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DESIGN AND REALIZATION OF A PROFILE NOTCHING DEVICE FOR AUTOMOTIVE ELASTOMER COMPONENTS

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Abstract: This paper presents the engineering design and constructive realization route of a profile notching device intended for automotive elastomer components manufactured in small and medium batches. Secondary profiling operations on rubber-based parts are difficult because elastomers combine low stiffness, large recoverable deformation, and sensitivity to local compression, which can generate dimensional scatter, tearing, or edge defects when conventional manual trimming is used. The proposed solution is a compact bench-mounted device built around a guided profiled punch, a dedicated locating nest, a stripper plate, an adjustable stop, and interchangeable cutting inserts. The study follows a structured design methodology including functional analysis, concept selection, preliminary force sizing, material selection, and risk-oriented constructive detailing. A representative load case is used to dimension the lever mechanism, punch holder, and frame under conservative assumptions. The resulting solution emphasizes repeatability, fast changeover, operator safety, and easy workshop manufacturing. The paper therefore offers a realistic mechanical-design basis for controlled notching of seals, gaskets, and similar elastomeric parts used in automotive assemblies.
Key words: Elastomer component; notching device; profile cutting; automotive manufacturing; tooling design; mechanical design.

1. INTRODUCTION

Automotive elastomer components such as sealing profiles, gaskets, cable grommets, and vibration-isolation elements are widely used because they combine flexibility, damping capacity, and resistance to aggressive service conditions. Their engineering behaviour is strongly influenced by large elastic strain, time-dependent deformation, and sensitivity to local stress concentration, which complicates secondary operations after moulding or extrusion [1-3].

In industrial practice, notching is often required to generate local assembly reliefs, corner joints, drainage features, or positioning references. When these cuts are made manually with knives or with simple open fixtures, productivity becomes operator-dependent and the final contour may suffer from local tearing, geometric deviation, or incomplete separation. The literature on elastomer cutting and machining shows that tool sharpness, fixture stiffness, and part support are decisive for process stability and cut quality [4-7].

The objective of this paper is to present the design and constructive realization route of a dedicated profile-notching device for automotive elastomer parts. The contribution is intentionally engineering-oriented: it translates material behaviour, tooling principles, and manufacturability constraints into a compact, workshop-feasible device architecture. Because the available case is primarily a design project, emphasis is placed on requirements definition, concept selection, preliminary sizing, and constructive detailing rather than on a full statistical production campaign.

2. DESIGN REQUIREMENTS AND ENGINEERING APPROACH

2.1 The sequential stages

The engineering approach included five sequential stages: identification of part and process requirements, generation of alternative concepts, weighted concept selection, preliminary sizing of the force path, and constructive detailing for manufacturing, adjustment, and maintenance. The target was not only to obtain a clean notch, but to do so with controlled positioning, reduced operator variability, and a structure that can be produced with standard workshop resources (Table 1).

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Table 1. Main design requirements for the proposed notching device

Requirement	Engineering target	Design implication
Cut quality	Clean profile without tearing	Sharp profiled punch and stable support
Dimensional repeatability	Constant notch position and depth	Dedicated nest and adjustable stop
Low part deformation	Limited local compression and slip	Contour support and stripper plate
Operator safety	Protected handling zone	Guarded actuation and controlled stroke
Quick changeover	Fast adaptation to new profiles	Interchangeable inserts
Maintainability	Simple sharpening and adjustment	Modular punch-die assembly

Three concept families were compared during the conceptual stage: an open knife guide, a screw-actuated vertical punch, and a lever-actuated guided punch with interchangeable inserts. The selection criteria were rigidity, repeatability, safety, changeover speed, manufacturability, and cost. The weighted assessment favoured the guided punch solution because it combines mechanical simplicity with a stable kinematic path and good operator feedback (Table 2).

Table 2. Weighted concept-selection matrix (authors' analysis)

Criteria	Weight	Open knife guide	Screw press	Lever guided punch
Rigidity of force path	25	2	4	5
Positioning repeatability	20	2	4	5
Operator safety	20	2	4	4
Change over speed	15	4	3	4
Manufacturing simplicity	10	5	3	4
Cost	10	5	2	4
Weighted total / 500	-	290	355	450

2.2 Functional design and preliminary sizing

The selected device is composed of a base plate, vertical side supports, an upper lever, a guided punch holder, a lower replaceable die insert, a contour-following nest, a stripper plate, an adjustable back stop, and a protected return spring. The elastomer part is positioned in the nest, constrained against lateral slip, and cut by a profiled blade moving on a controlled vertical path. The stripper plate limits elastic lifting of the workpiece and reduces the risk of the part sticking to the punch after separation.

Because elastomers deform significantly before fracture, the constructive philosophy was to minimize the unsupported span of the part, keep the tool path short and rigid, and maintain a small functional clearance between the profiled punch and the counter-support. Published studies on rubber cutting and elastomer milling show that work holding and tool geometry dominate process stability and surface quality, especially when the material is soft and highly compliant [6-7].

A representative design case was adopted to dimension the main components. The selected envelope corresponds to notches up to 30 mm effective length in parts up to 4 mm thickness. For preliminary sizing, the apparent cutting stress was conservatively taken as 4 MPa.

The estimated cutting force was therefore

$$F = \sigma \cdot A = 4 \times 10^{6} \times 30 \times 4 \times 10^{-6} \approx 480 \text{ N}. \quad (1)$$

To account for material variability, blade wear, and shock loading, the design force was raised to 1.2 kN. With a lever ratio of 1:6, the required nominal manual input becomes approximately 200 N, which remains acceptable for short-cycle manual operation. The frame, guide pins, and punch holder were therefore sized for a minimum static safety factor of 2 (Table 3).

Table 3. Preliminary sizing parameters for the representative design case

Parameter	Value/UM	Engineering role
Maximum part thickness	4 mm	Defines stroke and support geometry
Effective notch length	30 mm	Defines cutting area
Assumed apparent cutting stress	4 MPa	Conservative force estimate
Estimated cutting force	480 N	Initial load in the force path
Selected design force	1.2 kN	Robustness against

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		variability and wear
Lever ratio	1:6	Reduces operator effort
Nominal operator force	≈ 200 N	Ergonomic manual actuation
Minimum static safety factor	2	Structural reliability

From a constructive standpoint, the punch and die insert are specified from wear-resistant tool steel, while the structural frame may be produced from standard carbon-steel plates and machined spacers. Interchangeable inserts allow future adaptation to new notch geometries without rebuilding the complete device. Rubber-contact support areas should be smooth and, where necessary, backed by a compliant element to prevent local marking. Dimensional references for the finished parts must remain compatible with recognized rubber-product tolerance practice [8].

3. RESULTS AND DISCUSSION

3.1. Manufacturing and assembly

The realization route is intentionally compatible with a university workshop or a small industrial tool room. Base and side plates can be cut from steel plate and finish-machined on a milling machine. The guide set, punch holder, and adjustable stop can be produced by turning and drilling operations, while the insert contour is best manufactured by wire EDM or by finish grinding when high profile fidelity is required. Assembly begins with alignment of the base and guide elements, continues with installation of the lower insert and locating nest, and ends with adjustment of the punch stroke and the back stop.

3.2. Risk control and preventive measures

Preventive design measures were introduced early to reduce the most probable failure modes: blade wear, part slip, guide misalignment, incomplete cut, and accidental finger access. This type of risk-oriented detailing is essential because elastomer cutting is highly sensitive to local geometry and to the repeatability of the work holding condition (Table 4) [4-10].

Table 4. Preliminary sizing parameters for the representative design case

Potential issue	**Likely effect**	**Preventive measure**
Blade wear	Tearing and burr-like defects	Sharp enable insert and inspection intervals
Part slip in the nest	Wrong notch position	Back stop and contour support
Guide misalignment	Non-uniform cut and edge damage	Precision pins and adjustable setup
Insufficient stroke	Incomplete separation	Mechanical stop calibration
Operator contact with tool zone	Safety incident	Guarded actuation area and safe loading sequence

4. CONCLUSIONS

The paper presented an engineering route for the design and realization of a profile notching device dedicated to automotive elastomer components. The adopted solution, based on a guided profiled punch, a dedicated locating nest, and interchangeable inserts, was selected because it offers a favourable balance between repeatability, simplicity, safety, and manufacturability. Preliminary sizing based on a representative cutting case led to a design force of 1.2 kN and confirmed the feasibility of manual actuation through a lever mechanism.

From a practical perspective, the device can reduce dependence on manual knife trimming and can create a more controlled route for producing assembly notches in seals, gaskets, and similar parts. The modular tool concept also facilitates adaptation to different profiles without redesigning the entire structure. Future work should include prototype validation, direct force measurement, assessment of edge quality and dimensional repeatability, and optimization of punch geometry for different elastomer hardness classes.

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7. CRediT AUTHORS STATEMENT

Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review

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8. REFERENCES

[1]. Gent, A. N. (2012), Engineering with Rubber: How to Design Rubber Components, 3rd Edition, Munich, Hanser Publishers.

[2]. Bhowmick, A. K.; Stephens, H. L. (eds.) (2000), Handbook of Elastomers, 2nd Edition, New York, Marcel Dekker.

[3]. Bhowmick, A. K. (1994), Rubber Products Manufacturing Technology, Boca Raton, CRC Press.

[4]. Kalpakjian, S.; Schmid, S. R. (2014), Manufacturing Engineering and Technology, 7th Edition, Harlow, Pearson.

[5]. Suchy, I. (2005), Handbook of Die Design, 2nd Edition, New York, McGraw-Hill.

[6]. Yan, J.; Strenkowski, J. S. (2006), *A finite element analysis of orthogonal rubber cutting*, in Journal of Materials Processing Technology, 174 (1-3), pp. 102-108.

[7]. Teramoto, K.; Kunishima, T.; Matsumoto, H. (2017), *Analysis of Cutting Force in Elastomer End-Milling*, in International Journal of Automation Technology, 11(6), pp. 958-963.

[8]. ISO (2014), ISO 3302-1: Rubber - Tolerances for products - Part 1: Dimensional tolerances, Geneva, International Organization for Standardization.

[9]. Khomyakov, V., Savchuk, V., (2014), *Loading of scrap-metal on ship of "coaster" type*, in Journal of Marine Technology and Environment, vol. 2, pp 55-58, Nautica Publish House, Constanta, Romania.

[10]. Sulaiman O.O, Saharuddina.H., Wan Nik W.B, Saman A.B., (2011), *Environmental risk and reliability for sustainable dredging*, in Journal of Marine Technology and Environment, vol. 2, pp 127-148, Nautica Publish House, Constanta.

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