# **MOTORCYCLES**

### \*\*\*\*\* Overall Trends \*\*\*\*

# 1 Introduction

In 2021, motorcycle production in Japan increased by 33.5% from 2020 to 647,000 units, reversing the declines caused by the effects of the COVID-19 pandemic that started in 2019. Exports also increased by 40.1% to 437,000 units and shipments inside Japan rose by 15.3% to 379,000 units.

# **2** Production and Demand Trends

#### 2. 1. Production

As shown in Fig. 1, the number of motorcycles produced in Japan in 2021 increased by 33.5% from 2020 to a total of 647,000 units. Exports increased by 40.1% to 437,000 units, while shipments inside Japan rose 15.3% to 379.000 units.

#### 2. 2. Demand in Japan

Figure 2 shows motorcycle demand in Japan based on engine displacement. Despite lower demand for minisized motorcycles, which decreased by 0.5% compared to 2020, demand for all other categories of motorcycles increased, causing overall demand to rise by 15.3% to 379.000 units.

## (1) 50 cm<sup>3</sup> or Less Displacement Motorcycles (Class 1 Motor-Driven Cycles)

In 2021 the demand for this class of motorcycles increased by 4.3% from the previous year to 128,000 units.

# (2) 51 to 125 cm<sup>3</sup> Displacement Motorcycles (Class 2 Motor-Driven Cycles)

In 2021 the demand for this class of motorcycles increased by 23.5% from the previous year to 126,000 units.

# (3) 126 to 250 cm<sup>3</sup> Displacement Motorcycles (Mini-Sized Motorcycles)

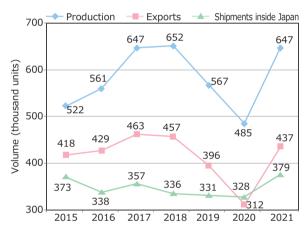
In 2021 the demand for this class of motorcycles decreased by 0.5% from the previous year to 67,000 vehicles,

# (4) 251 cm<sup>3</sup> or Higher Displacement Motorcycles (Small-Sized Motorcycles)

In 2021 the demand for this class of motorcycles increased by 58.4% from the previous year to 58,000 vehicles,

#### 2.3. Exports

In 2021, exports to all regions rose due to higher mo-



\* Source: Japan Automobile Manufacturers Association database

 $\textbf{Fig. 1} \quad \textbf{Trends for Production, Exports, and Shipments inside Japan}$ 



Fig. 2 Shipments inside Japan based on Engine Displacement

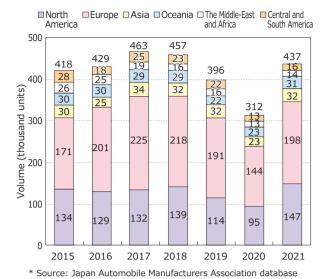


Fig. 2 Chinmonto nor Market

Fig. 3 Shipments per Market

torcycle demand for personal transportation and leisure during the global COVID-19 pandemic, increasing by 40.1% to 437,000 units (Fig. 3).

#### (1) North America

Motorcycle exports to North America in 2021 increased by 54.4% from the previous year to 147,000 units.

#### (2) Europe

Motorcycle exports to Europe in 2021 increased by 37.1% from the previous year to 198,000 units.

#### (3) Asia

Motorcycle exports to Asia in 2021 increased by 40.3% from the previous year to 32,000 units.

#### (4) Oceania

Motorcycle exports to Oceania in 2021 increased by 31.1% from the previous year to 31,000 units.

Table 1 Details of Main New Motorcycles Launched in 2021

Month of launch	New	Rede- signed	Manufacturer	Name of model	Characteristics
January		0	Kawasaki	Z900	Liquid-cooled/4 -stroke/parallel 4 -cylinder/DOHC/4 -valve/FI
		0	Suzuki	Address V50	Forced air-cooled/4 -stroke/single-cylinder/SOHC/2 -valve/FI
		0	Suzuki	Katana	Liquid-cooled/4 -stroke/inline 4 -cylinder/DOHC/4 -valve/FI
		0	Yamaha	YZF-R3 ABS	Liquid-cooled/4 -stroke/inline 2 -cylinder/DOHC/4 -valve/FI
		0	Yamaha	YZF-R25 ABS	Liquid-cooled/4 -stroke/inline 2 -cylinder/DOHC/4 -valve/FI
		0	Suzuki	GSX-R125 ABS	Liquid-cooled/4 -stroke/single-cylinder/DOHC/4 -valve/FI
		0	Suzuki	GSX-S125 ABS	Liquid-cooled/4 -stroke/single-cylinder/DOHC/4 -valve/FI
			Honda	PCX160	Liquid-cooled/4 -stroke/single-cylinder/OHC/2 -valve/FI
			Honda	PCX	Liquid-cooled/4 -stroke/single-cylinder/OHC/2 -valve/FI
			Honda	PCX e:HEV	Liquid-cooled/4 -stroke/single-cylinder/OHC/2 -valve/FI
			Honda	CB650 R	Liquid-cooled/4 -stroke/inline 4 -cylinder/DOHC/4 -valve/FI
		0	Honda	CBR650 R	Liquid-cooled/4 -stroke/inline 4 -cylinder/DOHC/4 -valve/FI
		0	Suzuki	SV650	Liquid-cooled/4 -stroke/V2 /DOHC/4 -valve/FI
		0	Suzuki	SV650 X	Liquid-cooled/4 -stroke/V2 /DOHC/4 -valve/FI
		0	Yamaha	YZF-R1 Race Base model	Liquid-cooled/4 -stroke/inline 4 -cylinder/DOHC/4 -valve/FI
		0	Yamaha	YZF-R6 Race Base model	Liquid-cooled/4 -stroke/inline 4 -cylinder/DOHC/4 -valve/FI
February	0		Kawasaki	Meguro K3	Air-cooled/4 -stroke/parallel 2 -cylinder/SOHC/4 -valve/FI
. 65. 44. 7		0	Kawasaki	Ninja 650	Liquid-cooled/4 -stroke/parallel 2 -cylinder/DOHC/4 -valve/FI
		0	Kawasaki	Ninja 650 KRT Edition	Liquid-cooled/4 -stroke/parallel 2 -cylinder/DOHC/4 -valve/FI
		0	Yamaha	Axis Z	Air-cooled/4 -stroke/single-cylinder/SOHC/2 -valve/FI
		0	Suzuki	GSX-S750 ABS	Liquid-cooled/4 -stroke/inline 4 -cylinder/DOHC/4 -valve/FI
		0	Honda	NC750 X	Liquid-cooled/4 -stroke/inline 2 -cylinder/OHC/4 -valve/FI
		0	Honda	NC750 X Dual Clutch Transmission	Liquid-cooled/4 -stroke/inline 2 -cylinder/OHC/4 -valve/FI
		0	Honda	Gold Wing	Liquid-cooled/4 -stroke/horizontally opposed 6 -cylinder/OHC (uni-cam)/F.
		0	Honda	Gold Wing Tour	Liquid-cooled/4 -stroke/horizontally opposed 6 -cylinder/OHC (uni-cam)/F.
		0	Honda	Dio 110	Air-cooled/4 -stroke/single-cylinder/OHC/FI
March		0	Yamaha	Joq	Liquid-cooled/4 -stroke/single-cylinder/SOHC/2 -valve/FI
		0	Yamaha	Jog Deluxe	Liquid-cooled/4 -stroke/single-cylinder/SOHC/2 -valve/FI
		0	Yamaha	Vino	Liquid-cooled/4 -stroke/single-cylinder/SOHC/2 -valve/FI
	0		Honda		
			Suzuki	V-Strom 650 ABS	Liquid-cooled/4 -stroke/V2 /DOHC/4 -valve/FI
		0	Suzuki	V-Strom 650 XT ABS	Liquid-cooled/4 -stroke/V2 /DOHC/4 -valve/FI
		0	Yamaha	SR400 Final Edition	Air-cooled/4 -stroke/single-cylinder/SOHC/2 -valve/FI
		0	Suzuki	V-Strom 1050 ABS	Liquid-cooled/4 -stroke/V2 /DOHC/4 -valve/FI
		0	Suzuki	V-Strom 1050 XT ABS	Liquid-cooled/4 -stroke/V2/DOHC/4 -valve/FI
			Suzuki	Burgman 200 ABS	Liquid-cooled/4 -stroke/single-cylinder/SOHC/4 -valve/FI
		0	Honda	CB1300 Super Four	Liquid-cooled/4 -stroke/inline 4 -cylinder/DOHC/4 -valve/FI
		0	Honda	CB1300 Super Four	Liquid-cooled/4 -stroke/inline 4 -cylinder/DOHC/4 -valve/FI
		0	Honda	CB1300 Super Four	Liquid-cooled/4 -stroke/inline 4 -cylinder/DOHC/4 -valve/FI
		0	Honda	CB1300 Super Four	Liquid-cooled/4 -stroke/inline 4 -cylinder/DOHC/4 -valve/FI
			Suzuki	Gixxer 150	Air-cooled/4 -stroke/single-cylinder/SOHC/2 -valve/FI
			Suzuki	GIXXEI 130	All -cooled/ + -scroke/single-cyllider/sonc/2 -valve/F1

 Table 1
 Details of Main New Motorcycles Launched in 2021 (Cont.)

Month of	New	Rede-	Manufacturer	Name of model	Characteristics
launch March		signed	Honda	CB1000 R	Liquid-cooled/4 -stroke/inline 4 -cylinder/DOHC/4 -valve/FI
riaicii		0	Honda	X-ADV	Liquid-cooled/4 -stroke/inline 2 -cylinder/OHC/4 -valve/FI
		Ö	Honda	Forza	Liquid-cooled/4 -stroke/single-cylinder/OHC/2 -valve/FI
		0	Honda	Grom	Air-cooled/4 -stroke/single-cylinder/OHC/FI
	0		Honda	Gyro e:	AC synchronous motor
April	0		Kawasaki	Z H2 SE	Liquid-cooled/4 -stroke/parallel 4 -cylinder/DOHC/4 -valve/FI
	0	0	Suzuki	Hayabusa	Liquid-cooled/4 -stroke/inline 4 -cylinder/DOHC/4 -valve/FI
		0	Yamaha	Tricity 125	Liquid-cooled/4 -stroke/single-cylinder/SOHC/4 -valve/FI
		0	Yamaha	Tricity 125 ABS	Liquid-cooled/4 -stroke/single-cylinder/SOHC/4 -valve/FI
		0	Suzuki	Gixxer SF250	Oil-cooled/4 -stroke/single-cylinder/SOHC/4 -valve/FI
		0	Honda	CB125 R	Liquid-cooled/4 -stroke/single-cylinder/DOHC/4 -valve/FI
	0		Honda	GB350	Air-cooled/4 -stroke/single-cylinder/OHC/FI
		0	Yamaha	MT-03 ABS	Liquid-cooled/4 -stroke/inline 2 -cylinder/DOHC/4 -valve/FI
		0	Yamaha	MT-25 ABS	Liquid-cooled/4 -stroke/inline 2 -cylinder/DOHC/4 -valve/FI
Maria		0	Yamaha	TMAX560 Tech Max ABS	Liquid-cooled/4 -stroke/inline 2 -cylinder/DOHC/4 -valve/FI
May	0		Honda Suzuki	Rebel 1100 Gixxer 250	Liquid-cooled/4 -stroke/inline 2 -cylinder/OHC/4 -valve/FI
		0	Kawasaki	Ninja ZX-10 R	Oil-cooled/4 -stroke/single-cylinder/SOHC/4 -valve/FI Liquid-cooled/4 -stroke/parallel 4 -cylinder/DOHC/4 -valve/FI
luno		_	Yamaha		Air-cooled/4 -stroke/V2 /SOHC/4 -valve/FI
June		0	Kawasaki	Bolt R-Spec ABS Ninja ZX-10 RR	Liquid-cooled/4 -stroke/v2/SOHC/4 -valve/FI Liquid-cooled/4 -stroke/parallel 4 -cylinder/DOHC/4 -valve/FI
		0	Yamaha	NMAX ABS	Liquid-cooled/4 -stroke/single-cylinder/SOHC/4 -valve/FI
July		0	Suzuki	Burgman 400 ABS	Liquid-cooled/4 -stroke/single-cylinder/DOHC/4 -valve/FI
Jul 7			Honda	GB350 S	Air-cooled/4 -stroke/single-cylinder/OHC/FI
		0	Kawasaki	Versys 1000 SE	Liquid-cooled/4 -stroke/parallel 4 -cylinder/DOHC/4 -valve/FI
		0	Honda	Cross Cub 110	Air-cooled/4 -stroke/single-cylinder/OHC/FI
		0	Honda	ADV150	Liquid-cooled/4 -stroke/single-cylinder/OHC/FI
		0	Yamaha	XMAX ABS	Liquid-cooled/4 -stroke/single-cylinder/SOHC/4 -valve/FI
		0	Yamaha	MT-07 ABS	Liquid-cooled/4 -stroke/inline 2 -cylinder/DOHC/4 -valve/FI
		0	Yamaha	Tracer 9 GT ABS	Liquid-cooled/4 -stroke/inline 3 -cylinder/DOHC/4 -valve/FI
	0		Yamaha	MT-09 SP ABS	Liquid-cooled/4 -stroke/inline 3 -cylinder/DOHC/4 -valve/FI
		0	Suzuki	GSX-R1000 R ABS	Liquid-cooled/4 -stroke/inline 4 -cylinder/DOHC/4 -valve/FI
August		0	Suzuki	GSX-S1000	Liquid-cooled/4 -stroke/inline 4 -cylinder/DOHC/4 -valve/FI
		0	Suzuki	Address 110	Air-cooled/4 -stroke/single-cylinder/SOHC/2 -valve/FI
		0	Yamaha	MT-09 ABS	Liquid-cooled/4 -stroke/inline 3 -cylinder/DOHC/4 -valve/FI
September		0	Kawasaki	Z900 RS	Liquid-cooled/4 -stroke/parallel 4 -cylinder/DOHC/4 -valve/FI
		0	Kawasaki	Z900 RS Cafe	Liquid-cooled/4 -stroke/parallel 4 -cylinder/DOHC/4 -valve/FI
		0	Kawasaki	Z250	Liquid-cooled/4 -stroke/parallel 2 -cylinder/DOHC/4 -valve/FI
		0	Kawasaki	Ninja 400	Liquid-cooled/4 -stroke/parallel 2 -cylinder/DOHC/4 -valve/FI
		0	Kawasaki Kawasaki	Ninja 400 KRT Edition Ninja ZX-25 R	Liquid-cooled/4 -stroke/parallel 2 -cylinder/DOHC/4 -valve/FI Liquid-cooled/4 -stroke/parallel 4 -cylinder/DOHC/4 -valve/FI
		0	Kawasaki	Ninja ZX-25 R SE	Liquid-cooled/4 -stroke/parallel 4 -cylinder/DOHC/4 -valve/FI
		0	Kawasaki	Ninja ZX-25 R SE KRT Edition	Liquid-cooled/4 -stroke/parallel 4 -cylinder/DOHC/4 -valve/FI
		0	Honda	CRF110 F	Air-cooled/4 -stroke/single-cylinder/OHC/FI
		O	Honda	CRF50 F	Air-cooled/4 -stroke/single-cylinder/OHC
		O	Kawasaki	KX450	Liquid-cooled/4 -stroke/single-cylinder/DOHC/4 -valve/FI
		0	Kawasaki	KX250	Liquid-cooled/4 -stroke/single-cylinder/DOHC/4 -valve/FI
		0	Kawasaki	KX450 X	Liquid-cooled/4 -stroke/single-cylinder/DOHC/4 -valve/FI
		0	Kawasaki	KX250 X	Liquid-cooled/4 -stroke/single-cylinder/DOHC/4 -valve/FI
		0	Kawasaki	KX112	Liquid-cooled/2 -stroke/single-cylinder/piston reed valve
		0	Kawasaki	KX85	Liquid-cooled/2 -stroke/single-cylinder/piston reed valve
		0	Kawasaki	KX85 L	Liquid-cooled/2 -stroke/single-cylinder/piston reed valve
		0	Kawasaki	KX65	Liquid-cooled/2 -stroke/single-cylinder/piston reed valve
			Suzuki	RM-Z450	Liquid-cooled/4 -stroke/single-cylinder/DOHC/4 -valve/FI
		0	Suzuki	RM-Z250	Liquid-cooled/4 -stroke/single-cylinder/DOHC/4 -valve/FI
		0	Kawasaki	Z400	Liquid-cooled/4 -stroke/parallel 2 -cylinder/DOHC/4 -valve/FI
		0	Honda	Super Cub C125	Air-cooled/4 -stroke/single-cylinder/OHC/FI
0 1 1		0	Honda	Monkey 125	Air-cooled/4 -stroke/single-cylinder/OHC/FI
October		0	Kawasaki	KLX110 R L	Air-cooled/4 -stroke/single-cylinder/SOHC/2 -valve/FI
		0	Kawasaki	Ninja 400	Liquid-cooled/4 -stroke/2 -cylinder/DOHC/4 -valve/FI
		0	Honda	CRF250 R	Liquid-cooled/4 -stroke/single-cylinder/DOHC/4 -valve/FI
		0	Honda	CRF250 RX	Liquid-cooled/4 -stroke/single-cylinder/DHC/4 -valve/FI
		0	Honda	CRF150 R	Liquid-cooled/4 -stroke/single-cylinder/OHC (uni-cam)/4 -valve
		0	Honda	CRF136 F	Liquid-cooled/4 -stroke/single-cylinder/OHC (uni-cam)/4 -valve
		0	Honda	CRF125 F YZ450 F	Air-cooled/4 -stroke/single-cylinder/OHC/FI
		0	Yamaha	YZ250 F	Liquid-cooled/4 -stroke/single-cylinder/DOHC/4 -valve/FI Liquid-cooled/4 -stroke/single-cylinder/DOHC/4 -valve/FI
	I .	$\cup$	Yamaha	12230 F	Liquid=cooled/+ -Stroke/Strigle=Cyllider/DOHC/4 -ValVe/FI

Table 1 Details of Main New Motorcycles Launched in 2021 (Cont.) Month of Rede-Manufacturer New Name of model Characteristics launch signed YZ250 Liquid-cooled/2 -stroke/single-cylinder October 0 Yamaha Yamaha 0 Y7125 Liquid-cooled/2 -stroke/single-cylinder 0 Yamaha YZ85 Liquid-cooled/2 -stroke/single-cylinder 0 Yamaha YZ85 LW Liquid-cooled/2 -stroke/single-cylinder Liquid-cooled/2 -stroke/single-cylinder 0 Yamaha Y765 YZ450 FX  $\bigcirc$ Yamaha Yamaha  $\bigcirc$ YZ250 FX 0 Yamaha YZ250 X Liquid-cooled/2 -stroke/single-cylinder 0 Yamaha YZ125 X Liquid-cooled/2 -stroke/single-cylinder Yamaha PW50

Liquid-cooled/4 -stroke/single-cylinder/DOHC/4 -valve/FI Liquid-cooled/4 -stroke/single-cylinder/DOHC/4 -valve/FI 0 Air-cooled/2 -stroke/single-cylinder Air-cooled/4 -stroke/parallel 2 -cylinder/SOHC/4 -valve/FI  $\bigcirc$ Kawasaki Meguro K3 Honda  $\bigcirc$ Gyro Canopy e: AC synchronous motor November 0 Honda CB1100 EX Final Edition Air-cooled/4 -stroke/inline 4 -cylinder/DOHC/4 -valve/FI

## (5) The Middle-East and Africa

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December

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Honda

CB1100 RS Final Edition

Tact

Z900

Tact Basic

KI X230 R

CRF450 R

W800

Z650

ZH2

Z H2 SE

Ninja 650

Ninja 650 KRT Edition

Cygnus Gryphus

Ninja ZX-10 R

Ninja ZX-10 RR

KLX230 R S

CRF450 RX

W800 Street

W800 Cafe

Motorcycle exports to the Middle East and Africa increased by 2.1% from the previous year to 14,000 units.

#### (6) Central and South America

Motorcycle exports to Central and South America in 2021 increased by 23.5% from the previous year to 16,000 units.

# 3 Product and Technological Trends —

#### 3. 1. Product Trends

Table 1 lists some of the representative motorcycle models launched in Japan in 2021.

Although virtually no class 1 motor-driven cycles debuted in 2021 other than the Honda Gyro e and Gyro Canopy e, which are electric motorcycles for business purposes, the class 2 motor-driven cycle segment saw the launch of the new Yamaha Cygnus Gryphus as well as minor redesigns for models such as the Honda PCX, CB125R, and Monkey 125, the Yamaha Axis Z, as well as the Suzuki Address 110 and GSX-R125 ABS.

Again, although no new mini-sized motorcycles debuted in 2021, partially redesigned versions of models such as the Honda PCX160, ADV150, and Forza, the Yamaha YZF-R25 ABS and MT-25 ABS, the Suzuki Burgman 200 ABS and Gixxer 250, as well as the Kawasaki Ninja ZX-25R and Z250 were launched.

Air-cooled/4 -stroke/inline 4 -cylinder/DOHC/4 -valve/FI

Air-cooled/4 -stroke/single-cylinder/SOHC/2 -valve/FI

Air-cooled/4 -stroke/parallel 2 -cylinder/SOHC/4 -valve/FI

Air-cooled/4 -stroke/parallel 2 -cylinder/SOHC/4 -valve/FI

Air-cooled/4 -stroke/parallel 2 -cylinder/SOHC/4 -valve/FI

Liquid-cooled/4 -stroke/parallel 2 -cylinder/DOHC/4 -valve/FI

Liquid-cooled/4 -stroke/parallel 4 -cylinder/DOHC/4 -valve/FI

Liquid-cooled/4 -stroke/parallel 4 -cylinder/DOHC/4 -valve/FI

Liquid-cooled/4 -stroke/parallel 2 -cylinder/DOHC/4 -valve/FI

Liquid-cooled/4 -stroke/parallel 2 -cylinder/DOHC/4 -valve/FI

Liquid-cooled/4 -stroke/parallel 4 -cylinder/DOHC/4 -valve/FI Liquid-cooled/4 -stroke/parallel 4 -cylinder/DOHC/4 -valve/FI

Liquid-cooled/4 -stroke/single-cylinder/SOHC/4 -valve/FI

Liquid-cooled/4 -stroke/parallel 4 -cylinder/DOHC/4 -valve/FI Air-cooled/4 -stroke/single-cylinder/SOHC/2 -valve/FI

Liquid-cooled/4 -stroke/single-cylinder/OHC (uni-cam)/4 -valve/FI

Liquid-cooled/4 -stroke/single-cylinder/OHC (uni-cam)/4 -valve/FI

Liquid-cooled/4 -stroke/single-cylinder/OHC/FI

Liquid-cooled/4 -stroke/single-cylinder/OHC/FI

In the small-sized motorcycle class, Honda launched the Rebel 1100 and GB350, models with classic and simple exterior designs, and Kawasaki debuted the Meguro K3. This year also saw minor redesigns for models such as the Honda CB1100 EX Final Edition, the Yamaha SR400 Final Edition, the Suzuki SV650X, and the Kawasaki W800.

Other new models included the Kawasaki Z H2 SE featuring an electronically controlled suspension. There were also minor redesigns for models such as the Honda X-ADV featuring enhanced electronic controls, Yamaha Tracer 9 GT ABS, and Suzuki Hayabusa.

### 3. 2. Technological Trends

Electrification is an important means of reducing carbon dioxide emissions. This year saw the debut of two new electric motorcycles from Honda: the Gyro e and Gyro Canopy e in the class 1 motor-driven cycle segment. The scale of electrification is likely to expand in the future with more electric models being launched in the class 2 motor-driven cycle segment as well.

Another trend is the growth in high-end variations of base models featuring electronically controlled suspensions and the like. The adoption of electronic technologies, such as engine and motor controls, multi-functional meter clusters with external connectivity, and so on is likely to continue across all segments in the future.



# **Engines**



# 1 Technological Trends in Japan

#### 1. 1. Overview

Table 1 lists the specifications of the engines equipped on the major new motorcycle models that went on sale from Japanese manufacturers in 2021. Since around 2020, the neo-classical trend that had been prominent on large models spread to medium sized models as well, creating combinations of the latest technologies with classical-looking engines and bodies.

#### 1. 2. Trends of Each Manufacturer

- (1) Honda Motor Co., Ltd.
- (a) Rebel 1100/1100 DCT

The Rebel 1100 is equipped with a 1,082 cm<sup>3</sup> liquid-cooled, 4-stroke, inline 2-cylinder, single overhead cam (SOHC), 4-valve engine. Compared to the CRF1100L, which also features the same engine, the mass of the flywheel was increased by 32% and modifications were made to the exhaust system, valve timing, and valve lift amount. This engine is notable for its powerful traction due to the uneven firing interval and power pulse created by a 270-degree crankshaft, as well as smooth revving up to high engine speeds. The Rebel 1100 is available with two different transmissions: a dual clutch transmission (DCT), and a manual transmission. Figure 1 shows the external appearance of this motorcycle.

#### (b) GB350/350S

These models are equipped with a 348 cm<sup>3</sup> air-cooled, 4-stroke, single-cylinder, SOHC, 2-valve engine with a 70 mm bore and a long stroke of 90.5 mm. This engine is paired with a wide ratio transmission and features a flywheel with increased mass. Balancers were added to the main shaft as well as the balancer shaft. Various features were also adopted to reduce friction and realize excellent fuel economy, including an offset cylinder that reduces sliding resistance between the piston and the internal cylinder walls and an asymmetrical connecting rod to prevent contact with the bottom internal cylinder wall. These models also feature an assist and slipper clutch that reduces the operation load of the clutch lever and

alleviates discomfort from the shock of sudden engine braking during a downshift. Figure 2 shows the external appearance of this motorcycle.

#### (2) Yamaha Motor Co., Ltd.

#### (a) MT-09 SP ABS

This model is equipped with a 890 cm<sup>3</sup> liquid-cooled, 4-stroke, inline 3-cylinder, dual overhead cam (DOHC), 4-valve engine that features a wide range of newly designed parts, such as the pistons, connecting rod, crankshaft, camshaft, and crank case. As a result, the main engine unit is 300 g lighter than the 2020 model. The injectors were also moved from a position directly mounted on the cylinder head to the throttle valve side. As a result, injection is directed toward the back of the valve head, thereby enhancing combustion and reducing weight. These measures helped to improve fuel economy by 9% compared to the 2020 model. An excellent balance between easy-to-handle launch performance and a powerful torque sensation was realized by optimizing the transmission ratio (1st gear: 2.666 → 2.571, 2nd gear:  $2.000 \rightarrow 1.947$ ), adopting a crank with a higher moment of inertia, and adjusting the fuel injection (FI) settings. Floating shift forks with springs inserted into the fork guides help to realize an excellent shift feeling. Figure 3 shows the external appearance of this motorcycle.

#### (b) YZF-R7 (export spec)

This model is equipped with a  $689 \text{ cm}^3$  liquid-cooled, 4-stroke, inline 2-cylinder, DOHC, 4-valve engine. This is a crossplane 2-cylinder (CP2) engine with the same specifications as the engine adopted on the MT-07 in 2021. The secondary ratios were optimized from 43/16 = 2.687 in the MT-07 to 42/16 = 2.625. This model is also the first in the MT-07 series to feature an assist and slipper clutch. Figure 4 shows the external appearance of this motorcycle.

#### (3) Suzuki Motor Corporation

#### (a) Hayabusa

This model is equipped with a 1,339 cm<sup>3</sup> liquid-cooled, 4-stroke, inline 4-cylinder, DOHC, 4-valve engine featuring combustion chambers with enhanced charging effi-

Table 1 Specifications of New Engines in 2021

Manufacturer	Name of model	Engine type	Displacement	Bore	Stroke	Max. power	Max. torque
Manuracturer	Name of model	Engine type	(cm³)	(mm)	(mm)	(kW/rpm)	(N·m/rpm)
Honda	Rebel 1100/1100 DCT	Liquid-cooled/4-stroke/inline 2-cylinder/SOHC/4-valve	1,084	92.0	81.5	64 /7,000	98 /4,750
	GB350/350S	Air-cooled/4-stroke/single-cylinder/SOHC/2-valve	348	70.0	90.5	15/5,500	29/3,000
Yamaha	MT-09 SP ABS	Liquid-cooled/4-stroke/inline 3-cylinder/DOHC/4-valve	888	78.0	62.0	88/10,000	93/7,000
	YZF-R7	Liquid-cooled/4-stroke/inline 2-cylinder/DOHC/4-valve	688	80.0	68.6	54 /8,750	67/6,500
Suzuki	Hayabusa	Liquid-cooled/4-stroke/inline 4-cylinder/DOHC/4-valve	1,339	81.0	65.0	138/9,700	149 /7,000
	GSX-S1000	Liquid-cooled/4-stroke/inline 4-cylinder/DOHC/4-valve	998	73.4	59.0	110/11,000	105/9,250
Kawasaki	Ninja ZX-10RR	Liquid-cooled/4-stroke/inline 4-cylinder/DOHC/4-valve	998	76.0	55.0	150/14,000	112/11,700
	Bimota Tesi H2	Liquid-cooled/4-stroke/inline 4-cylinder/DOHC/4-valve	998	76.0	55.0	170/11,500	141/11,000



Fig. 1 Rebel 1100



Fig. 2 GB350



Fig. 3 MT-09 SP



Fig. 4 YZF-R7



Fig. 5 Hayabusa



Fig. 6 GSX-S1000

ciency compared to the previous Twin Swirl Combustion Chambers (TSCCs). This engine also features a newly developed 43 mm electronic throttle body. Valve overlap is reduced and both performance and controllability are increased in low- and mid-rpm ranges using a connecting pipe between exhaust pipes #1 and #4 as well as #2 and #3. Strength and rigidity are optimized using lightweight pistons and connecting rods. The crankshaft modifies the oil distribution in the engine by adopting a different oil passage, helping to improve the lubrication of each component. The Hayabusa also adopts a wide range of newly designed parts, including the transmission and cam chain tensioner. Figure 5 shows the external appearance of this motorcycle.

#### (b) GSX-S1000

This model is equipped with a 998 cm<sup>3</sup> liquid-cooled, 4-stroke, inline 4-cylinder, DOHC, 4-valve engine featuring a modified cam profile and intake/exhaust system. It

also adopts an electronic throttle and throttle-by-wire system, which increase maximum power by 1 kW to 110 kW. The GSX-S1000 is also equipped with the Bi-directional Quick Shift System that allows the rider to change gears without operating the clutch or throttle. The Suzuki Clutch Assist System (SCAS) was added to the slipper function on the previous model to make clutch operations easier. Figure 6 shows the external appearance of this motorcycle.

#### (4) Kawasaki Motors Corporation

### (a) Ninja ZX-10RR

This model is equipped with a 998 cm<sup>3</sup> liquid-cooled, 4-stroke, inline 4-cylinder, DOHC, 4-valve engine featuring a new liquid-cooled oil cooler in addition to titanium connecting rods. The weight of each of the two ring pistons used on the specially designed camshaft was reduced by 30 g. Although maximum power remains unchanged, the rev limit was raised by 400 rpm to 14,700



Fig. 7 Ninja ZX-10RR



Fig. 8 Bimota Tesi H2



Fig. 9 M1000RR



Fig. 10 Multistrada V4



Fig. 11 Speed Triple 1200 RS



Fig. 12 890 Adventure

rpm. Figure 7 shows the external appearance of this motorcycle.

#### (b) Bimota Tesi H2

This model is equipped with a 998 cm<sup>3</sup> liquid-cooled, 4-stroke, inline 4-cylinder, DOHC, 4-valve engine. This is Kawasaki's supercharged engine that generates maximum power of 170 kW. Although the Bimota Tesi H2 has attracted attention for its hub-center steering system, it also achieves superb maneuverability due to its dry weight of only 207 kg, 31 kg lighter than the Ninja H2. Figure 8 shows the external appearance of this motorcycle.

# 2 Technological Trends outside Japan

## (a) BMW M1000RR

This model is equipped with a 999 cm³ liquid-cooled, 4-stroke, inline 4-cylinder, DOHC, 4-valve engine that generates 156 kW at 14.500 rpm, up from the 154.4 kW at 13,500 rpm of the S1000RR. The rev limit was also raised by 500 rpm to 15,100 rpm. This engine features major modifications such as 101 mm titanium connecting rods (length increased by 2 mm) and dual ring forged pistons with cross ribs that were each reduced in weight by 85 g and 12 g, respectively. The width of the rocker arms was also reduced by 1.5 mm to lower weight by 0.45 g. Figure 9 shows the external appearance of this motorcycle.

#### (b) Ducati Multistrada V4

This model is equipped with a 1,158 cm<sup>3</sup> liquid-cooled, 4-stroke, V4, DOHC, 4-valve engine. The desmodromic valve system (forcible valve opening and closing system) that Ducati has traditionally adopted on the Multistrada V4 was replaced by spring-driven valves, which extend the valve clearance inspection and adjustment interval to 60,000 km. This engine is also equipped with a mechanism that deactivates the rear cylinders during idling. Optimum riding performance from low to high speeds was realized by changing the transmission ratios from the Panigale V4 that adopts the same engine (1st gear:  $2.400 \rightarrow 3.077$ , 6th gear:  $1.227 \rightarrow 1.080$ ). Figure 10 shows the external appearance of this motorcycle.

#### (c) Triumph Speed Triple 1200 RS

This model is equipped with a 1,160 cm<sup>3</sup> liquid-cooled, 4-stroke, inline 3-cylinder, DOHC, 4-valve engine. Displacement was increased from 1,050 cm<sup>3</sup>, the bore widened from 70 to 90 mm, and the stroke shortened from 71.4 to 60.8 mm. Compared to the Speed Triple 1050S, power was increased by 22. 4 kW to 132.4 kW. In addition, the inertial mass of the crankshaft was reduced, helping to realize agile maneuverability. Figure 11 shows the external appearance of this motorcycle.

#### (d) KTM 890 Adventure

This model is equipped with an 889 cm<sup>3</sup> liquid-cooled, 4-stroke, inline 2-cylinder, DOHC, 4-valve engine. Dis-

placement was raised from 799 to 889 cm<sup>3</sup> with the same basic layout. Maximum power was increased by 7 kW to 77 kW by widening the intake and exhaust valves, improving the balancer, reducing the weight of the pistons, and increasing the inertial mass of the crankshaft. Figure 12 shows the external appearance of this motorcycle.

# 3 Research and Development Trends

In 2021, each manufacturer launched new models that comply with the Euro 5 emissions standards. Research and development into alternative fuels and electrification is also making progress as part of measures to address environmental issues. As the global COVID-19 pandemic spreads, the development of products that meet changing market needs it is also expected.

## 

# 1 Introduction -

Current issues and trends affecting motorcycles are complex. In addition to long-standing trends pushing the transformation of the industry such as actions to address global warming as well as connected, autonomous, sharing- and service-related, and electrification (CASE) technologies, the industry has been buffeted by the effects of the COVID-19 pandemic, which still seems to have no end in sight. During the COVID-19 pandemic, motorcycles have come to be seen as the ideal form of transportation for the times due to their relatively low price, isolation from crowded spaces, and depth of personal interest. Currently, all sectors of industry are being called upon to take rapid steps toward a decarbonized society. The electrification of motorcycles is also progressing, and engines are being developed that use hydrogen, synthetic fuels, and the like. Consequently, with social and technological demands on motorcycles growing more sophisticated and diverse, the following sections look back over motorcycle design trends in 2021 across the main motorcycle categories.

# 2 Design Trends

Currently, in many categories of motorcycles, the number of high-cost specialist models is decreasing. There is a growing trend of developing platforms that share fundamental components such as the engine and body, and most models are now derived from these platforms. As a result, design is growing in importance as a way to differentiate between models. Motorcycle categories are defined from perspectives of image based on external appearance, application, riding feel, and so on. These categories are complemented by terminology derived from unique motorcycle-related trends such as "cafe." As

these definitions can be cross-related with each other, it can be difficult to place certain motorcycles into specific categories. With this in mind, the following sections describe the key design trends in 2021.

# 2. 1. Adventure Motorcycles (Long-Legged Models)

One of the most popular global motorcycle categories is the so-called "adventure" category. Adventure motorcycles have a tall, upright image. As the name suggest, this category is meant to evoke the impression of adventurous riding or travelling. However, motorcycle categories have become further segmented in recent years and some users have come to express a preference for offroad models. Although off-road capabilities can be expressed in terms of actual performance, models that project a more genuine impression appeal to users look-



Fig. 1 Ducati DesertX



Fig. 2 Husqvarna Motorcycles Norden 901



Fig. 3 Honda ADV350



Fig. 4 Aprilia SR GT



Fig. 5 Honda GB350

ing for a tough and free lifestyle. Two examples of this are the Ducati DesertX (Fig. 1) and the Norden 901 from Husqvarna Motorcycles (Fig. 2). The design of the DesertX is rooted in the rally raid race bikes that competed in events such as the Paris-Dakar Rally in the 1990s. In contrast, the Norden 901 retains the simple and modern image that is at the core of Husqvarna's design language. Both models have extremely interesting yet contrasting design approaches while still expressing a genuine offroad image.

A crossover category between adventure and easy riding models equipped with automatic transmissions is also enjoying significant expansion. In 2017, Honda took the initiative in this category with the X-ADV. An increasing number of models have entered the market since then, supported by the following wind of a global



Fig. 6 Kawasaki Z650RS



Fig. 7 Yamaha XSR900



Fig. 8 Suzuki GSX-S1000

boom in outdoor leisure activities, as typified by the Honda ADV350 (Fig. 3) and Aprilia SR GT (Fig. 4). The ADV350 features a further refined version of the modern and tough styling of the same series, whereas the SR GT has a more dynamic and sporty design.

#### 2. 2. Neo-Retro and Neo-Classic Motorcycles

These are also popular categories that have expanded significantly in recent years. These models combine a retro or classical exterior design with modern internals or functions.

The styling is characterized by the adoption of new technologies, particularly in the lamp system or functional parts, and design elements are used to actively differentiate between models. The design expresses the heritage of models in these categories, which is advantageous for historical brands. Some of the stand out models in these categories in 2021 were as follows.

#### (a) Honda GB350 (Fig. 5)

The GB350 has simple and harmonious styling based



Fig. 9 Yamaha YZF-R7



Fig. 10 BMW CE 04

on a traditional sleek silhouette. The excellent overall balance of the design and presentation of metallic components creates a superb sense of high-class refinement.

#### (b) Kawasaki Z650RS (Fig. 6)

Although based on flowing styling that pays homage to models from the 1970s, the design of the Z650RS has been rebalanced to reflect modern proportions, creating a casual image typical of a mid-size model.

#### (c) Yamaha XSR900 (Fig. 7)

The XSR900 combines a modern-flavored styling with a sporty silhouette resembling a racing machine of the 1980s with the fairings removed. Elements such as a tail lamp embedded in the rear end of the seat and mirrors mounted on both ends of the handlebars help to create a fresh and wild image akin to that of a custom model.

#### 2. 3. Standard and Sporty Motorcycles

This year also saw strong demand for these universal motorcycle categories. As a whole, despite weaker demand for pure performance models across the overall motorcycle market, ordinary riders seem to be prioritizing higher performance. Accompanying this trend, design plays a major role in differentiating between models, and manufacturers are adopting a wide range of techniques to stand out. Some typical models are described below.

#### (a) Suzuki GSX-S1000 (Fig. 8)

The organic image of the previous model has been completely updated to create sharp and robust styling. Design elements such as a compact front end due to vertically stacked small dual LED headlights and winglets positioned at the radiator shroud make effective use of new technologies, resulting in a fresh image.

#### (b) Yamaha TXF-R7 (Fig. 9)

Inspired by Yamaha's MotoGP machines, the TXF-R7 has a racy design with extremely slim styling that takes advantage of the characteristics of the base model. In addition to performance, this is an example of design that also factors in rider-friendliness. Compact LED headlamps are located inside the front ducts to create a deliberately unobtrusive impression that combines both an attractive design and functionality.

#### 2. 4. Electrification and New Technologies

Motorcycle manufacturers are launching a wide variety of electric models with an eye on the future. The designs of these models also incorporate various new ideas. Compared to conventional internal combustion engine (ICE) models, electric motorcycles have simpler structures and more flexibility in terms of body layout. This enables major innovations in design. One example is the BMW CE 04 (Fig. 10). The CE 04 has a low and long horizontal silhouette that distinguishes it from conventional motorcycles and scooters. Each part of the body is covered by solid panels to create an appearance that evokes the coming future.

While adopting new technologies throughout, such as LED lamps, daytime running lamps (DRLs), aerodynamic devices, a full-color LCD meter cluster, and smart phone connectivity, this model has an advanced design and interface that is both keenly influenced by and makes use of these technologies. Advanced rider assistance systems (ARAS) were a major subject of motorcycle technologies in 2021. Although these technologies have been adopted relatively quickly by cars and other four-wheeled vehicles, it is more difficult to install large sensors on motorcycles and create cohesive designs. However, as these technologies help to further enhance safety and comfort, their adoption is likely to become mandatory in the future.

#### 3 Future Trends

In addition to the adoption of various new technologies and measures to comply with increasingly stringent regulations, higher material prices and supply chain constrictions due to the effects of the COVID-19 pandemic are pushing up development and manufacturing costs. Reflecting these trends, the adoption of common plat-

forms is likely to accelerate in accordance with electrification and, combined with market entries from different industries, there is the concern that motorcycles will become more and more commodified. In what is regarded as a once-in-a century transformation of the industry, manufacturers are expected to, better than ever, predict the ever-changing needs of the market while enhancing perceived product value. Therefore, it is important for design development to constantly follow customer needs with a close awareness of market trends and new technologies, and make every effort to create even greater new value.

#### References

· S&P Global Mobility: Light Vehicle Sales