Applicability of Folded Structures for Enhancement of Helicopter Radar Transparency

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The main focus in *Stealth* technology is given to reduction of radar visibility as radar stations were and still remain the principal means for detection and guidance. Since radar detection range is proportionate to square in fourth power of value of absolute cross-section (ACS) of a target, then to achieve sufficient advantages one has to significantly reduce ACS. For instance, in order to shorten aerial vehicle (AV) range by factor 2 one has to reduce its ACS approximately by factor 100.

To reduce intensity of reflected signal it needs to:

- diminish area of lateral and frontal surfaces;
- exclude vertical surfaces as they are effective reflectors because radar station range much longer than difference in heights of radar station and AV, and radiation from both directions is most likely;
- all the edges, junctions, planes must be parallel to one of two directions, which constitute acute angle with longitudinal axis of AV as rays reflected from the edges in this case are going to distribute in narrow sector sideways to radar station.

Thus to lead a reflected ray away from radar station, reflected surfaces must be as small as possible and be sloped against a radiant ray.

In order to diminish reflected signal a fuselage structure is designed in such a way to minimize a number of surfaces placed at right angle to a radar ray. But such the structure has some drawbacks. Fuselage turns out to be faceted, consisting of multiple flat faces limited by edges. As a result the aerodynamic performance of AV significantly deteriorates and in consequence its speed and maneuverability diminish.

In this paper for reduction of ACS with no damage to aerodynamic characteristics we offer to use sandwich panels with folded structure in fuselage core (FC).

The main idea of FC application in reduction of reflected signal is concluded in the following:

- folded cores represent a group of faces sloped at an angle to radiation source. Where at the same time curvilinear surface (outer radio transparent skin) can be positioned orthogonally to it;

- folded structure pattern represent a labyrinth of flat faces positioned at different angles. Re-reflecting repeatedly from labyrinth faces radiant signal will lose its intensity. In the end the reflected signal will be substantially weaker. Hence folded core may serve as radio absorbent structure.

Panels' structure (fig. 1) composed of two skins (outer and inner) and core.

Outer skin of the panels is made from radio transparent material, for example from glass- or organ plastic, while core is made from conducting material (foil-coated, metalized polymer composite or carbon plastic). Inner skin material is of no importance.

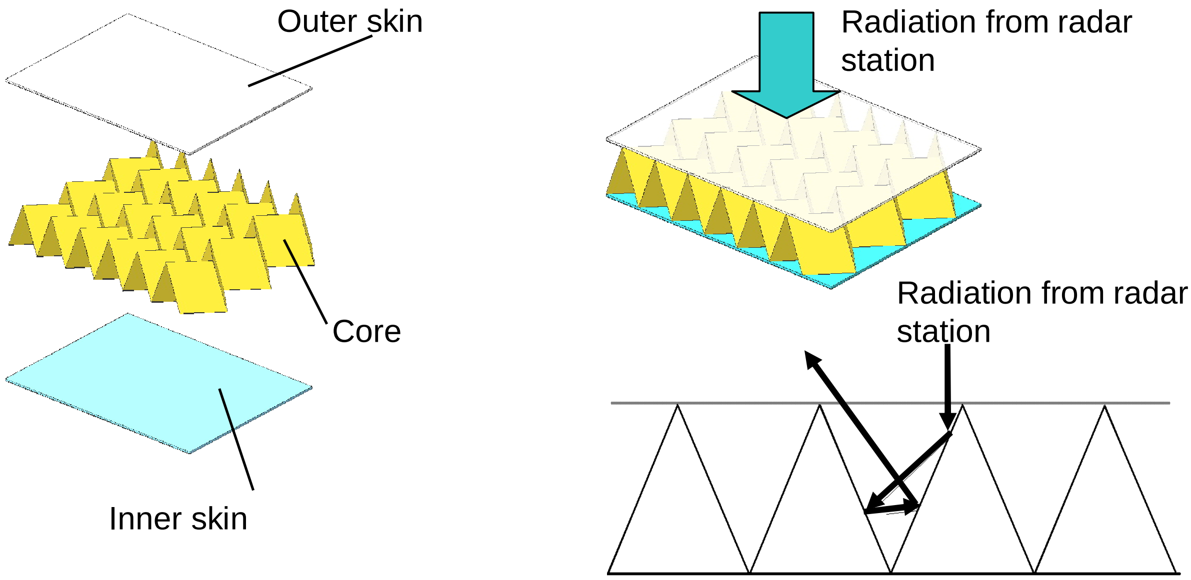


Fig.1 Scheme of panel with zigzag crimp and reflection of a ray from radar station

For assessment of ACS effect reduction an experimental studies were conducted in non-echoed chamber 8x8x25 meters (figure 2). Its walls were lined with pyramids which absorb radio signal. In center of the chamber is placed an investigated specimen of folded design. Specimen size in plan is 400x400 mm. At the one side of the specimen is set vertical radio transparent skin. Onto another side was hanged flat reference plate from aluminum alloy. Size of the plate is equal to projection of the specimen.

Fig.2 Non-echoed chamber

The specimens with folded patterns along with reference plate are mounted onto a table. In process of the experiment the table is turning around vertical axis on 360°. In that way radiation of a specimen and reference plate is carried at aspect angle from 0° to 180°.

In the course of the experiment was investigated an influence of the following factors on specimens' reflective capability:

- relief type (z-crimp, M-crimp);
- influence of shielding of specimen by metallic net;
- specimens height (from 12 to 90 mm);
- relief density;
- influence of specimens material.

The experimental studies suggest the following conclusions. A signal reflection from flat plate is featured by single peak which corresponds to its orthogonal position relative to shed ray.

Folded structures are featured by several reflective peaks. Most of all there are 3 or 5 of them. These peaks correspond to perpendicular position of faces relative to ray at specimen turn.

The least reflective signal is given by specimens with low height, close to length of semi-wave, with dense relief. In fig. 3 and 4 is given comparison of reflective signal for z-crimp with different height and flat plate.

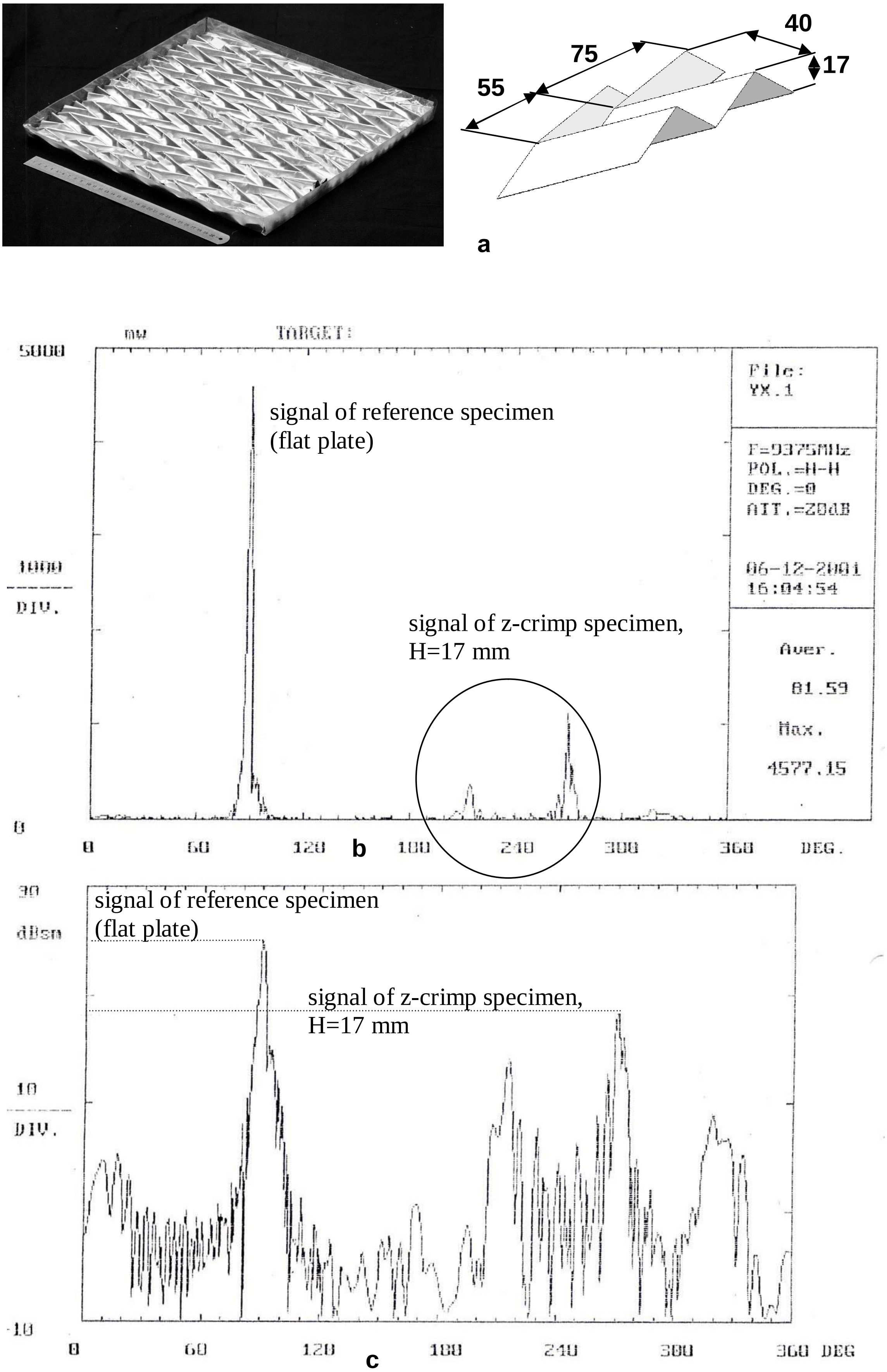
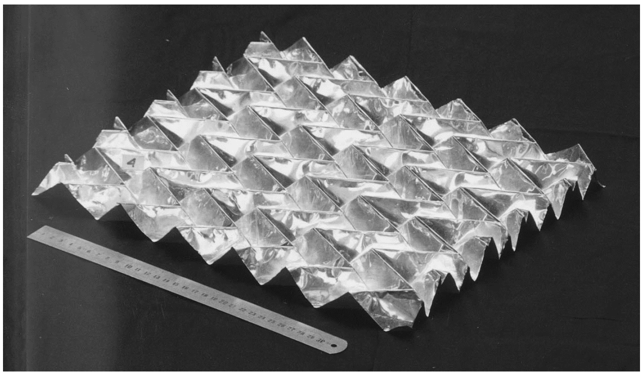
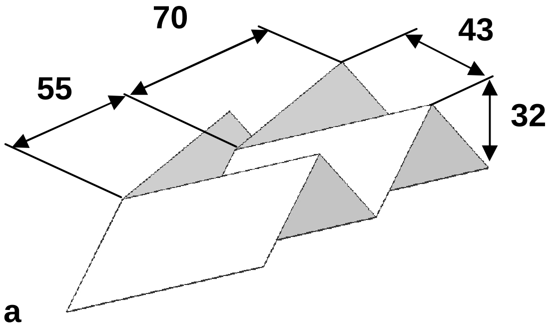
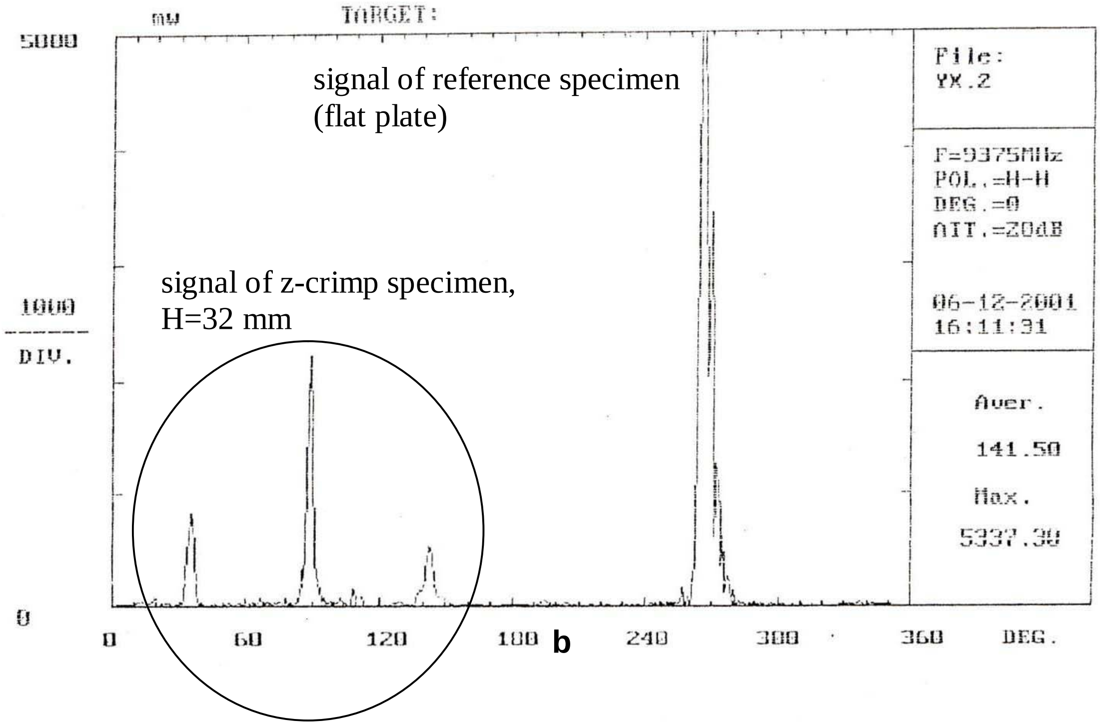


Fig.3 Comparison of reflected signals for z-crimp, height 17 mm:
a – parameters of z-crimp relief; b – reflected signal by absolute scale;
c – reflected signal by logarithmic scale.







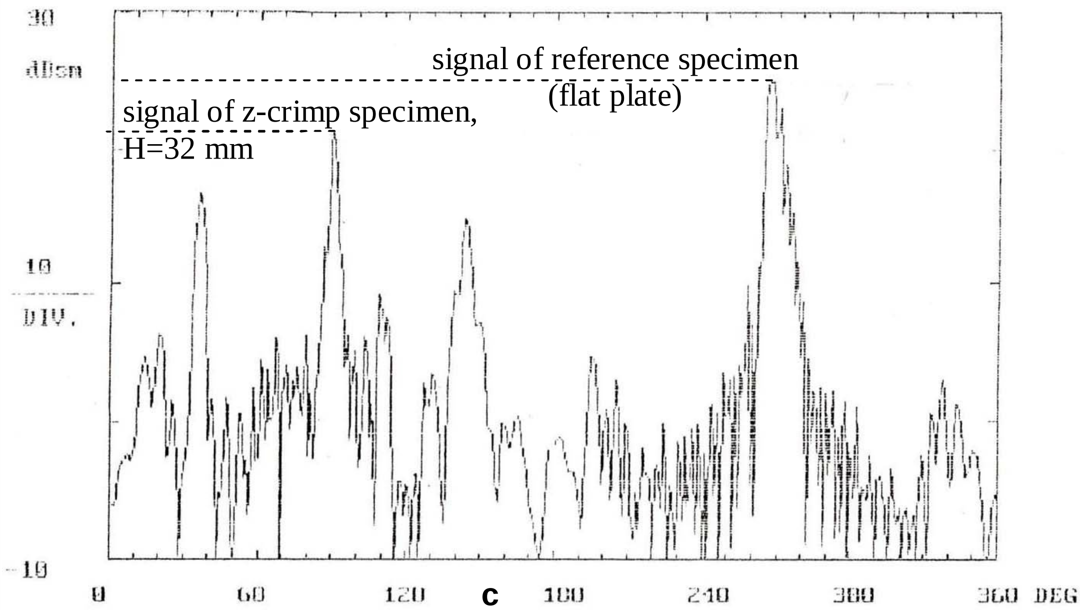


Fig.4 Comparison of reflected signals for z-crimp, height 32 mm:
a – parameters of z-crimp relief; b – reflected signal by absolute scale;
c – reflected signal by logarithmic scale.

Value of reflected signal is much influenced by an object size. The carried out experiments reveal that a crimp with lesser height gives lesser reflected signal as compared to a crimp with larger height. In this connection it would be expedient to study folded structures with height approaching to quarter of wave length. At that it is possible to overlap signal due to waves' interference.

The best values are attributed to aluminum sheets and carbon plastic. In some cases was achieved reflected signal reduction to 8.2 dB.

The experiment was carried out with shielding of reference specimen (plate): where in front of a plate was set carbon z-crimp specimen (fig. 5). The result turned out to be positive as carbon plastic z-crimp completely shielded a reference specimen.

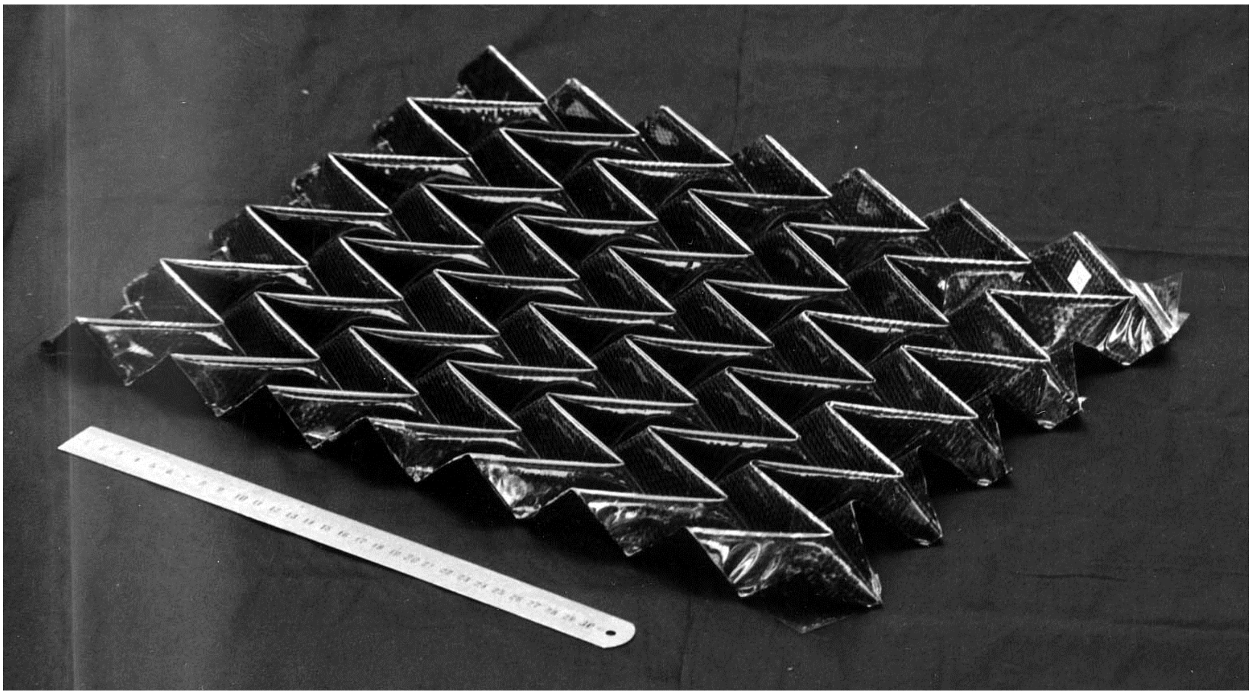
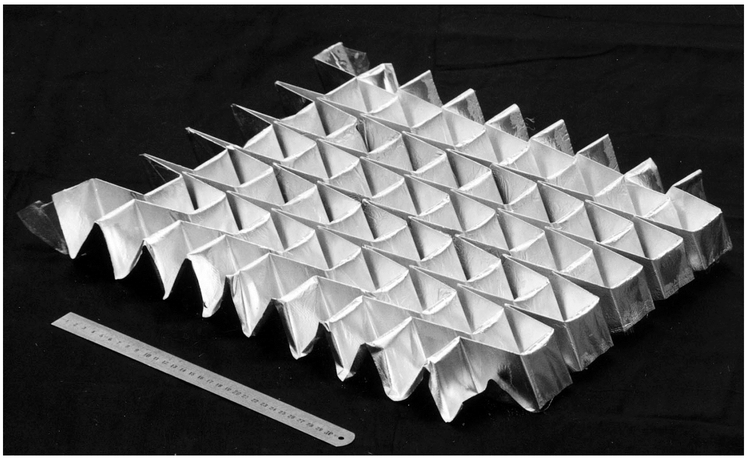
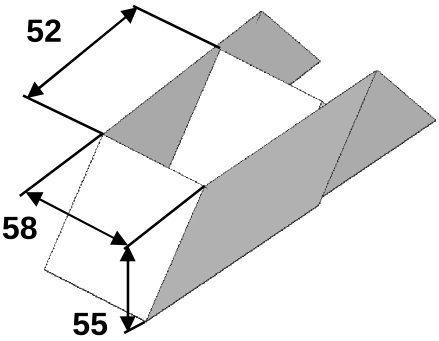


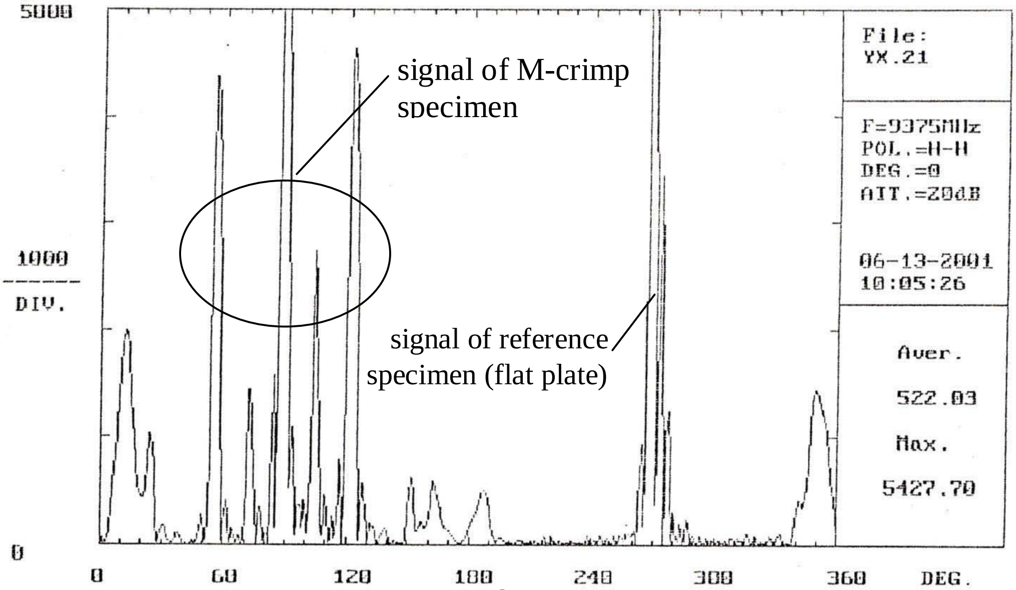
Fig.5 Specimen of zigzag crimp from carbon plastic

Besides the zigzag crimp, a study was given to radio transparent capabilities of M-crimp (fig. 6).





a



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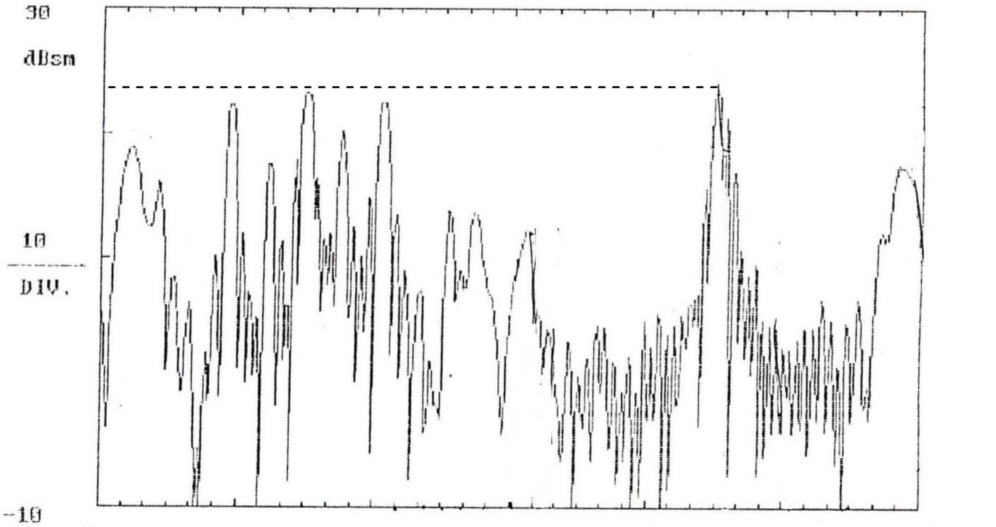

c

Fig.6 Comparison of reflected signals for M-crimp, 55 mm height:
a – parameters of M-crimp relief; b – reflected signal by absolute scale;
c – reflected signal by logarithmic scale.

M-crimp has tapered cells; in other words by its structure it represents kind of a set of rhythmically repeated corner reflectors which efficiently generate reflected signal. M-crimp gave a signal identical to signal of flat specimen except that reflection occurred in wider range of angles of wave shedding onto a structure. Such the structure may be efficiently used as a decoy (brightly reflective) target.

By the experiment results we may draw the following conclusions:

- folded core pattern, height and density exert significant influence on reflected signal. The least reflected signal might be given by z-crimp structure with height from a quarter of wave length. M-crimp gives strong and wide by slope angles reflected signal;
- the best performance of materials are shown by aluminum sheet and carbon plastic. In some cases was achieved reflected signal reduction to 8.2 dB;
- utilizing carbon z-crimp we succeed in shielding reference specimen.