorting tasks. The symmetry-diagram is the individual characteristic of configurations however the diagrams of configuration with near similarity are also near similar. So during sorting by giving a value-zone to the differences curves the parts can be grouped.

The value of the zone concerning to Z parameter gives the difference allowed considered to one another of the configurations examined. The rule of the zone is to take into account the defects, the inaccuracies (above all picture processing inaccuracies, maybe deformations deriving from the position of parts) as well as the red deformation of parts occurring during processing data. The algorism does not reckon with the dimension of parts their differences, it takes only into account the shape.

The zone gives contains collectively also the values the deformation deriving from picture processing and from the real differences considered to one another of parts. Because of this during picture processing it has to be act carefully reducing by this the mistakes made during data recording.

To test the algorism I have placed unsystematically joint-elements known from engineering practice on a table. The parts had various shapes and dimensions. Among the parts were also damaged and stuck together.
At using the sorting algorism it has to be taken down the outer outline of configurations. Part aggregation can be seen in Figure 22, where the red colour marks the outlines of parts. Numbers mark certain parts in the sake for later identification. I handle separately with the algorism the outline of certain parts. In case of each part I take down the picture points of outlines forming the parts in a co-ordinate system. The symmetry-diagram calculated to each part after the algorism run can be seen in Figure 23, arranged. It can be seen well on the symmetry-diagrams the parts examined can be simply grouped. The sorting of parts can be carried out by taken to the Z-parameter to difference but characteristic ranges.
Those parts are similar to circle which $Z$ parameter is greater than 0.9 in all rotation angle-positions of symmetry-diagrams. For each diagram to be seen in Figure 24. is true $0.9 < Z < 1$. The great majority of curves can be found within a strict range in the Figure, these can be seen magnified in Figure 25. The curve marked 7 in Figure 24. though is circular but it differs significantly from the others therefore it has to be examined separately. The curve also shows high $Z$ parameter on the whole however there is also a preferred direction where the value of symmetry-parameter $Z = 0.976$ at $\alpha = 61^\circ$. That means such axis can be taken down surely to the configuration examined which approximate symmetry.

![Figure 24. Symmetry-diagrams of circular configurations (SZAKÁL, 2009)](image)

The number 7 part is put together by a set of washer and pipe-piece with the marks of Figure 22. The configuration stuck together during taking a photo succeeded to photograph on a optional position this causes deformation on the picture examined. In this case just this deformation makes possible to recognize it as a faulty part. The algorism would have been surely recognized as a washer if it had been arranged exactly in the vertical position under the camera. Avoiding such cases it is worth to examine pictures made from camera line-up with two different angular positions.
Further grouping possibility present oneself in Figure 25. The value of Z parameter can be found between 0.974-0.98 in 0.006 zone. Examining the shape of curves found in the very strict zone it comes to light that the 11. and 18. configuration differs in some measures from the other similar circular configurations. Beyond on that they resemble to the circle there is surely on then a preferred point (the shot of spring washer). The outstanding parameter values to be found on the various angular positions of the 11. and 18. configuration curve derive from the different orientations of washers.

The number 5. part of the Figure 22. is also a spring washer which can not be distinguished with the present single-camera examination from the other washers. In this case the examination from two separate camera line-ups gives sure solution.

Figure 26. Rectangular like configurations with large side-edge ratio (SZAKÁL, 2009)
The characteristic of curves to be seen in Figure 26. is that it can be found parameter near to $Z=1$ in two angular positions. This type symmetry-diagram is characteristic to rectangulars with at least $1/6$ side ratio. The diagrams of number 1. and 4. pin like parts can be seen in present care. In case of both parts the value of visible approximate symmetry in the $90^\circ$ angular position of the curves is smaller than in $0^\circ$ angular position of these. The non full symmetry is due to smaller slots on configurations.

![Figure 27. Curves of bolt like configurations (SZAKÁL, 2009)](image)

The curves of Figure 27 resemble to curves shown in Figure 26. here it is also true that they mark rectangular like configuration with large side-edge ratio (in 2D rectangular, in 3D it can be just like cylindric). The cause of local parameter reduction of the symmetry-diagram in $90^\circ$ angular position is the result of irreversible symmetry defect. The symmetry deformation derives from the head formation of bolts and rivets in present case. The aggregation contains also bolts and rivets during examination to which I have carried out the run. The algorism can not distinguish these parts in this resolution. If there are previous knowledge concerning the configuration examined then increasing the resolution of picture processing these parts already be distinguished, too.
The curves have got 6 local maximums to be seen in Figure 28. This means that the configuration 6. and 16. are hexagon among the configurations examined. That comes also to light from the symmetry-diagram that damages, deformations can be found on the hexagon configurations examined. The curves should reach six times the Z=1 value in ideal case.

The parts examined can be seen grouped in Figure 29. Based on the symmetry-diagram I have selected the circular, bolt like, rectangular and hexagon like parts. I have marked separately those parts which can go is though into the tolerance range of one-one group but they are different for something than the others. Among the parts tested by me the number 1. 3. and 7. parts were faulty. During run I have selected the number 3. and 7. parts as uncertain classification. These parts can not be put in a row really in this form into one of groups yet. The number 1 part is a bolt of which I sawed off its head so I cleared away the part characteristic therefore with the setups used. I could not distinguish from a simple pin on the basis of symmetry-diagram. In case of grater resolution the threaded part of the part alters the symmetry-diagram, so it can already be decided that into which group must it put in now.
The symmetry searching algorism is independent from dimension which I use to sort parts. It sorts into group the parts based on the symmetry characteristics calculated on the basis of merely their shapes.

