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Process Engineering Transformation of Blind Rivet Production at KOOBESH Kavir Semnan (KKS) Company (Refinement and Improvement)

Dr. Masoud Lajevardi
Corresponding author, PhD in marketing management, Commercial manager of KKS company, iran,Semnan,
E-mail: Lajevardi_masoud@yahoo.com , co_kks@yahoo.com
Abolfazl albooyeh
CEO of KKS company
Mehran shahi
Factory manager and head of technical department of KKS company
Mohammah Mohammadi
Laboratory manager of KKS company
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Abstract

One of the major technical challenges in the production of blind rivets at KKS Company has been the repeated failure of dies mounted on the press machine. This issue led to increased costs for die manufacturing and additional punches. Another significant challenge was the formation of undesirable cracks on the surface of the blind rivets, which resulted in higher defect rates and customer dissatisfaction. The objective of this paper is to improve and modify the production method and process by focusing on redesigning production elements and optimizing the machine mechanism. In this regard, as a first step, the company's specialists replaced the conventional multi-die method commonly used worldwide for blind rivet production with a single-die approach. The results demonstrate that production efficiency has increased by up to three times, accompanied by a significant boost in production speed. As part of the effort to improve the blind rivet production process, the company's engineers evaluated and reviewed the cold forging process used to form the rivet head, which contains three times more material volume compared to the shank. By transitioning from a multi-die method to a single-die approach, the skilled engineers of the company not only addressed this challenge but also significantly enhanced overall productivity by reducing the number of processing stages. This technological advancement was successfully implemented for the first time in the world. In terms of its objective, this study is classified as fundamental research, as it introduces a novel method being implemented for the first time. At the same time, given that its results have led to improvements in quality, process efficiency, quantity, and productivity, it also falls under the category of applied research. Furthermore, based on the data collection and analysis methods—including metallurgical testing and real-world production trials—this study is considered experimental research.

Key words: Blind Rivet, dies, punches, KKS, operational production process.

Introduction

Blind rivets are widely used mechanical fasteners in various industrial sectors due to their structural reliability, ease of application, and suitability for automation. Their application is particularly significant in the automotive, aerospace, and construction industries where joint integrity and fatigue resistance are critical [1,2]. Among the different types of blind rivets, dome head rivets are known for their superior stress distribution properties and ability to maintain structural integrity under both shear and tensile loads, making them ideal for use in load-bearing areas such as chassis assemblies, suspension systems, and impact zones [3].

Traditionally, the manufacturing process of blind rivets involves multiple forming stages and complex tooling systems, which increases production cost, cycle time, and the likelihood of tool wear or failure [4]. The cold forging method, despite its advantages such as high material utilization, excellent mechanical properties, and high production speed, poses significant challenges in forming components with large head-to-shank volume ratios, such as dome-head blind rivets [5]. In multi-die forging systems, controlling material flow and achieving dimensional accuracy across all forming stages require precise die alignment and frequent maintenance, which further adds to operational complexity [6].

In response to these challenges, this study presents a novel approach developed by Koobesh Kavir Semnan Company to produce dome-head blind rivets using a single-die double-stroke cold forging method. This innovation replaces the traditional three-die system (extrusion die, preforming die, and final head-forming die) with a simplified yet highly efficient one-stage forming system. The results demonstrate substantial improvements in tool life, cost reduction, dimensional accuracy, and production speed. Moreover, the company designed and built a custom heat treatment furnace to optimize the post-forming mechanical properties of the rivets, addressing the problem of excessive hardness and surface cracking observed in earlier stages of production.

This paper highlights the engineering design considerations, process transformation strategies, material selection criteria, and the final performance evaluation of the rivets, setting a new benchmark in the field of high-volume precision forging for fastening solutions.

Dome-headed rivets, also known as rounded head rivets, possess high strength primarily due to the dome-shaped design of their heads, making them particularly suitable for use in the automotive industry. The dome-shaped head allows for uniform stress distribution across the rivet, resulting in enhanced resistance to failure within the joint. These types of fasteners are utilized in the automotive sector in various diameters, which expands their application range to critical areas of the vehicle. Such positions include main chassis joints, connections between the fuel tank and chassis, and impact-prone areas such as front and rear bumper mounts. Figure 1 illustrates the pressing mechanism when using a rivet. As depicted, two plates with holes of specified diameter are positioned parallel and in contact with each other. Subsequently, a press machine with a dome-shaped die applies pressure to the opposite side of the pin, while supporting the other side, forming the end of the shank into a rivet head shape. Given its placement, the rivet is subjected to significant tensile and shear loads. Therefore, considering all the aforementioned factors, precise design—particularly at stress concentration points susceptible to failure—is essential. Additionally, certain mechanical properties must be ensured through the appropriate selection of the wire grade used in rivet manufacturing.

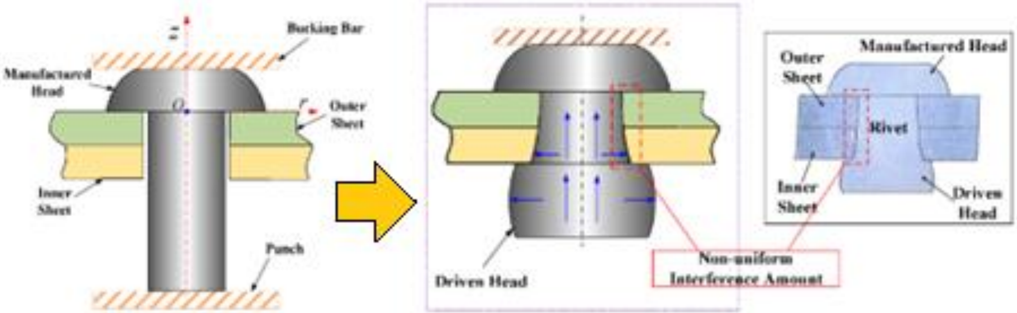

Fig1.
Positioning of the Blind Rivet and the Pressing Mechanism During Application

Critical properties of the wire used include adequate tensile strength and fracture toughness, good wear resistance, and uniform hardness distribution—which requires a well-engineered and homogeneous microstructure. Additionally, the wire material must be nearly free of internal defects such as voids, air pockets, and inclusions, as the presence of such flaws can alter stress distribution and hardness throughout the structure. Figure 2 illustrates the detailed mechanism of pressing and forming the blind rivet during application.

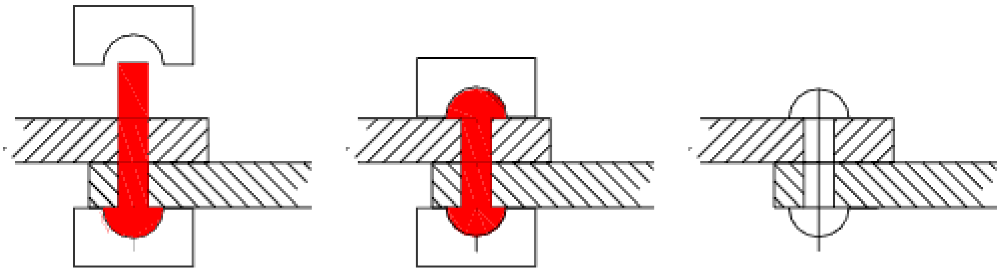

Fig2. Stages and Pressing Mechanism of the Blind Rivet During Application

Since 2004, KKS Company has been manufacturing blind rivets for the Nissan Junior, which are used in chassis and suspension system connections fig3. However, over consecutive years, technical and quality issues such as multiple surface cracks on the product—resulting in increased waste and customer dissatisfaction—and repeated failures of the cold forging heading machine dies, prompted the company's research and development specialists to undertake a comprehensive review, redesign, engineering transformation, and process improvement effort aimed at resolving these problems.

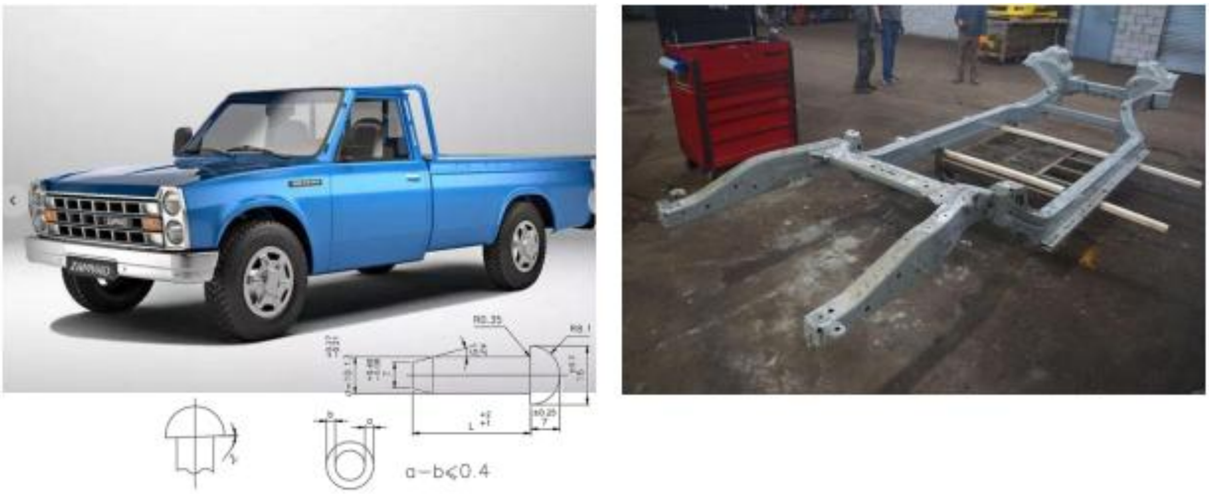

Fig3. Nissan blind rivet used for chassis and suspension system connections.

Pressing Process in the Production of Nissan Junior Blind Rivet

After completing all initial stages including preparation, drawing, and storage of incoming wire rods, the raw material enters the production line and is transferred to the press machine. In this phase, the wire is first cut into equal-length pieces by the machine using a die and cutting blade. Each piece is then positioned in front of the die cavity by a finger mechanism, and finally, cold forming is performed on the raw wire by a hammer strike from the machine. The production of the Nissan Junior blind rivet is fully based on standard D2411_1986, which defines all dimensional specifications. In the early stages of producing the Nissan Junior blind rivet, the pressing process was carried out using a P8 machine (Figure 4), a four-die single-stroke machine. In this setup, two dies were used during production. In the first die and punch set, a pear-shaped form was created, and in the next die and punch set, the head and chamfered end of the shank were formed

Fig4. A view of the P8 single-stroke four-die machine, which was initially used for producing the Nissan Junior blind rivet

Due to recurring issues such as frequent die breakage, increased production costs for additional dies and punches, and various operational challenges with the mentioned machine, the engineering team at Koobesh Kavir Semnan launched a new project to redesign the die, punch, and the production machine itself. In this context, various design alternatives were explored, ultimately leading to the decision to carry out the entire forming process using a single die and punch.

This meant that the complete shaping process of the blind rivet would occur instantaneously in a single stage using just one die-punch set, applying high-speed stress to the forming materials. To ensure the feasibility of such rapid deformation for the selected alloy, the R&D team conducted a thorough evaluation, since the entire head-forming operation had to be completed in one step. Subsequently, the carbide grade for the die material was selected based on an algorithm similar to that used in the design of hose clamp dies. The selection of the die material was made considering the working conditions, as well as the magnitude and speed of the applied forces. After extensive research and through the efforts of the technical engineering team, a suitable die and punch set was successfully designed and manufactured. The design was developed based on the deformation behavior of the target metal and validated through simulations using advanced engineering software. Furthermore, the new design includes two air-vent holes to ensure complete evacuation of trapped air between the workpiece and the die, enabling a more effective and complete cold forming process. Trapped air can hinder material flow during forming, resulting in incomplete shaping of certain sections of the final part. The previous and new blank designs for the Nissan Junior blind rivet are illustrated in Figure 5.

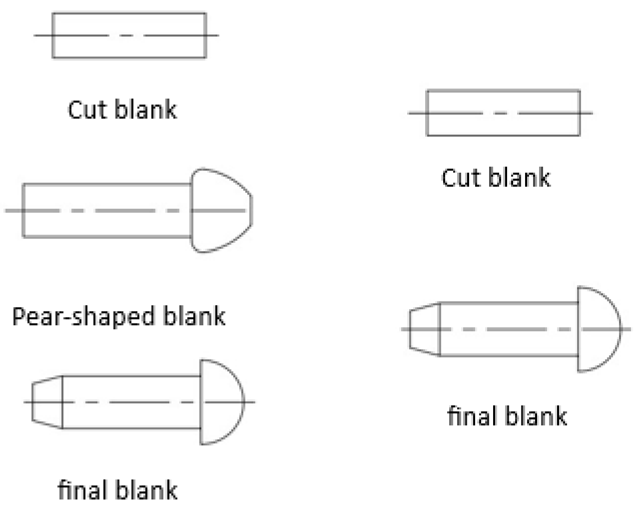

Fig5. Blanks Used in the Production of the Nissan Junior Blind Rivet Before and After the Design Modification

Subsequently, due to the increased forming force required for blind rivet production—resulting from the reduction in the number of dies—as well as the growing demand for rivet pin production, the production machine was completely upgraded. The former single-stroke four-die machine was replaced with a new model named P10-1. A major advantage of this machine over similar models is its capability to produce pins and bolts with diameters up to 12 mm. To further boost production volume, several structural modifications were implemented, including increasing the pulley diameter, modifying the cam profiles, and adjusting the timing of the finger mechanism. As a result, production output increased by up to 24% without compromising quality.

Figure set 6 illustrates the P10-1 press machine, which is currently used for the production of the Nissan Junior blind rivet.

Fig6. P10-1 Machine Used for the Current Production of Nissan Junior Blind Rivet

Overall, with the modifications made to the production factors, manufacturing machine, and raw materials, a continuous production cycle for the Nissan Junior blind rivet was established at Koobesh Kavir Factory. The process was conducted under the strict supervision of the factory's quality control team and subsequently delivered to the market. The improvement of the P10-1 machine not only enhanced the aesthetic quality of the parts but also significantly improved their functional performance. Moreover, production output was increased from 45 units per minute to 85 units per minute. This reflects the excellent technical expertise and profound understanding of the machine's operational nature.

After implementing changes to the power and torque transmission mechanism of the machine, and ordering new equipment for optimization, the engineers at Koobesh Kavir Factory, utilizing 3D and analytical software, designed the necessary components. Taking into account the complete structure of the machine, they optimized it with minimal cost and high speed, successfully returning it to the production cycle while doubling the production volume. This demonstrates that the company, relying on its internal knowledge and ability to identify and optimize foreign machinery, possesses the capability to optimize equipment without dependence on foreign engineering.

Heat Treatment of the Nissan Junior Blind Rivet

One of the most significant challenges during the initial production of the Nissan Junior blind rivet was the formation of cracks (fig7) on the product, which became a key issue for customer standards and satisfaction. According to the provided statistics, up to 30% of the products were discarded daily due to these cracks. The technical team, along with the R&D team, conducted extensive studies and experiments from the onset of this problem. They implemented innovative and transformative changes based on technical knowledge and supported by metallurgical expertise. Over time, these improvements successfully resolved the issue and significantly enhanced the process quality and productivity.

Fig7. Crack formation on the blind rivet

Cold Forging Process and Heat Treatment in Blind Rivet Production

Cold forging, due to inducing plastic deformation at very high strain rates, typically results in a 30–40% increase in mechanical properties such as hardness and ultimate strength of the final product compared to the base material. However, this enhancement depends on several factors, including the amount of deformation applied to different areas of the part, the material type, surface coating, temperature, and more. This increase in material strength is primarily attributed to material densification, dislocation multiplication, dislocation movement, and in some cases, dislocation entanglement or locking. Moreover, the high strain rates involved in cold forging further contribute to hardness enhancement, as the accelerated deformation limits the time available for dislocation motion within the material structure. Consequently, dislocation density increases, and the critical stress required for dislocation movement also rises. Additionally, higher strain rates promote the formation of new dislocations. Altogether, these phenomena lead to an increase in hardness and strength during cold forging.

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Based on the hardness values specified in the customer's test plan and applicable standards, the final product's hardness exceeded the acceptable range. As a result, heat treatment became necessary to reduce the product hardness during the rivet manufacturing process. Initially, the produced rivets were outsourced to external suppliers for heat treatment. However, given the required hardness range of 45–75 HRB (Rockwell B), external vendors were unable to meet this requirement due to furnace limitations, particularly in customizing temperature and thermal conditions. Therefore, the construction of a dedicated tempering furnace was prioritized at Koobesh Kavir Semnan Factory. In general, heat treatment processes are performed to reduce, enhance, or homogenize the mechanical properties of a given part. Thermal behavior and phase transformations occurring at various temperatures are typically analyzed using the iron–carbon phase diagram. A sample Fe–C diagram is shown in Figure 8.

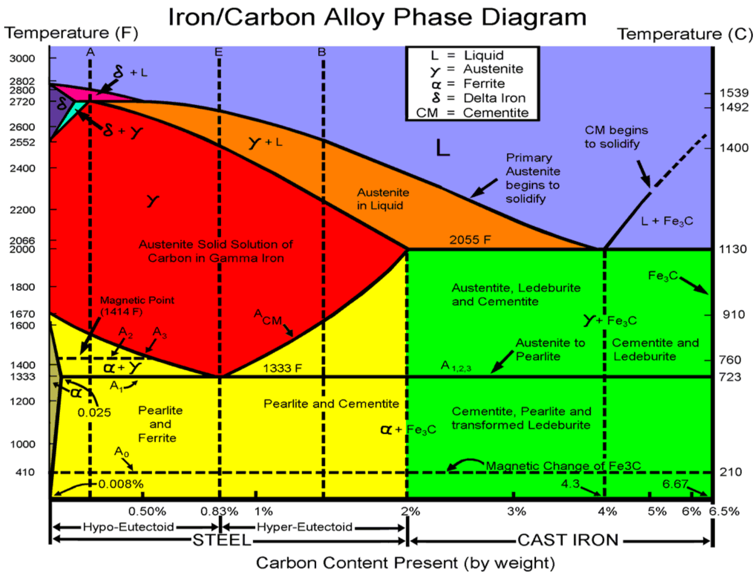

Fig8. Iron–Carbon Phase Diagram with Phases Present at Various Temperatures

In cases where the hardness of the product exceeds the acceptable limit, a specially designed heat treatment process is employed to reduce the hardness to the desired range. This process is typically conducted at temperatures below the solidus line of the material. For tempering steel, various procedures are applied depending on the specific steel grade. The simplest form of tempering is carried out as follows: The steel is heated to a temperature just below the austenite region. The final temperature is selected based on the desired final structure required by the customer. However, it can generally be stated that the tempering temperature range lies between 450°C and 720°C. At this temperature, the steel sacrifices some of its hardness in exchange for improved toughness. This is because the hard and brittle structures allow the carbon within them to slightly diffuse, enabling more stable, equilibrium microstructures to form within the steel.

After being held at the desired temperature for a specific period, the steel is slowly cooled in ambient air, completing the tempering process and making the steel ready for use. To carry out this heat treatment process, a floor-mounted furnace was constructed at Koobesh Kavir Semnan Factory, equipped with two active burners and precise temperature control. After production, the rivet products are placed inside the furnace and subjected to the tempering process. Figure 9 shows the custom-built tempering furnace at Koobesh Kavir Semnan Factory.

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Fig9. The heat treatment furnace built at Koobesh Kavir Semnan Factory, along with the tubes prepared for charging the furnace

After heat treatment is performed on the produced rivets, three samples are taken from each tube in every furnace batch—specifically from the top, middle, and bottom sections of the tube. One surface of each heat-treated sample is then smoothed using a controlled machining (chip removal) process with coolant, and subjected to hardness testing using a dedicated fixture. This method not only allows for the hardness of each sample to be measured but also enables the evaluation of hardness distribution across different areas of the tube. The measured hardness values are compared against the customer's test plan and applicable standards. Upon approval by the Quality Control Unit, the batch is forwarded to the weighing and packaging unit. Figure 10 shows the hardness testing process of a heat-treated Nissan Junior blind rivet sample.

Fig 10. Hardness Testing Process of Nissan Junior Blind Rivet After Tempering Heat Treatment

Conclusion

Koobesh Kavir Semnan Company, leveraging its extensive experience and deep domestic engineering knowledge in die manufacturing and production processes, has successfully improved the blind rivet production process through the cold forging method. By utilizing its technical expertise in tooling and manufacturing, the company transitioned to a single-die double-stroke method, which led to a threefold increase in production efficiency and a significant rise in production speed. These improvements were achieved through optimized die design and the use of high-quality die materials, resulting in maximum productivity with minimal die manufacturing costs. This achievement serves as a model that can help other industries enhance similar manufacturing processes and benefit from the results.

Traditionally, blind rivet production worldwide is conducted using multi-stage die forming. To reach the final shape of the rivet, three different dies are commonly employed: an extrusion die, a pre-forming (pear-shaped) die, and a final die to form the rivet head. The engineering team at Koobesh Kavir successfully replaced this multi-die approach with an innovative single-die solution. The outcomes revealed not only a threefold increase in production efficiency but also a substantial improvement in manufacturing speed.

In pursuit of process improvement, the company's engineers critically evaluated the cold forming of the rivet head—an area that contains nearly three times the material volume compared to the shank. Achieving this increased volume in a single stroke is challenging and, if not done correctly, can lead to severe issues such as die fracture, material underfill, or an oval-shaped head. The skilled engineers at Koobesh Kavir overcame these challenges by redesigning the process to use a single die, thereby reducing production stages and significantly enhancing productivity. This technological innovation was implemented for the first time in the world.

Based on the company's unique experience in blind rivet production using cold forging and its optimization of the single-die forming method, a comprehensive analysis of conventional global production methods was conducted. The research indicated that common practices—relying on three-die systems—increase tooling costs significantly and directly affect the overall production cost. Koobesh Kavir succeeded in developing a process that reduced the final product's cost by 45% compared to international counterparts. Moreover, the company developed an exclusive single-die double-stroke production machine that not only reduced tooling material consumption but also improved efficiency and minimized tooling costs. By harnessing advanced in-house tooling expertise, Koobesh Kavir transitioned the manufacturing process to cold forging, solving many production challenges and delivering a high-quality, cost-effective product capable of competing globally, even with manufacturers in China.

These innovations, rooted in the company's in-house engineering capabilities and extensive R&D investment, led to improvements in product safety, surface finish, reduced shank deviation, minimized deep cracking, and increased daily output to 50,000 pieces. Ultimately, this transformation drastically reduced foreign currency outflow and stands as a testament to the value added through domestic knowledge, youth-driven innovation, and technological self-reliance.

Acknowledgments

KKS Company is a leading Iranian manufacturer specializing in the production of custom-designed industrial fasteners, including bolts, nuts, pins, and rivets. Established in 2002 in the East Industrial Park of Semnan Province, the company was founded with the aim of enhancing the national economy and meeting the domestic demand for specialized fastening components. With a commitment to quality and innovation, KKS has developed a comprehensive manufacturing infrastructure, including state-of-the-art laboratories and mold-making facilities. The company adheres to international quality standards, including IATF, and has implemented a robust organizational framework to ensure consistent product excellence. Through continuous research and development efforts, KKS has pioneered advancements in the design and production of hose clamp bolts, introducing innovative solutions that have set new benchmarks in the industry. The company's dedication to technical excellence and customer satisfaction has solidified its position as a trusted partner in the industrial fastener sector.

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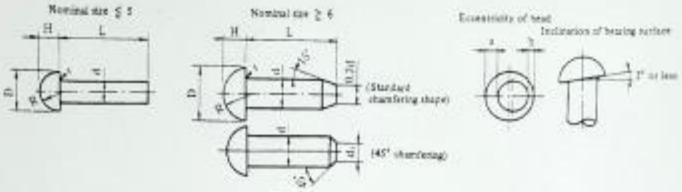
Appendix 1

Nissan Engineering Standard
Standard Parts for Automobile

NES	Rivets-Round Head	D 2411 Revised 1986



Unit: mm

Nominal size		3	4	5	6	8	10	13
d	Basic size	3	4	5	6	8	10	13
	Tolerance	+0.12 −0.03	+0.16 −0.04	+0.2 −0.05	+0.24 −0.06	+0.32 −0.08	+0.4 −0.08	+0.5 −0.08
D	Basic size	5.2	7	8.8	10	13.3	16	21
	Tolerance	±0.2		±0.3				
H	Basic size	1.85	2.6	3	4.2	5.6	7	9
	Tolerance	±0.15	±0.2			±0.25		
R	(Reference)	2.8	3.8	4.7	5.1	6.8	8.1	10.8
r		0.1 ~ 0.2		0.15 ~ 0.25	0.2 ~ 0.3	0.3 ~ 0.4		0.3 ~ 0.5
a − b (Maximum)		0.2		0.3		0.4		0.5
d_1		−	−	−	4	5	6	8
Hole dia. (ref.)		3.2	4.2	5.3	6.3	8.4	10.6	13.8

Part Numbers

L mm	3	4	5	6	8	10	13
4	6-10304	6-10404					
6	6-10306	6-10406	6-10506	6-10606			
8	6-10308	6-10408	6-10508	6-10608	6-10808		
10	6-10310	6-10410	6-10510	6-10610	6-10810	6-11010	
12	6-10312	6-10412	6-10512	6-10612	6-10812	6-11012	
14	6-10314	6-10414	6-10514	6-10614	6-10814	6-11014	6-11314
16	6-10316	6-10416	6-10516	6-10616	6-10816	6-11016	6-11316
18	6-10318	6-10418	6-10518	6-10618	6-10818	6-11018	6-11318
20	6-10320	6-10420	6-10520	6-10620	6-10820	6-11020	6-11320
22		6-10422	6-10522	6-10622	6-10822	6-11022	6-11322
24		6-10424	6-10524	6-10624	6-10824	6-11024	6-11324
26			6-10526	6-10626	6-10826	6-11026	6-11326
28			6-10528	6-10628	6-10828	6-11028	6-11328
30			6-10530	6-10630	6-10830	6-11030	6-11330
32				6-10632	6-10832	6-11032	6-11332
35				6-10635	6-10835	6-11035	6-11335
38					6-10838	6-11038	6-11338
40					6-10840	6-11040	6-11340
45						6-11045	6-11345
50						6-11050	6-11350
55							6-11355
60							6-11360

Tolerance of L (¹)	3 – 5	6 – 13
≦ 4	+0.4 / 0	−
4 < ≦ 10	+0.5 / 0	+1.7 / +1 (+0.7 / 0)
10 < ≦ 20	+0.6 / 0	+1.8 / +1 (+0.8 / 0)
20 < ≦ 40	+0.8 / 0	+2 / +1 (+1 / 0)
40 <	+1 / 0	+2 / +1 (+1 / 0)

Appendix 2

3. Manufacturing method

The rivets shall be manufactured by cold working form wire rod material and annealed after the manufacture.

Shot blasting may also apply.

4. Quality

4.1 Appearance

The surface of the rivets of various types shell be smooth and free from defects such as cracks , flaws , sharp edges , streak , burrs , scale , etc .

with an exception of slight irregularities to the head which may however be permitted .

4.2 Hardness

The hardness after annealing shell be HRB 45 – 75 .

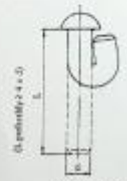
5. Tests

5.1.1 Bending test of shank

The shank shell not be cracked or split on the outer surface when being bent 180° up to touching , at normal temperature .In this test , length " L " shall preferably be more than 4 times as large as diameter "d " of the shank .

5.1.2 Hammering test of Head

The rivet is inserted into a hole provided with a fitting face for the rivet head , having an inclination angle of 30° to the horizontal line . The head is then hammered until it comes in contact with the inclined face . At that time , the rivet shall not be fractured , cracked or split .



Bending test of shank

Hammering test of head

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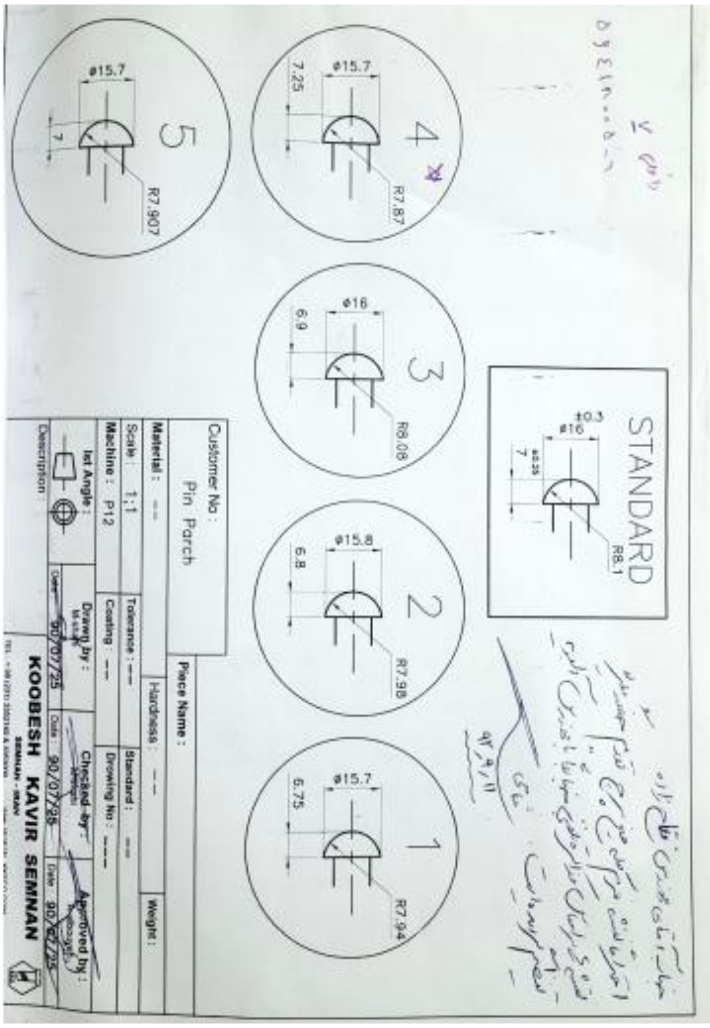
Appendix 3



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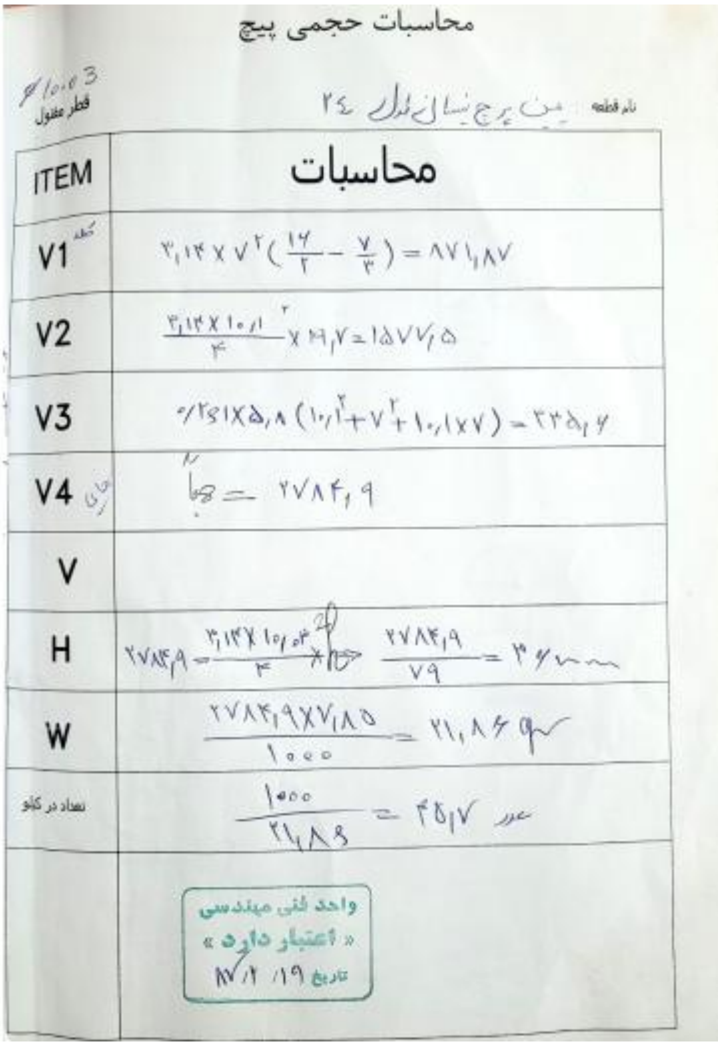
Appendix 4



محاسبات حجمی پیچ

قطر مفتول Ø10.03

نام قطعه: پین برج نیسان لول ۲۴

ITEM	محاسبات
V1	۳٫۱۴ × ۷^۲ (۱۶/۲ − ۷/۳) = ۸۷۱٫۸۷
V2	(۳٫۱۴ × ۱۰٫۱^۲)/۴ × ۱۹٫۷ = ۱۵۷۷٫۵
V3	۰٫۲۶۱ × ۵٫۸ (۱۰٫۱^۲ + ۷^۲ + ۱۰٫۱ × ۷) = ۳۳۵٫۴
V4	Σ = ۲۷۸۴٫۹
V	
H	۲۷۸۴٫۹ = (۳٫۱۴ × ۱۰٫۰۳^۲)/۴ × h ⇒ ۲۷۸۴٫۹/۷۹ = ۳۵mm
W	(۲۷۸۴٫۹ × ۷٫۸۵)/۱۰۰۰ = ۲۱٫۸۶ gr
تعداد در کیلو	۱۰۰۰/۲۱٫۸۶ = ۴۵٫۷ عدد
	واحد فنی مهندسی «اعتبار دارد» تاریخ ۸۷/۲/۱۹

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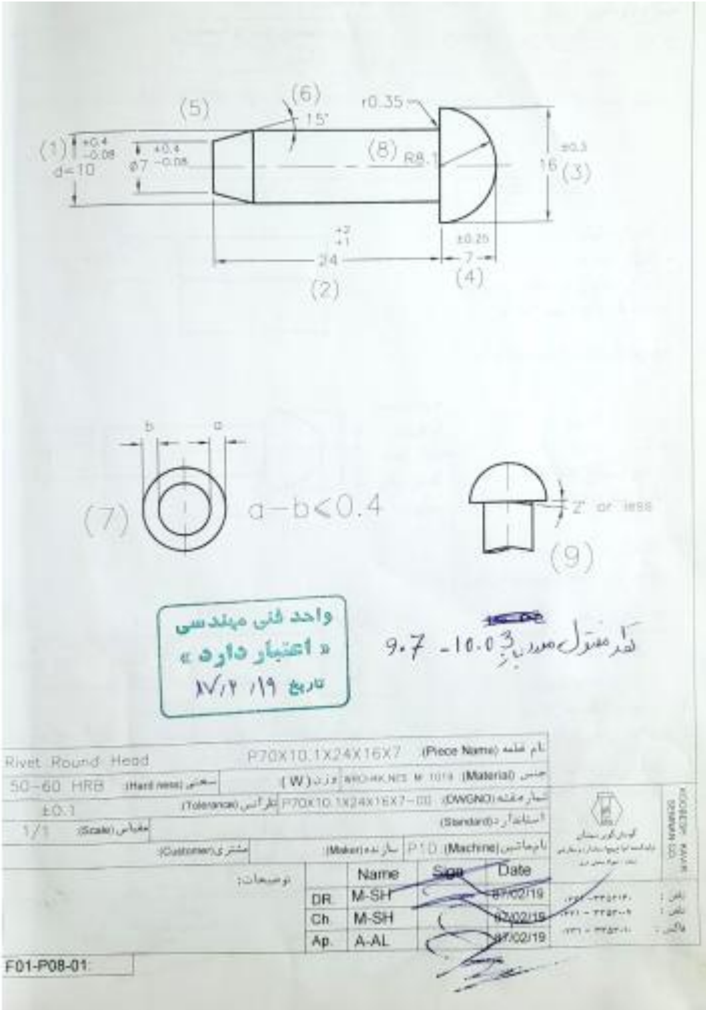
Appendix 5



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ABOUT AUTHORS

Mr. Abolfazl Albouyeh

- Founder and owner of KKS Company
- Head of R&D team at KKS company
- Over 40 years of experience and activity in the fastener industry.
- Tel: +(098) 9121318067
- E-mail: co_kks@yahoo.com
- Master's degree in Mechanical Engineering.
- Manufacturer of specialized automotive bolts and nuts with IATF certification.

Dr. Masoud Lajevardi

- PhD in marketing management
- Commercial manager of KKS company
- Member of R&D team at KKS company
- Assistant professor
- Head of the KKS Company office at the Science and Technology Park of Semnan University.
- Corresponding author
- International scientific journals editorial board membership
- E-mail: Lajevardi_masoud@yahoo.com , co_kks@yahoo.com

Mr. Mehran Shahi

- KKS company manager
- Head of technical department
- Over 40 years of experience and activity in the fastener industry.
- Member of R&D team at KKS company
- Specialist in the design and manufacturing of various industrial molds.
- E-mail: co_kks@yahoo.com

Mr. Mohammad Mohammadi

- Master's degree in Metallurgical Engineering.
- Laboratory manager of KKS company
- Member of R&D team at KKS company
- E-mail: co_kks@yahoo.com