It can be seen from the results got during the run that the software produced by me recognizes the similarity of optional planer configurations. The algorism is not suitable determining symmetry characteristic in case of configurations with concentric outline (for example: washer). This during sorting of parts it can not neither distinguish the washer from a disc.

Figure 29. The examined configurations sorted
3.7 New scientific results

During my research work I have examined the questions connected to axial symmetries of planar (2D) configurations. The results of my research work:

1. I have worked out a new symmetry searching method to be capable to search the symmetry-axis of optional plane figures. With the new method the approximate symmetry can be unambiguously identified, too.

2. I have defined the Z parameter to describe the symmetry, which is a number between 0 and 1. The symmetry parameter is suitable to look for the approximate symmetry axis(es) also in that case when there is no exact symmetry.

3. I have defined the symmetry-diagram describing the angle dependence of the Z symmetry-parameter as compared to the configuration examined. I have established that the symmetry-diagram is independent from geometric dimension of the configuration and is suitable to recognize the configurations with similar geometry.

4. I have shown that the symmetry-diagram can be applied to look for the symmetry-axis(es) also in case of multiple complex configurations, as well as in case of identical configurations to recognize the geometric features. The configurations multiple combined and with concentric border curves mean the limit of application.

5. I have shown that the symmetry-diagram defined primarity so recognize the symmetry can be applied to recognize similarity and shape as well as to sort according to shape, too. Because of sensitivity to deformation of the symmetry-diagram the tasks to recognize the shape can be carried out with optional accuracy.
4. CONCLUSION and SUGGESTION

The symmetry searching algorism developed during my research work is suitable to sort for example bulk joint-elements. Presently the algorism makes possible the classification according to shape. The pre-sorting of bulk parts can be solved by this. It can not be used to sort according to dimension. However the algorism determines the symmetry characteristics based on digital pictures by setting up proportions from geometric dimensions, because of from the pictures examined the geometric dimensions of configurations can be also decided during processing. By utilizing this the algorism can be made suitable classify according to dimension, too.

It has been started the realization in technological circumstances the automatized pre-sorting of bulk joint-elements. We have started with the engineers of the company renewing aeroplane power plants in Veresegyház the practical realization of the method worked out by me. The work is presently in the phase of planning and instrument obtaining.

The cold forming standard (MSZ EN 10142:2000) containing low-carbon content strip steel and plate hot-dip galvanized qualifies the determination the so called zinc-flowers formed during the process by measuring number that can be determined with non exact made. The standard uses the following ideas for putting in row according to dimension of zink-flowers formed on the surface galvanized: small-, medium, large zinc-flowers. Putting in row the zinc-flowers according to the standard is important concerning use, as for example cold formability, colorability.

I think so that with the symmetry searching method worked out by me, based on the symmetry characteristics it could be determined unambiguously the dimension steps of zinc-flowers according to various fields of use.

There are in trade straw cutters developed for this aim with various constructions for using as an energetics aim of agricultural crops. The most important viewpoint is the sturdy structure durability and the reliability at designing harvesting machines. The size and the shape of chaff are an important viewpoint during using for energetics aim. The dimension, shape and surface of the chippings have got a emphasized rule concerning the firing technique. The presently wide-spread stem chippings is suitable for firing, but for operating boilers with good efficiency is indispensible to produce homogeneous-and optimum size solid fuel for equipment given.

By using the method drawn up to search the symmetry it can be worked out an appliance provided with an online data collecting system which qualifies the chippings considering morphology during cutting chaff. Based on the results by this way % a control can be developed for optimizing the technological parameters of straw cutters.
SUMMARY

During my research work I have been examining the plane configurations from the standpoint of the axial symmetry. I have worked out the so called symmetry – parameter calculating method to examine the axial symmetries of plane configurations. With the algorithm it is possible to search every symmetry axis as well as the approximate symmetries.

During analysing the configurations scanning through their whole areas I give the exact space of symmetry axis(es) and I give the numerical data of the symmetries approximate dimension, too. I have examined all possible variations from the standpoint of axial symmetry with the new symmetry searching algorithm scanning the lot of straight lines passing over the centre of gravity drawing up by me. I have set out from that presumption at determining the symmetry-parameter that a certain configuration symmetry axis(es) pass over the centre of gravity calculated to its area. I have drawn up a new symmetry-parameter which is a number between 0 and 1. This numerical parameter characterizes the configuration examined. If the parameter value is 1, then the straight line examined is exactly the symmetry axis of the configuration given. If the parameter value only approximates to 1, then the straight line examined is only an approximate symmetry axis of the configuration given. I present the symmetry-parameter in the diagram according to the orientation of the symmetry axis presumed in the so called symmetry-diagram. With the help of the symmetry-diagram those axes can be safely determined onto which the configuration is symmetric or is approximately symmetric.

I have found that the symmetry-diagram is an individual shape characteristic independently whether the configuration is symmetric or is not. It is suitable to identify according to shape of optional plane configurations independently from size. The algorithm can be applied by means of individual characteristic of symmetry-diagrams’ configurations still then if the geometrical analogy has got approximate characteristic.

During my research work I have worked out a software by which I can run the method capable calculating the symmetry-parameter. It is possible by this program to examine the symmetry characteristics of configurations, to determine the symmetry-parameter exactly and approximatively, to present numerically the results got as well as to select the similar or near configurations.
5. PUBLICATIONS IN CONNECTION WITH THE THEME OF DOCTORAL DISSERTATION

Referred articles in English:


Referred articles in Hungarian:

Szakál Zoltán (2008e), Szimmetria a reverse engineering szolgálatában, GÉP, LIX. évfolyam, 2008/3, 35-37 o.

International conference proceedings:


Hungarian conference proceedings: